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Compilation of Economic Reports Assessing the Impacts of Mid-Term Measures on Caribbean States



Prepared For :
Caribbean Shipping Lanes (CSL)

Prepared By :
UWI, UCL, CMU



This report comprises the following sections:

- [**Section 1 - Economic and Trade Data Validation**](#)
- [**Section 2 - Impact Analysis for the Caribbean Region**](#)
- [**Section 3 - Reviewing analysis of the impact of the IMO mid-term measures on Caribbean economies**](#)
- [**Section 4 - Distributing shipping carbon revenue in the Caribbean Small Island Developing States**](#)
- [**Section 5 - Assessing the Potential Impact of the IMO Mid-Term GHG Mitigation Measures on Food Security in Caribbean Nations.**](#)

SECTION 1

ECONOMIC AND TRADE DATA VALIDATION



ECONOMIC AND TRADE DATA VALIDATION

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EXECUTIVE SUMMARY

The objective of this Economic and Trade Data Validation report is to validate existing public domain data on trade volumes, values, and transport costs for the Caribbean region, including cross-checking with in-region data from ports and governments and evaluating the reliability of these datasets in IMO-specific analyses such as the Comprehensive Impact Assessment (CIA). The analysis will focus on the Caribbean states of Jamaica, Trinidad and Tobago, Antigua and Barbuda, Barbados, and Saint Lucia.

Generally, datasets concerning trade volume are found to be broadly consistent for the Caribbean countries considered in this analysis; however substantial deviations are observed across datasets representing transport costs. Based on these findings, care should be taken when interpreting CIA results for the Caribbean region. The data quality is sufficient to understand the relative impacts across various policy options. However, estimates of the overall impact on the economy are likely unreliable and under-represented. Results are likely to be similar, if not worse, for Pacific SIDS, where only Australia and New Zealand are represented as individual regions in the database.

Table 1.1. Indicative quality of merchandise trade statistics contained in the GTAP-11 database representing the 5 Caribbean countries of interest and its implications in terms of interpretation of CIA Task 3 results.

Representing	Source	Country	Quality	Implication for understanding...	
				Relative Impact Across Policy Scenarios	Overall Magnitude of MTM Impact
Merchandise Trade	GTAP-11	Jamaica	Medium	Weak	Moderate
		Trinidad and Tobago	Good	Weak	Weak
		Antigua and Barbuda	Poor	Moderate	Strong
		Barbados	Poor	Moderate	Strong
		Saint Lucia	Poor	Moderate	Strong

Representation of these countries' merchandise trade in the GTAP-11 database utilised by the CIA is observed to be poor for these Caribbean economies. Three of the five countries are aggregated into the 'Rest of Caribbean' category, and large discrepancies, representing factors between 1.2 and 2.0, are observed in merchandise trade statistics for Jamaica and Trinidad and Tobago. The implications of this are likely to be weak in terms of interpreting relative impacts across potential policy scenarios; however, they are likely to be strong in terms of interpreting the overall magnitude of impact.

Table 1.2. Indicative quality of transport cost statistics contained in the GTAP-11 database representing the 5 Caribbean countries of interest and its implications in terms of interpretation of CIA Task 3 results

Representing	Source	Country	Quality	Implication for understanding...	
				Relative Impact Across Policy Scenarios	Overall Magnitude of MTM Impact
Transport Costs	GTAP-11	Jamaica	Poor	Weak	Strong
		Trinidad and Tobago	Poor	Weak	Strong
		Antigua and Barbuda	Poor	Weak	Strong
		Barbados	Poor	Weak	Strong
		Saint Lucia	Poor	Weak	Strong

Significant variability is observed across alternative sources of transport costs representing the five Caribbean countries, resulting in uncertainty as to the quality of transport cost rates recorded in the GTAP-11 database. The implications of this are likely to be weak in terms of interpreting relative impacts across potential policy scenarios; however, they are strong in terms of interpreting overall magnitudes of impact.

1.1. Introduction

The objective of this report is to validate existing public domain data on trade volumes, values, and transport costs for the Caribbean region, including cross-checking with in-region data from ports and governments and evaluating the reliability of these datasets in IMO-specific analyses such as the Comprehensive Impact Assessment (CIA) (DNV, 2024; UNCTAD, 2024a; Starcrest, 2024). The analysis will consider the Caribbean states of Jamaica, Trinidad and Tobago, Antigua and Barbuda, Barbados, and Saint Lucia.

For the purposes of this research, it's assumed that the accuracy of recorded trade volumes mirrors that of trade values; however more pronounced differences may exist. Therefore, two types of statistics, those representing merchandise trade and transport costs, are considered for the task.

1.1.1. Data Sources

Table 1.3. What datasets are available for the task, specific data element do they cover and where are they available?

Data Source	Merchandise Trade	Transport Costs	Resource Link
Desk-based Research	Yes	Yes	Desk-based research.
Comtrade	Yes	No	(UNCTAD, 2024b)
T-and-T	Yes	Yes	(UNCTAD, 2024c)
GTAP-11	Yes	Yes	(Aguiar et al, 2022)

Four sources of data were considered to compare merchandise trade and transport cost statistics. Whilst not an exhaustive list of all publicly available data sources, focus has been placed on those associated with Task 2 of the CIA (UNCTAD, 2024a). In the case of merchandise trade, statistics obtained via desk-based research serve as a 'ground truth' with which to benchmark alternative sources. No equivalent 'ground truth' for transport cost statistics exists. Therefore, sources of transport costs are compared against each other instead. The coherence of each data source across both statistic types is first quantitatively evaluated, then qualitatively described with reference to implications for IMO-specific analyses such as the CIA.

1.1.1.1. Source 1: Desk-based Research

The first data source involves a comprehensive review of the availability of datasets from publicly accessible online sources, including the websites of government ministries, non-governmental organisations, and private commercial entities. The

objective of this review is not necessarily to compile an exhaustive list of all relevant publications, but rather to understand the availability and quality of literature and data for each country.

1.1.1.2. Source 2: Comtrade

The second source of data is the Comtrade database (UNCTAD, 2024b), a publicly accessible database comprised of international merchandise trade statistics from national statistics offices and customs authorities representing the majority of nations worldwide. Whilst the availability of merchandise trade figures is not guaranteed, there is a good representation of the five Caribbean countries considered in this research.

1.1.1.3. Source 3: Trade and Transport

Transport cost statistics can concisely convey the magnitude of, and differences between, the barriers to merchandise trade experienced by nations worldwide. In recent years, the analysis of transport cost statistics has emerged as a primary mechanism through which to understand potential impacts of IMO policy. However, statistics of this nature are typically difficult to obtain and often of poor quality, issues exacerbated for SIDS and LDCs.

It is within this context that UNCTAD formally released the Trade and Transport dataset in May 2024 (UNCTAD, 2024c). The dataset is described as “detailing the value and volume of merchandise trade, including the associated costs and transport efforts for imports and exports across over 170 economies”, in addition to offering the “first-ever data showing trade costs by country, commodity and mode of transport”. A tremendously useful resource for research on transport policy, the dataset has been utilised extensively in Task 2 of the CIA (UNCTAD, 2024a).

1.1.1.4. Source 4: GTAP-11

The Global Trade Analysis Project (GTAP) represents a network of researchers and policy makers developing quantitative analysis techniques to improve the quality of global economic analysis. GTAP analysis relies on a comprehensive data repository containing detailed bilateral trade information, including domestic industry linkages, transport supply, transport margins, and details of trade ‘protections’ such as import and export taxes, tariffs, and subsidies (Aguilar et al, 2022).

The GTAP representation of global trade has expanded from 15 regions and 37 sectors in its first release in 1993 (GTAP-1) to 160 regions and 65 sectors in the latest GTAP-11, based on the year 2017. The database is built upon a number of data sources including FAO and EUROSTAT for agricultural data, IEA and UN for energy data, ILO for labour data, and FAO for climate data. The final dataset provides a snapshot of the world economy for a given reference year, formatted to ensure compatibility with its associated general equilibrium analysis framework (Corong et al, 2017).

1.2. Merchandise Trade

Table 1.4. Merchandise import and export value statistics by country, derived from multiple sources. Data representing 2021 merchandise trade is shown for all countries, except Saint Lucia for which 2020 data is shown. GTAP-11 data is based on the reference year

Country	Imports, US\$				Exports, US\$			
	Desk-based Research	Comtrade	Trade-and-Transport	GTAP-11	Desk-based Research	Comtrade	Trade-and-Transport	GTAP-11
Jamaica	6,026,669,180	5,970,850,078	5,244,889,858	8,817,000,000	1,480,526,275	1,480,709,867	969,781,714	4,326,000,000
Trinidad and Tobago	5,735,643,663	5,760,698,896	5,121,879,469	8,255,000,000	8,581,707,472	8,620,228,625	9,305,666,045	10,346,000,000
Antigua and Barbuda	594,930,400	595,524,418	615,004,626	-	19,128,251	19,147,287	1,573,169,903	-
Barbados	1,670,986,322	1,673,255,488	1,493,206,799	-	349,888,898	350,172,911	246,436,664	-
Saint Lucia	504,026,210	532,913,977	469,183,582	-	55,147,760	67,424,832	1,591,487,524	-

Four alternative sources of merchandise trade statistics for the five Caribbean countries have been identified and are presented above. Across all countries considered, some level of national merchandise trade statistics was available from reputable organisations such as a National Statistics Office or Central Bank. All sources were further able to provide statistics covering at least one recent year, the least recent being 2020 in the case of Saint Lucia.

Similarly high coverage levels were observed in Comtrade-recorded merchandise trade statistics, with availability across all five countries and the least recent year being 2020 for Saint Lucia. Merchandise trade data for 2021 was also available from UNCTAD's Trade and Transport database; however, records in the GTAP-11 database were limited to Jamaica and Trinidad and Tobago, while trade statistics for Antigua and Barbuda, Barbados and Saint Lucia were included in the 'Rest of Caribbean' aggregation.

1.2.1. Jamaica

Two online resources representing merchandise trade statistics for Jamaica were identified as part of desk-based research (Bank of Jamaica, 2024; Statistics Institute of Jamaica, 2024). Given its improved format and the absence of a currency conversion step, records (Bank of Jamaica, 2024) are regarded as 'ground truth' to compare against alternative sources.

Table 1.5. Merchandise import value statistics for Jamaica by source between the years 2016 and 2023. Data acquired throughout 2024 via desk-based research, Comtrade, Trade and Transport and GTAP.

Source	Imports							
	2016	2017	2018	2019	2020	2021	2022	2023
Desk-based Research	-	-	6,220,680,100	6,451,335,816	4,802,866,285	6,026,669,180	7,809,561,961	-
Comtrade	4,767,089,174	5,818,098,181	6,170,534,660	6,389,126,910	4,765,478,926	5,970,850,078	7,731,213,540	7,592,057,990
Trade-and-Transport	4,143,701,999	5,214,502,800	5,616,163,704	5,809,765,377	4,275,138,256	5,244,889,858	-	-
GTAP-11	-	8,817,000,000	-	-	-	-	-	-

Reference data presented in (Bank of Jamaica, 2024) indicates that imports into Jamaica amounted to US\$6.0bn in 2021, ranging from US\$4.8bn to US\$7.8bn between 2018 and 2022. Statistics obtained from the Comtrade platform indicate merchandise import values into Jamaica align within 1% of reference figures between the years 2018-22.

Data from the Trade and Transport dataset indicates that Jamaica's imports amounted to between US\$4.3-5.8bn between the years 2018-21 representing values of 9.7-13.0% less than reference figures for those same years. The GTAP-11 database most recently calibrated on 2017, indicates Jamaica's imports totalled US\$8.8bn, exceeding alternative estimates for that year by close to one third.

Table 1.6. Merchandise export value statistics for Jamaica by source between the years 2016 and 2023. Data acquired throughout 2024 via desk-based research, Comtrade, Trade and Transport and GTAP.

Source	Exports							
	2016	2017	2018	2019	2020	2021	2022	2023
Desk-based Research	-	-	1,960,744,054	1,653,127,701	1,250,502,376	1,480,526,275	1,901,415,954	-
Comtrade	1,201,786,561	1,309,718,443	1,960,739,707	1,651,161,084	1,250,599,436	1,480,709,867	1,901,415,819	2,001,802,217
Trade-and-Transport	737,634,765	897,372,865	1,212,847,134	1,183,637,167	915,195,807	969,781,714	-	-
GTAP-11	-	4,326,000,000	-	-	-	-	-	-

Reference data presented in (Bank of Jamaica, 2024) indicates that exports from Jamaica amounted to US\$1.5bn, ranging from US\$1.3bn to US\$2.0bn between the years 2018-22. Statistics obtained from the Comtrade platform indicate that merchandise export values from Jamaica correlate to within 0.2% of reference figures during the years 2018-22.

Data from the Trade and Transport dataset indicates that Jamaica's exports amounted to between US\$0.9-1.2bn between the years 2018-21, representing values of 26.8-38.1% less than reference figures for those same years. GTAP-11 data most recently calibrated on 2017, indicates that Jamaica's exports totalled US\$4.3bn in 2017, more than 3x greater than the figure observed in Comtrade for that year and over double any figure observed across desk-based research and Comtrade between the years 2016-23.

1.2.2. Trinidad and Tobago

Two online resources representing merchandise trade statistics for Trinidad and Tobago were identified as part of desk-based research, published by the (Central Bank of Trinidad and Tobago, 2024; Trinidad and Tobago CSO, 2024). The data presented in (Central Bank of Trinidad and Tobago, 2024) is taken forward as reference data to validate alternative sources of trade statistics. A small margin of uncertainty has been introduced in converting this data to US\$ from \$TTD.

Table 1.7. Merchandise import value statistics for Trinidad and Tobago by source between the years 2016 and 2023. Data acquired throughout 2024 via desk-based research, Comtrade, Trade and Transport and GTAP.

Source	Imports							
	2016	2017	2018	2019	2020	2021	2022	2023
Desk-based Research	-	-	-	6,318,096,814	4,866,305,385	5,735,643,663	6,200,637,360	8,875,469,621
Comtrade	8,048,587,661	6,898,750,366	7,717,407,418	6,338,601,314	4,875,999,395	5,760,698,896	6,202,573,330	-
Trade-and-Transport	7,296,976,408	6,347,918,074	7,176,914,026	5,814,332,438	4,458,715,375	5,121,879,469	-	-
GTAP-11	-	8,255,000,000	-	-	-	-	-	-

Reference data presented in (Central Bank of Trinidad and Tobago, 2024) indicates that imports into Trinidad and Tobago totalled US\$5.7bn in 2021, ranging from US\$4.8bn to US\$8.9bn between the years 2019-23. Statistics from the Comtrade database indicate that imports into Trinidad and Tobago amounted to US\$5.8bn in

2021, with import values observed to correlate to within 0.5% of reference values between the years 2019-22.

Merchandise trade statistics, as recorded in the Trade and Transport database, totalled US\$5.1bn in 2021, which is 10.7% less than the reference value identified for that year, indicating trade values of between 8.0-10.7% less than the reference figure across 2019-21. The GTAP-11 database suggests a merchandise import value of US\$8.3bn for its reference year, 2017, around 19.7% higher than the Comtrade recorded value for that year, and it is observed to align well with reference data.

Table 1.8. Merchandise export value statistics for Trinidad and Tobago by source between the years 2016 and 2023. Data acquired throughout 2024 via desk-based research, Comtrade, Trade and Transport and GTAP.

Source	Exports							
	2016	2017	2018	2019	2020	2021	2022	2023
Desk-based Research	-	-	-	7,169,814,387	5,507,265,042	8,581,707,472	13,217,699,730	7,718,975,140
Comtrade	7,608,632,116	8,740,876,130	10,530,263,001	7,191,889,250	5,519,378,228	8,620,228,625	11,529,004,579	-
Trade-and-Transport	7,094,411,207	8,247,069,795	175,425,328,505	9,647,886,340	6,339,609,635	9,305,666,045	-	-
GTAP-11	-	10,346,000,000	-	-	-	-	-	-

Reference data presented in (Central Bank of Trinidad and Tobago, 2024) indicates that exports from Trinidad and Tobago amounted to US\$8.6bn in 2021, ranging from US\$5.5bn to US\$13.2bn between the years 2019-23. Statistics from the Comtrade database indicate export values correlating to within 0.5% of reference values for the years 2019-21, however providing an export value of 12.8% less than the reference value for the year 2022.

Merchandise trade statistics recorded in the Trade and Transport database totalled US\$9.3bn in 2021, reflecting an increase of 8.4% over the reference figure, and indicating export trade values ranging from 8.4-34.6% across 2019-21 when compared with reference data for those years. The Trade and Transport data also indicates an export value of for 2018 of 15x the corresponding Comtrade value (US\$175.4bn compared to US\$10.5bn). The GTAP-11 database suggests a merchandise export value of US\$10.3bn for its reference year 2017, around 18.4% higher than the recorded Comtrade value for that year, which is observed to broadly align with reference data.

1.2.3. Antigua and Barbuda

One online resource representing merchandise trade statistics for Antigua and Barbuda was identified as part of desk-based research. The agency's online resource (MFCG, 2024) is taken as a benchmark for alternative sources. It is noted that applying a currency conversion between EC\$ to US\$ to the data has led to a level of uncertainty (a flat conversion rate of 0.3700 was identified for the years 2018-22 based on research).

Table 1.9. Merchandise import value statistics for Antigua and Barbuda by source between the years 2016 and 2023. Data acquired throughout 2024 via desk-based research, Comtrade, Trade and Transport and GTAP.

Source	Imports								
	2016	2017	2018	2019	2020	2021	2022	2023	
Desk-based Research	-	-	698,060,130	700,191,330	497,617,070	594,930,400	819,075,660	-	
Comtrade	490,525,305	629,819,172	569,155,191	568,340,063	498,112,635	595,524,418	627,945,130	669,653,744	
Trade-and-Transport	356,934,561	483,639,570	521,159,384	519,781,174	491,579,267	615,004,626	-	-	
GTAP-11	-	-	-	-	-	-	-	-	

Reference data from (MFCG, 2024) indicates that imports into Antigua and Barbuda amounted to US\$595m in 2021, ranging from US\$498-819m between the years 2018-22. Statistics from the Comtrade database indicate that imports totalled US\$596m in 2021. Whilst within around 0.1% of the reference figure for 2020 and 2021, Comtrade statistics were observed to be between 18-24% less than reference figures for the years 2018, 2019 and 2022.

Data from the Trade and Transport database indicates that imports amounted to US\$615m in 2021, 3.4% greater than the reference figure. However, the data displayed a misalignment of up to 26% when compared with reference figures for 2018-21. No import data for Antigua and Barbuda could be drawn from the GTAP-11 database due to its aggregation into the 'Rest of Caribbean' region.

Table 1.10. Merchandise export value statistics for Antigua and Barbuda by source between the years 2016 and 2023. Data acquired throughout 2024 via desk-based research, Comtrade, Trade and Transport and GTAP.

Source	Exports								
	2016	2017	2018	2019	2020	2021	2022	2023	
Desk-based Research	-	-	25,815,266	37,641,003	22,167,971	19,128,251	21,854,520	-	

Comtrade	61,043,254	62,390,603	25,841,082	37,400,118	22,199,425	19,147,287	21,876,396	30,496,874
Trade-and-Transport	227,898,635	205,302,547	222,795,843	1,855,415,959	1,405,698,946	1,573,169,903	-	-
GTAP-11	-	-	-	-	-	-	-	-

Reference data from (MFCG, 2024) indicates that exports from Antigua and Barbuda amounted to US\$19.1m in 2021, ranging from US\$19.1-37.6m between the years 2018-22. Export statistics from the Comtrade database were observed to closely align with reference figures (within 1%).

Data from the Trade and Transport database indicates that exports from Antigua and Barbuda amounted to US\$1.6bn in 2021, ranging between US\$1.4-1.9bn between the years 2019-21, which represents substantial overestimations of 48-82x the value of reference figures for those years. No export values could be drawn from the GTAP-11 database due to the nation's aggregation within the 'Rest of Caribbean' region.

1.2.4. Barbados

Two online resources representing merchandise trade statistics for Barbados were identified as part of desk-based research (Barbados Statistics Service, 2024; Central Bank of Barbados, 2024). The most comprehensive data were those presented in (Central Bank of Barbados, 2024).

Trade data from the years 2018-22 are taken forward as reference data to validate alternative sources of Barbados' trade data. It is noted that a degree of uncertainty has been introduced to the reference data after applying BD\$ to US\$ conversion rates of between 0.4996 to 0.5000.

Table 1.11. Merchandise import value statistics for Barbados by source between the years 2016 and 2023. Data acquired throughout 2024 via desk-based research, Comtrade, Trade and Transport and GTAP.

Source	Imports							
	2016	2017	2018	2019	2020	2021	2022	2023
Desk-based Research			1,577,845,510	1,580,896,214	1,496,205,780	1,670,986,322	2,144,741,912	-
Comtrade	1,621,269,759	1,599,597,495	1,599,911,169	1,580,842,477	1,500,813,629	1,673,255,488	2,151,007,542	2,142,606,689
Trade-and-Transport	1,451,850,082	1,480,267,979	1,485,242,373	1,351,388,376	1,377,752,729	1,493,206,799	-	-
GTAP-11	-	-	-	-	-	-	-	-

Reference data from (Central Bank of Barbados, 2024) indicates that imports amounted to US\$1.7bn in 2021, ranging from US\$1.5-2.1bn between 2018 to 2022. Statistics from the Comtrade database were observed to closely align with the reference data, representing values of within 2% across the same years.

Data from the Trade and Transport dataset indicates that imports totalled US\$1.5bn in 2021, around 10.6% less than the reference value, and were observed to underestimate import value by between 5-15% across 2018-21. No import data for Barbados were able to be obtained from the GTAP-11 database due to its aggregation into the 'Rest of Caribbean' region.

Table 1.12. Merchandise export value statistics for Barbados by source between the years 2016 and 2023. Data acquired throughout 2024 via desk-based research, Comtrade, Trade and Transport and GTAP.

Source	Exports							
	2016	2017	2018	2019	2020	2021	2022	2023
Desk-based Research			447,935,223	444,118,405	345,068,135	349,888,898	497,236,130	-
Comtrade	516,825,882	485,387,948	457,709,751	444,085,369	345,206,217	350,172,911	497,818,698	475,842,549
Trade-and-Transport	297,317,461	359,854,805	365,957,153	323,831,884	229,537,425	246,436,664	-	-
GTAP-11	-	-	-	-	-	-	-	-

Reference data from (Central Bank of Barbados, 2024) indicates that exports amounted to US\$350m in 2021, ranging from US\$345-497m between 2018-22. Statistics from the Comtrade database were observed to closely align with the reference data, representing values within 3% across the same years.

Data from the Trade and Transport dataset indicates that exports totalled US\$246m in 2021, 29.6% less than the reference value. It was observed that these figures underestimate export value by between 18-34% across 2018-21. No export data for Barbados could be drawn from the GTAP-11 database due to its aggregation into the 'Rest of Caribbean' region.

1.2.5. Saint Lucia

The Saint Lucia Central Statistics Office is identified as the sole source of merchandise trade data available online and is taken here as reference data against which to compare alternative sources of merchandise trade data (Saint Lucia CSO, 2024). Some uncertainty has been introduced into these statistics as a result of applying US\$ to EC\$ exchange rates for the years 2016-20.

Table 1.13. Merchandise import value statistics for Saint Lucia by source between the years 2016 and 2023. Data acquired throughout 2024 via desk-based research, Comtrade, Trade and Transport and GTAP.

Source	Imports							
	2016	2017	2018	2019	2020	2021	2022	2023
Desk-based Research	624,417,451	623,179,900	658,075,710	597,654,340	504,026,210	-	-	-
Comtrade	668,503,690	663,692,158	672,941,163	623,792,718	532,913,977	-	-	-
Trade-and-Transport	570,206,450	570,004,106	610,960,407	566,236,589	469,183,582	696,440,622	-	-
GTAP-11	-	-	-	-	-	-	-	-

Reference data from (Saint Lucia CSO, 2024) indicates that imports into Saint Lucia totalled US\$504m in 2020, ranging from US\$504m to US\$658m between the years 2016-20. Statistics from the Comtrade database indicate that Saint Lucia's imports amounted to US\$533m in 2020, 5.7% greater than the reference figure for that year, and indicate import trade values of 2.2-7.1% greater than reference figures across the years 2016-20.

Data from the Trade and Transport dataset indicates that imports amounted to US\$469m in 2020, 6.9% less than the reference value for that year. The dataset also indicated export values of 7.2-8.7% less than the reference values across the years 2016-20. No import data for Saint Lucia could be drawn from the GTAP-11 database due to its aggregation into the 'Rest of Caribbean' region.

Table 1.14. Merchandise export value statistics for Saint Lucia by source between the years 2016 and 2023. Data acquired throughout 2024 via desk-based research, Comtrade, Trade and Transport and GTAP.

Source	Exports							
	2016	2017	2018	2019	2020	2021	2022	2023
Desk-based Research	68,917,913	78,313,090	93,924,500	81,977,570	55,147,760	-	-	-
Comtrade	119,806,601	141,655,244	116,813,984	97,255,260	67,424,832	-	-	-
Trade-and-Transport	1,439,148,586	1,972,435,584	2,417,025,151	2,405,235,560	1,591,487,524	2,931,992,765	-	-
GTAP-11	-	-	-	-	-	-	-	-

Reference data from (Saint Lucia CSO, 2024) indicates that exports from Saint Lucia totalled US\$55.1m in 2020, ranging from US\$55.1-93.9m between the years 2016-20. Statistics from the Comtrade database indicate that Saint Lucia's exports amounted

to US\$67.4m in 2020, 22.3% greater than the reference figure for that year, and indicate export trade values of 18.6-80.9% greater than the reference figures across the years 2016-20.

Data from the Trade and Transport dataset indicates that exports from Saint Lucia ranged from US\$1.4bn to US\$2.4bn between the years 2016-20, representing between 19.9-28.3x the reference values obtained via desk-based research. No export data for Saint Lucia could be derived from the GTAP-11 database due to its aggregation into the 'Rest of Caribbean' region.

1.3. Results

1.3.1. Source 1: Desk-based Research (reference)

The availability and diversity of publicly available merchandise trade data for baselining against alternative sources has been found to vary across the five Caribbean countries. Multiple sources of merchandise trade data were identified for the largest economies of Jamaica, Trinidad and Tobago, and Barbados, typically from the National Statistics Office and at least one other reputable source, such as a Central Bank. However, public trade datasets for the smaller nations of Antigua and Barbuda and Saint Lucia were less readily available, with the National Statistics Office of both countries representing the sole source of this data.

1.3.2. Source 2: Comtrade

Import values recorded in the Comtrade database generally align well with reference figures observed in desk-based research sources, with discrepancies not exceeding 5% in the majority of cases. Records of import values tended to display greater alignment with reference figures compared to export values, where discrepancies of import statistics against reference values did not exceed 2% in the majority of cases or 25% in any case. Export value discrepancies did not exceed 5% in the majority of cases; however, did exceed 10% in a few instances with a maximum deviation of over 80%.

1.3.3. Source 3: Trade and Transport

A substantial range of deviation in import and export values is observed in Trade and Transport data as compared with reference figures. Discrepancies of -26% to +3% were observed in the import values recorded in the Trade and Transport dataset. Values associated with exports from Jamaica, Trinidad and Tobago and Barbados were observed to diverge from reference figures by between -39% to +35%. However, this divergence increased from 2000% to 2800% in the case of Saint Lucia and from 4800% to 8200% in the case of Antigua and Barbuda.

1.3.4. Source 4: GTAP

The divergence of GTAP-11 statistics representing Jamaica's merchandise trade for its reference year of 2017 amounted to more than 51% for imports and over 230% for exports when compared with Comtrade data for the same year, which aligns well with reference data in later years. For Trinidad and Tobago's imports and exports, the divergence ranged from +18-20% when compared to Comtrade for that year, itself also demonstrating good alignment with reference figures in later years. No trade data representing Antigua and Barbuda, Barbados, and Saint Lucia could be drawn from GTAP-11 dataset due to their aggregation into the 'Rest of Caribbean' region.

1.4. Discussion

The Comtrade database (UNCTAD, 2024b) generally aligns well with reference trade statistics derived from desk-based research. Reduced alignment with reference figures is observed for statistics describing exports compared to imports, as well as when characterising trade from a smaller economy compared to a larger one. It should be caveated that these findings apply only to instances where the country has reported its trade statistics to the Comtrade platform for the year in question; Comtrade statistics derived from 'partner-recorded' records will be significantly less reliable.

Trade statistics contained in the Trade and Transport (UNCTAD, 2024c) database demonstrate significant deviation from reference trade figures. Divergencies tend to represent between one-quarter and one-half of the reference figure. However, exceedances of 20x to 80x the reference value have been found in the case of exports from Antigua and Barbuda and Saint Lucia. These findings reinforce the trend that alignment with reference figures is observed to diminish for export statistics, particularly with smaller economies.

The GTAP-11 database (Aguilar et al, 2022) represents only Jamaica and Trinidad and Tobago as distinct 'regions' in its modelling, while Antigua and Barbuda, Barbados, and Saint Lucia accounted for in its 'Rest of Caribbean' aggregation. Whilst reference figures were not available for its calibration year of 2017, the deviation from Comtrade data (itself found to align well with reference data in later years) was significant, amounting to around one-fifth for Trinidad and Tobago but around one-half to 2x Jamaica's merchandise trade value.

1.5. Transport Costs

Table 1.15. Statistics representing the amount paid for transport costs, as either itself or a CIF-FOB margin, as a proportion of CIF-value for each country, by source for the year 2017. Values denoted with an asterisk (*) represent transport cost rates derived from the ‘Rest of Caribbean’ aggregate region of the GTAP-11 database. Data acquired throughout 2024 via desk-based research, Trade and Transport and GTAP.

Country	Imports (%CIF)				Exports (%CIF)			
	Desk-based Research	Comtrade	Trade and Transport	GTAP-11	Desk-based Research	Comtrade	Trade and Transport	GTAP-11
Jamaica	12.1%	-	9.5%	3.7%	-	-	10.9%	2.1%
Trinidad and Tobago	-	-	7.9%	3.3%	-	-	9.0%	6.1%
Antigua and Barbuda	-	-	8.3%	*2.4%	-	-	6.3%	*0.8%
Barbados	-	-	7.2%	*2.4%	-	-	7.8%	*0.8%
Saint Lucia	-	-	8.5%	*2.4%	-	-	3.4%	*0.8%

Transport costs are defined here as the difference between the CIF and FOB values of a good, referred to as the ‘CIF-FOB margin’, expressed as a proportion of the CIF value of the good (for Trade and Transport data, it is assumed that the CIF value can be evaluated as the sum of the FOB value and the transport cost expenditure). This definition of transport cost allows for consistency and comparability across all three sources of transport cost data, as well as compatibility with the methodology employed in Task 3 of the CIA (UNCTAD, 2024a).

Three alternative sources of transport cost statistics for the five Caribbean countries have been identified and are presented above. Transport costs specific to each country’s imports and exports were available online via the Trade and Transport platform (UNCTAD, 2024c), and Trade and Transport data is therefore used to benchmark alternative sources.

Transport costs specific to Jamaica and Trinidad and Tobago were able to be derived from the GTAP-11 database (Aguiar et al, 2022), whilst rates for the ‘Rest of Caribbean’ were also derived and used to represent the transport costs of Antigua and Barbuda, Barbados, and Saint Lucia in accordance with their membership in this aggregate. The year 2017 is primarily used for analysis given its occurrence within all three sources. Only one resource of transport cost data containing CIF and FOB valued trade was identified via desk-based research, which was presented in (Bank of Jamaica, 2024).

1.5.1. Jamaica

Table 1.16. Statistics representing the amount paid for transport costs, as either itself or a CIF-FOB margin, presented as a proportion of CIF-valued imports into Jamaica, by source for the years 2016-23. Data acquired throughout 2024 via desk-based research, Trade and Transport and GTAP.

Country	Imports							
	2016	2017	2018	2019	2020	2021	2022	2023
Desk-based Research	-	12.1%	12.0%	11.9%	12.6%	29.3%	16.6%	-
Comtrade	-	-	-	-	-	-	-	-
Trade-and-Transport	11.9%	9.5%	8.5%	9.0%	10.1%	12.1%	-	-
GTAP-11	-	3.7%	-	-	-	-	-	-

Data from the Trade and Transport database indicates that transport costs accounted for 9.5% of the CIF valued imports into Jamaica in 2017, ranging from 8.5% to 12.1% between 2016-21. The GTAP-11 database indicates that transport costs associated with imports amounted to 3.7% of the CIF value in 2017, representing a transport cost 56-69% lower than those observed in Trade and Transport data for 2016-21.

The data presented in (Bank of Jamaica, 2024) represents the sole resource for characterisation of transport costs identified via desk-based research. The dataset indicates that transport costs amounted to 12.1% of the import CIF value in 2017, ranging from 11.9% to 29.3% between 2017 to 2022. The dataset suggests a transport cost rate equal to 24-142% of that observed in Trade and Transport data between 2017-21, and equal to between 221-691% of the transport cost rate observed in the GTAP-11 database for the year 2017. No derivation of the CIF-FOB margin associated with Jamaica's imports was possible with Comtrade data.

Table 1.17. Statistics representing the amount paid for transport costs, as either itself or a CIF-FOB margin, presented as a proportion of CIF-valued exports from Jamaica, by source for the years 2016-23. Data acquired throughout 2024 via desk-based research, Trade and Transport and GTAP.

Country	Exports							
	2016	2017	2018	2019	2020	2021	2022	2023
Desk-based Research	-	-	-	-	-	-	-	-
Comtrade	-	-	-	-	-	-	-	-

Trade-and-Transport	14.4%	10.9%	8.5%	10.0%	10.8%	12.3%	-	-
GTAP-11	-	2.1%	-	-	-	-	-	-

Data from the Trade and Transport database indicates that transport costs accounted for 10.9% of CIF valued exports from Jamaica in 2017, ranging from 8.5-14.4% between 2016 to 2021. The GTAP-11 database indicates that transport costs amounted to 2.1% of CIF valued exports in 2017, representing a transport cost 75-85% lower than those observed in the Trade and Transport data for 2016-21. No sources of transport cost data were identified via desk-based research. No derivation of the CIF-FOB margin associated with Jamaica's exports was possible with Comtrade data.

1.5.2. Trinidad and Tobago

Table 1.18. Statistics representing the amount paid for transport costs, as either itself or a CIF-FOB margin, presented as a proportion of CIF-valued imports into Trinidad and Tobago, by source for the years 2016-23. Data acquired throughout 2024 via desk-based research, Trade and Transport and GTAP.

Country	Imports							
	2016	2017	2018	2019	2020	2021	2022	2023
Desk-based Research	-	-	-	-	-	-	-	-
Comtrade	-	-	-	-	-	-	-	-
Trade-and-Transport	9.2%	7.9%	6.9%	8.2%	8.5%	11.0%	-	-
GTAP-11	-	3.3%	-	-	-	-	-	-

Data from the Trade and Transport database indicates that transport costs accounted for 7.9% of CIF valued imports into Trinidad and Tobago in 2017, ranging from 8.5% to 12.1% between 2016-21. The GTAP-11 database indicates that transport costs amounted to 3.3% of CIF valued imports in 2017, representing a transport cost 52-70% lower than those observed in Trade and Transport data for 2016-21. No sources of transport cost data were identified via desk-based research. No derivation of the CIF-FOB margin associated with Trinidad and Tobago's imports was possible with Comtrade data.

Table 1.19. Statistics representing the amount paid for transport costs, as either itself or a CIF-FOB margin, presented as a proportion of CIF-valued exports from Trinidad and Tobago, by source for the years 2016-23. Data acquired throughout 2024 via desk-based research, Trade and Transport and GTAP.

Country	Exports							
	2016	2017	2018	2019	2020	2021	2022	2023
Desk-based Research	-	-	-	-	-	-	-	-
Comtrade	-	-	-	-	-	-	-	-
Trade-and-Transport	10.8%	9.0%	8.3%	8.0%	10.0%	11.4%	-	-
GTAP-11	-	6.1%	-	-	-	-	-	-

Data from the Trade and Transport database indicates that transport costs accounted for 9.0% of CIF valued exports in 2017, ranging from 8.0-11.4% between 2016-21. The GTAP-11 database indicates that transport costs amounted to 6.1% of CIF valued exports in 2017, representing a transport cost that was 24-46% lower than those observed in Trade and Transport data for 2016-21. No sources of transport cost data were identified via desk-based research. No derivation of the CIF-FOB margin associated with Trinidad and Tobago's exports was possible with Comtrade data.

1.5.3. Rest of Caribbean

Table 1.20. Statistics representing the amount paid for transport costs, as either itself or a CIF-FOB margin, presented as a proportion of CIF-valued imports into Antigua and Barbuda, Barbados and Saint Lucia (derived from the Trade and Transport database), and into the 'Rest of Caribbean' region (derived from GTAP-11). Data acquired throughout 2024 via Trade and Transport and GTAP

Country	Imports							
	2016	2017	2018	2019	2020	2021	2022	2023
Antigua and Barbuda	12.2%	8.3%	8.3%	8.5%	8.7%	12.1%	-	-
Barbados	10.1%	7.2%	6.8%	6.9%	7.9%	10.3%	-	-
Saint Lucia	10.1%	8.5%	7.6%	7.8%	8.8%	14.0%	-	-
GTAP-11 'RoC'	-	2.4%	-	-	-	-	-	-

Data from the Trade and Transport database indicates that transport costs ranged from 8.3-12.2%, 6.8-10.3% and 7.6-14.0% of CIF valued imports into Antigua and Barbuda, Barbados and Saint Lucia respectively, between 2016-21. The GTAP-11 database indicates that transport costs associated with the 'Rest of Caribbean' region, to which all three countries belong, amounted to 2.4% in its reference year of 2017, representing a transport cost 65-83% lower than those observed in the Trade and Transport data for each of the three countries between 2016-21.

Table 1.21. Statistics representing the amount paid for transport costs, as either itself or a CIF-FOB margin, as a proportion of CIF-valued exports to Antigua and Barbuda, Barbados and Saint Lucia (derived from the Trade and Transport database), and into the 'Rest of Caribbean' region (derived from GTAP-11). Data acquired throughout 2024 via Trade and Transport and GTAP

Country	Exports							
	2016	2017	2018	2019	2020	2021	2022	2023
Antigua and Barbuda	6.6%	6.3%	5.8%	10.6%	11.1%	15.1%	-	-
Barbados	10.2%	7.8%	7.5%	7.5%	10.2%	10.3%	-	-
Saint Lucia	4.0%	3.4%	3.1%	4.3%	6.1%	4.4%	-	-
GTAP-11 'RoC'	-	0.8%	-	-	-	-	-	-

Data from the Trade and Transport database indicates that transport costs ranged from 5.8-15.1%, 7.5-10.3% and 3.1-6.1% of CIF valued exports from Antigua and Barbuda, Barbados and Saint Lucia respectively between 2016-21. The GTAP-11 database indicates that transport costs associated with the 'Rest of Caribbean' region, to which all three countries belong, amounted to 0.8% in its reference year of 2017, representing a transport cost 74-95% lower than those observed in the Trade and Transport data for each of the three countries between 2016-21.

1.6. Results

1.6.1. Source 1: Trade and Transport

Transport cost data was available for all five countries representing the years 2016-21. However, data representing years outside this range are not currently available. Transport cost rates were observed to range between 6.8% to 14.0% of CIF valued imports and 3.4% to 15.1% of CIF valued exports across all five countries between 2016-21.

1.6.2. Source 2: GTAP

Transport costs inferred from the GTAP-11 database were found to be substantially lower than those identified via the Trade and Transport dataset. Transport costs

derived via GTAP-11 were found to be 50% less than those derived from the Trade and Transport database in all but one case, ranging from between 24% and 95% smaller. Transport costs from the GTAP-11 database were observed to deviate to a lesser degree for the individual regions of 'Jamaica' and 'Trinidad and Tobago'. Specifically, these deviations were 24-85% less than those indicated in the Trade and Transport data. However, the GTAP-11 transport cost rate representing the 'Rest of Caribbean' aggregation, including Antigua and Barbuda, Barbados, and Saint Lucia, was found to be 65-95% less than the rates indicated in Trade and Transport data for the same countries. Greater deviations were observed for the transport cost rates associated with exports as opposed to imports for four of the five countries.

1.6.3. Source 3: Desk-based Research

One source of transport costs data was identified via desk-based research (Bank of Jamaica, 2024). The dataset provides CIF and FOB value statistics for imports into Jamaica for 2017-22, from which the CIF-FOB margin has been estimated with reference to the CIF value to derive the transport cost rate. Transport costs inferred from the dataset are observed to be moderately to significantly greater than those derived from Trade and Transport data depending on the year, ranging from 27-142% of the equivalent Trade and Transport rate between 2017-22. Transport costs derived from the Bank of Jamaica are observed to be substantially higher than the transport cost rate of 3.7% inferred from the GTAP-11 database, 227% greater for the specific year 2017 and ranging from 221% to 691% in general between the years 2017-22.

1.7. Discussion

Data from the Trade and Transport database (UNCTAD, 2024c) are available for each of the five countries, though in all cases represent synthetic (labelled as 'experimental') data and their accuracy is therefore difficult to verify. Transport cost rates identified via GTAP-11 (Aguiar, 2022) are observed to be systematically below those recorded in the Trade and Transport dataset, across the unaggregated regions of 'Jamaica' and 'Trinidad and Tobago' as well as the aggregate region of 'Rest of Caribbean'. Estimations of transport costs derived from the GTAP-11 database were found to deviate more when representing smaller economies or export trade value.

A single source of transport costs data was available that could be considered as 'ground-truth' reference data (Bank of Jamaica, 2024). The dataset, representing Jamaican imports between 2017-22, indicates that transport cost rates for the five countries in the Trade and Transport database may be being substantially underestimated. Remaining less than 50% greater than Trade and Transport figures for 2017-20, the Bank of Jamaica data implies a transport cost rate 142% greater for the year 2021.

If accurate, the data presented in (Bank of Jamaica, 2024) implies an even greater underestimation of transport cost rates as represented in the GTAP-11 dataset (Aguiar et al, 2022), ranging from 3x to over 7x between 2017-22. This implies that transport cost rates derived from GTAP-11 data are not suitable regardless of year, but particularly for years where transport cost rates may have been affected by recent geopolitical events such as the pandemic or Russia-Ukraine conflict.

1.8. Conclusion

Generally, datasets on trade volume are found to be broadly consistent for the Caribbean countries considered in this analysis. However, large deviations are observed across datasets representing transport costs. Based on these findings, caution should be exercised when interpreting CIA results for the Caribbean region. Data quality is sufficient to understand relative impacts across various policy options; however, estimates of the overall impact on the economy are likely to be unreliable and under-represented. Results are likely to be similar, if not worse, for Pacific SIDS, where only Australia and New Zealand are represented as individual regions in the database.

Table 1.22. Table 1 - Indicative quality of merchandise trade statistics contained in the GTAP-11 database representing the 5 Caribbean countries of interest and its implications in terms of interpretation of CIA Task 3 results.

Representing	Source	Country	Quality	Implication for understanding...	
				Relative Impact Across Policy Scenarios	Overall Magnitude of MTM Impact
Merchandise Trade	GTAP-11 (Aguiar et al, 2022)	Jamaica	Medium	Weak	Moderate
		Trinidad and Tobago	Good	Weak	Weak
		Antigua and Barbuda	Poor	Moderate	Strong
		Barbados	Poor	Moderate	Strong
		Saint Lucia	Poor	Moderate	Strong

Representation of these countries' merchandise trade in the GTAP-11 database utilised by the CIA, appears to be poor for these Caribbean economies. Three of the five countries are aggregated into the 'Rest of Caribbean' category, and large discrepancies representing factors of between 1.2 and 2.0 are observed in merchandise trade statistics for Jamaica and Trinidad and Tobago. The implications of this are likely to be weak in terms of interpreting relative impacts across potential policy scenarios; however, they are likely to be strong in terms of interpreting the overall magnitude of impact.

Table 1.23. Indicative quality of transport cost statistics contained in the GTAP-11 database representing the 5 Caribbean countries of interest and its implications in terms of interpretation of CIA Task 3 results.

Representing Source	Country	Quality	Implication for understanding...	
			Relative Impact Across Policy Scenarios	Overall Magnitude of MTM Impact
Transport Costs	Jamaica	Poor	Weak	Strong
	Trinidad and Tobago	Poor	Weak	Strong
	Antigua and Barbuda	Poor	Weak	Strong
	Barbados	Poor	Weak	Strong
	Saint Lucia	Poor	Weak	Strong

There is considerable variability across alternative sources of transport costs representing the five Caribbean countries, resulting in uncertainty as to the quality of transport cost rates recorded in the GTAP-11 database. The implications of this are likely to be weak in terms of interpreting relative impacts across potential policy scenarios. However, the implications are strong in terms of interpreting overall magnitudes of impact.

1.8.1. Merchandise Trade

Four sources of merchandise trade statistics were identified and analysed. Across three alternative sources of merchandise trade figures, reduced alignment with reference data derived via desk-based research is observed for statistics representing smaller economies and export trades.

Comtrade generally aligns well with reference trade statistics derived via desk-based research, with deviations limited to within 5% in most cases and around 80% in the most significant cases. Conversely, trade statistics contained in the Trade and Transport database are observed to demonstrate significant deviation away from reference trade statistics derived via desk-based research, with deviations representing 25-50% in most cases but factors of more than 20 in the most significant cases.

Merchandise trade statistics for Antigua and Barbuda, Barbados, and Saint Lucia are not available in GTAP-11 data due to their inclusion in the 'Rest of Caribbean' aggregation. Representation of merchandise trade in the GTAP-11 data was found to significantly differ from Comtrade records for the year 2017, with deviation limited to a

factor of around 1.2 for Trinidad and Tobago but exceeding a factor of 2 in the case of Jamaican exports.

1.8.1.1. Further discussion:

- The strong correlation between Comtrade and reference trade statistics derived via desk-based research is understandable given that its often the same national statistics office and customs authority agencies that both compile and publish summaries of customs-derived trade records on their websites and submit these datasets to the Comtrade platform.
 - However, it is noteworthy that this strong alignment may only apply when considering Comtrade records representing years for which data has been submitted by the national statistics office or customs authority.
 - As the MDS Transmodal database used in the CIA process is itself based on Comtrade, estimates of impact derived for countries with a poor track record of contributing to the platform, may therefore be more uncertain.
 - Further details on the creation of the Comtrade database are provided in (UNCTAD, 2019).
- Significant deviation has been observed in merchandise trade statistics in the Trade and Transport database as compared with reference figures derived via desk-based research.
 - The utility of this dataset lies in its representation of transport costs. Therefore, implications of these discrepancies are likely limited with respect to the CIA process.
- GTAP-11 aggregates three of the five case study countries analysed here into the 'Rest of Caribbean' country aggregation.
 - The implications suggest that the impacts on smaller economies may not be accurately represented, with potentially more volatile impacts on these smaller economies masked by their inclusion within a larger aggregation.
- Merchandise trade statistics derived from the GTAP-11 database show significant deviations from Comtrade data for 2017 and reference trade data for 2018-23.
 - The impacts of this are likely to be weak when assessing relative impacts across potential policy scenarios, however, are likely to be strong when interpreting the overall magnitude of impact.

1.8.2. Transport Costs

Three sources of transport costs data were analysed for the five Caribbean countries under consideration. Transport cost rates derived from the three sources were found to be highly variable, ranging from 2.2-41.4% annually in recent years. Deviation in transport costs across all three sources was observed to be greater for statistics representing smaller economies and export trades.

Transport cost rates derived from the Trade and Transport database were available for all countries between the years 2016-21 and observed to range between 6.8% and

14.0% of CIF-valued imports and 3.4% to 15.1% of CIF-valued exports. Transport costs derived from the GTAP-11 database were found to be substantially lower than those identified in the Trade and Transport data, with deviation up to 50% in most cases and up to 95% in the most significant case. Greater alignment is observed for the individual regions of Jamaica and Trinidad and Tobago, as opposed to where the generalised 'Rest of Caribbean' transport cost rate is used to represent Antigua and Barbuda, Barbados and Saint Lucia.

One source of transport costs data was identified via desk-based research (Bank of Jamaica, 2024) that represents Jamaican imports between 2017-22. Depending on the reliability of the data and calculations, the source implies that transport costs as represented in the Trade and Transport and GTAP-11 databases may be being considerably under-represented, with deviation by a factor of 1.5 to 2.5 and 3 to 7 respectively.

1.8.1.2. Further discussion:

- Data from the Trade and Transport database were all labelled as 'experimental' and therefore represent 'synthetic' data. Further detail regarding the methods employed to generate these values can be found in the methodological paper underpinning the dataset (UNCTAD, 2022).
- All three sources of transport costs data indicate that transport costs in the GTAP-11 database may be being substantially under-estimated.
 - The implications of this are likely to be weak in terms of interpreting relative impacts across potential policy scenarios, however, are strong in terms of interpreting overall magnitudes of impact.
 - A further explanation on a possible mechanism through which this underestimation may occur is given in below.
- If reliable, the Bank of Jamaica indicates that the impacts of recent geopolitical events may not be being accurately represented in the various sources of transport costs data considered.
 - The dataset is freely available for further exploration, with details provided in (Bank of Jamaica, 2024).

1.8.3. Additional CIA Implications

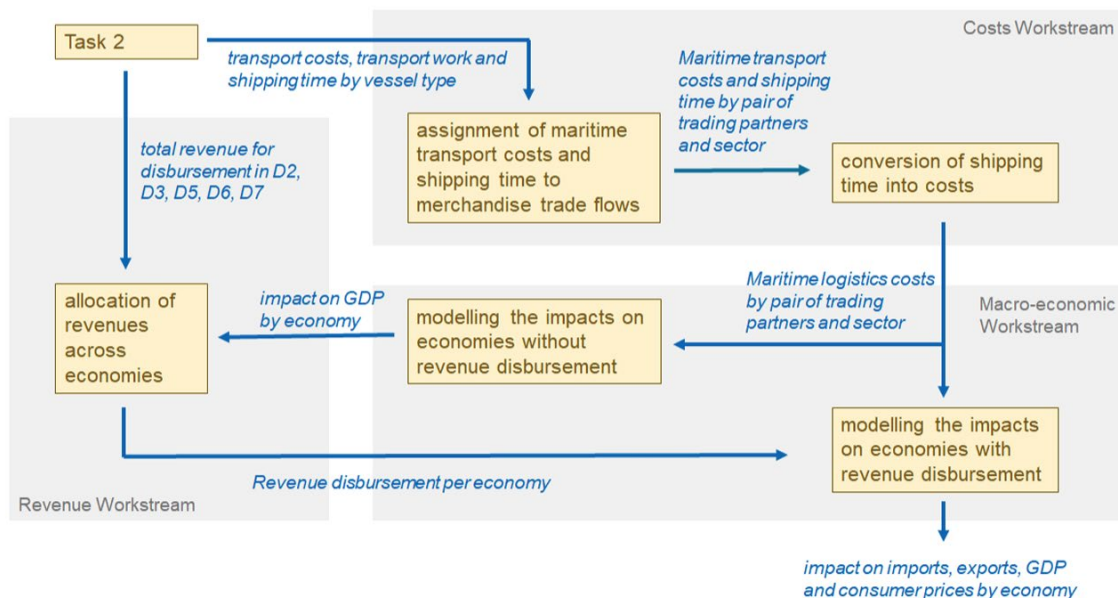


Figure 1.1. Workstream and data flows from the UNCTAD’s CIA Task 3 modelling process. Illustration taken from Figure 1 of UNCTAD’s Final Task 3 Report.

The figure above outlines the workstream designed and undertaken by UNCTAD as part of Task 3 of the IMO-led CIA process (UNCTAD, 2024a). This assessment focuses on the suitability of the merchandise trade and transport cost datasets, which constitute two types of data most at risk of leading to inaccuracies in results derived via the CIA for the five Caribbean countries in question.

On Page 39 of (UNCTAD, 2024a), it is stated that, “UNCTAD modifies the maritime trade costs recorded in GTAP for each bilateral trade flow by commodity group under the baseline scenario. The modification entails inflating the maritime trade costs with percentage difference reflecting the impact of the policy scenario on maritime logistics costs calculated under the Cost Workstream mentioned above.” It is inferred that the maritime trade costs in 2023, $MTC_{GTAP-11, 2023}$, are represented by the CIF-FOB margin recorded in GTAP-11, and that this variable is multiplied by the increase in maritime logistics costs, $DELTA_{MLC, UNCTAD}$.

$$MTC_{GTAP-11, 20XX} = MTC_{GTAP-11, 2023} \times DELTA_{MLC, UNCTAD} = CIF-FOB_{GTAP-11} \times DELTA_{MLC, UNCTAD} \quad [A]$$

Equation A therefore implies uncertainty in the magnitude of the shock applied in the GTAP-11 model (Corong et al, 2017) is directly proportional to the uncertainty of the maritime trade cost, or $CIF-FOB_{GTAP-11}$, recorded in the GTAP-11 database (Aguiar et al, 2022). Therefore, if GTAP-11 transport cost margins are under-representing true

transport costs across Caribbean economies by a factor of up to 7, the shock being applied in GTAP as part of the CIA process may be being underestimated by a factor of up to 7 also. Whilst this is likely to have modest implications in terms of relative impacts across policy scenarios (as the same level underestimation is present), the overall magnitude of impact on Caribbean states derived in (UNCTAD, 2024a) may be being substantially underestimated.

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SECTION 2

IMPACT ANALYSIS FOR THE CARIBBEAN REGION



IMPACT ANALYSIS FOR THE CARIBBEAN REGION

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March 2025

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List of Abbreviations

BAU:	Business As Usual
CARICOM:	Caribbean Community: A regional organization of Caribbean nations and territories focused on economic integration, cooperation, and policy coordination.
CIA:	Comprehensive Impact Assessment: A methodical evaluation of potential effects associated with policies, projects, or regulations.
CIF:	Cost, Insurance, and Freight: A trade term requiring the seller to cover costs, insurance, and freight to the buyer's port.
Feebate:	A system that imposes fees on higher-emitting vessels and provides rebates or financial incentives to vessels that outperform the required emission standards.
GDP:	Gross Domestic Product: A measure of a country's economic performance, representing the total value of goods and services produced.
GFI:	GHG Fuel Intensity: Greenhouse gas fuel intensity, measuring the emissions impact of different fuels used in maritime and other industries.
GHG:	Greenhouse Gas: Gases that trap heat in the atmosphere, contributing to global warming.
GT:	Gross Tonnage: A measure of a ship's overall internal volume.
ILO :	International Labour Organization: A United Nations agency that sets international labor standards.
IMO:	International Maritime Organization: A specialized UN agency responsible for regulating shipping.
LDCs:	Least Developed Countries: Countries with low income, economic vulnerability, and weak human assets.
Levy:	A system that applies a fee or levy based on the amount of GHGs emitted by a ship, designed to make polluters pay and encourage the reduction of emissions.
LNG:	Liquefied Natural Gas: Natural gas that has been cooled to a liquid state for easier storage and transport.
MEPC:	Marine Environment Protection Committee: An IMO body addressing pollution from ships.
MTM:	Mid-Term Measure: Policies or actions implemented within a medium-term timeframe to address a specific issue.
MLC:	Maritime Logistics Cost: The expenses associated with shipping goods, including handling and transportation.
SIDS:	Small Island Developing States: Low-lying coastal nations facing economic and environmental vulnerabilities.
UNCTAD:	UN Trade and Development: A United Nations body promoting trade and development, especially in developing nations.

OECD: Organization for Economic Cooperation and Development: An international organization fostering economic growth and trade among member countries.

WTW: Well to Wake: Refers to the full lifecycle of GHG emission, from fuel production to consumption.

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EXECUTIVE SUMMARY

To effectively address carbon emissions within the shipping industry and to achieve its decarbonization objectives, the International Maritime Organization (IMO) is anticipated to reach an agreement on a series of midterm measures (Xu & Miao, 2023). These measures are expected to encompass both a technical component, which includes a goal-based marine fuel standard, and an economic component, which consists of a greenhouse gas (GHG) emissions pricing mechanism. The main policy architectures proposed for approval at MEPC 83 include:

- a flexibility mechanism in isolation
- a feebate/reward mechanism in isolation
- a combination of feebate/reward and flexibility mechanisms

To evaluate the potential impacts of these midterm measures on member states, a Comprehensive Impact Assessment (CIA) was undertaken throughout 2024. This assessment comprised four tasks, with Tasks 3 and 4 employing complementary modelling approaches to understand potential impacts of the midterm measures on states. However, these methodologies did not sufficiently capture the impact on the Caribbean region, where most economies were aggregated into broader regional groupings or excluded entirely.

The objective of this research is to enhance the evidence base regarding potential impacts of the IMO's midterm measures, employing methodologies pioneered in the IMO-led CIA process to ascertain the likely economic impacts on selected trade flows in five Caribbean countries not well represented in CIA findings. Key findings from the research include:

1. **Positive Impacts Across All Scenarios:** Positive cost impacts are projected for all 30 modelled commodity flows, irrespective of the policy scenario or the year considered, with expected impacts ranging from 0.43% to 26.22% of commodity value.
2. **Variation Among Policy Scenarios:** In 2030, the high levy scenario results in considerably greater impacts relative to the flexible GFI or feebate mechanisms, however effects of revenue distribution are not considered. Differentiation of impact by policy architecture is reduced by 2040, and by 2050 impacts across all policy scenarios considered broadly align.
3. **Greater Impacts Where Transport Costs Are Higher:** The most pronounced impacts are observed in commodities where transport costs constitute a larger proportion of final price and resulting in two important implications for the Caribbean region:
 - a. **Increased Vulnerability for Smaller, Less Integrated Economies:** Caribbean economies which contend with elevated transport costs and

reduced integration into the global transport system (e.g. Saint Lucia and Antigua and Barbuda) are projected to experience more severe impacts.

- b. **Increased Vulnerability for Lower-valued Commodities:** impacts are likely to be greater for commodities where greater transport cost rates represent a larger share of total costs paid. With regards to imports, this implies higher impacts for lower valued essential goods such as food and agricultural products. Conversely, export trades originating in Caribbean economies risk being made uncompetitive thanks to the higher transport cost rates they face (e.g. Jamaican Bauxite).

Through investment in green technologies such as alternative fuels, energy-efficient shipping, and eco-friendly infrastructure at ports, a levy-based policy architecture offers the opportunity to offset some of the negative impacts introduced on Caribbean economies by the midterm measures. The effects of revenue distribution have been unable to be considered in this research due to the specific nature of the modelling approach employed. However, the reader is instead pointed towards the Section 3 and Section 5 of this compilation for a more detailed understanding of how the redistribution of levy revenues can be utilised to mitigate midterm measures impact.

This research emphasizes the necessity of considering regional differences and specific economic conditions when assessing the impact of global policy measures. It provides valuable insights into the potential effects of the IMO's decarbonization strategy on the Caribbean region, characterized by its unique economic structure and trade patterns.

2.1. Introduction

The international shipping industry plays a significant role in global greenhouse gas (GHG) emissions, accounting for an estimated 2.89% of total emissions in 2018, as indicated by the 4th IMO Greenhouse Gas Study. Projections suggest that if current practices continue unabated, emissions from the sector could increase by 90% to 130% by 2050 compared to levels observed in 2008 (Faber et al., 2020).

Considering this growing environmental challenge, the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO, 2024) has adopted the 2023 IMO Strategy for reducing GHG Emissions from Ships (IMO, 2023). This strategy establishes clear objectives, including a 40% reduction in CO₂ emissions per transport work by 2030, zero or near-zero GHG emission technologies accounting for at least 5% of international shipping energy by 2030, and achieving net-zero emissions by 2050 (IMO, 2024; OECD, 2024).

To address carbon emissions within the shipping industry and to meet its decarbonization objectives, the International Maritime Organization (IMO) is expecting to agree upon the implementation of a range of candidate midterm measures (Xu & Miao, 2023), encompassing a technical component such as a goal-based marine fuel standard and an economic component based on a GHG emissions pricing mechanism (IMO, 2024). The main policy architectures proposed for approval at MEPC 83 include:

- a flexibility mechanism in isolation
- a feebate/reward mechanism in isolation
- a combination of feebate/reward and flexibility mechanisms

The proposed mechanisms constitute alternative strategies aiming to mitigate GHG emissions in international shipping in-line with the Revised Strategy targets. However, the nature of the maritime transition for the Caribbean region is likely to vary considerably depending on the final design of the basket of midterm measures (UNCTAD, 2024a). Given the Caribbean's reliance on international shipping for trade, tourism, and economic development, all architecture options will ultimately increase shipping companies' operational costs, which in turn may result in higher prices for end-consumers (UNCTAD, 2024d).

The research presented herein employs methodologies pioneered in the IMO-led Comprehensive Impact Assessment process to ascertain the likely economic impact on selected trade flows in five Caribbean countries. The research evaluates potential impacts across scenarios representing each of the leading policy architecture options presented above. A comprehensive understanding of these effects will assist policymakers in formulating effective regulations and incentives that strike a balance between environmental objectives and economic growth. Additionally, such analysis

will help anticipate the potential challenges faced by shipping companies and other stakeholders.

2.2. Methodology

The IMO commissioned a Comprehensive Impact Assessment (CIA) to be conducted throughout 2024 with the objective of assessing the potential impacts on states of the introduction of midterm measures. Comprising five major work streams, Task 2 of the CIA focused on modelling the projected increases in shipping costs and ships' operational speed for the years 2030, 2040, and 2050, based on a variety of policy scenarios aimed at reducing greenhouse gas (GHG) emissions in line with Revised Strategy targets. The modelling approach considered two cost components: maritime transport costs and shipping time.

Task 3, utilizing the methodology developed in (UNCTAD, 2024a), applied a composite of the two cost components—termed Maritime Logistics Costs (MLC)—as a shock to a set of general equilibrium equations representing global economic activity. This approach enabled a comprehensive top-down evaluation of the impacts of the policy measures worldwide, focusing on changes to import and export volumes, GDP, and consumer prices. However, due to the standardized nature of Task 3, the results are only directly comparable for countries that are well-represented within its underlying datasets. This limitation affects the Caribbean, as the majority of its economies are aggregated under broad regional categories which serve to limit the granularity of analysis results available. The implications of this limitation are explored further in 'Economic and Trade Data Validation'. Furthermore, results are either presented as total aggregate in the economy (e.g., change in GDP) or aggregated in large commodity groups (e.g. agricultural products). Therefore, detailed results for specific commodities are not available.

Task 4 of the CIA process offers a more targeted modeling approach, focusing on a limited set of individual commodity flows and trade routes (Starcrest, 2024). Although the scope of trade flows considered in Task 4 is smaller than that of Task 3, this approach allows for greater flexibility and can be applied to regions such as the Caribbean that are not well-represented in the Task 3 process. Due to time and resource constraints, the research for this study utilizes the Task 4 methodology to provide a more regionally relevant analysis.

The various steps taken in applying the methodology are presented below, with assumptions underpinning the vessel-side modeling outlined in Annex I and assumptions underpinning the cargo-side modeling presented in Annex II. Final impact results (incorporating vessel-side and cargo-side considerations for each individual country) are presented in the main body of the report, and a detailed justification for the methodology is provided in Annex III.

2.2.1. Methodology Steps

Step 1: Analysis of Merchandise Trade Statistics

The first step involved the analysis of merchandise trade statistics to understand the most prominent import and export commodities associated with each of the five Caribbean countries. Merchandise trade statistics were sourced from the UN Comtrade database for the year 2023, with details of the most important import and export commodities identified for each country presented at the beginning of each country's section.

Step 2: Commodity-Route Selection

Making use of the trends observed in the merchandise trade flows analysed in Step 1, as well as other expertise on the importance of certain goods to the national economy, the next step involved selecting three import commodities and three export commodities to be taken forward for further analysis across each of the five Caribbean countries. The selection was made to include the commodity description, the partner country facilitating the trade and the value of that trade across one recent year as identified in Comtrade statistics.

Step 3: Research of Route Details

The routes accommodating each trade flow identified in Step 2 were then further investigated. It is first useful to understand the typical vessel type that facilitates transit of the commodity along the selected trade route, for example whether facilitated by tanker, bulk carrier or containership transport. Tanker and bulk carrier voyages are typically performed under individual charters, and associated route details may therefore amount to just the origin and destination ports of the trade flow alone. For containership transport, several stops in between origin and destination ports may be more appropriate. To conduct this task, typical routes were first identified using the vessel-finder.com website. The most prominent vessel class in terms of size and age was assumed to facilitate the entirety of the commodity flow. With the trade route established, the subsequent task is to link each port-pair with the typical distance travelled by a vessel between those two ports. The calculator tool featured on sea-distances.org was made use of for this.

Step 4: Research of Transit Speed

With details of the route established, typical transit speeds associated with the most prominent vessel class were inferred from 4th IMO GHG Study AIS datasets (Faber et al, 2020).

Step 5: Research of Vessel-Side Cost Assumptions

The vessel-side cost assumptions are comprised of two parts. The first involves understanding the projected vessel-side cost intensity changes associated with the

main policy options and taken from Figure 6-1 of CIA Task 2 Final Report (DNV, 2024a). Further details and context regarding the four leading policy options can be found in (Smith et al, 2024). The second step required the assumption of an ‘ad-valorem’ freight rate, which is the typical freight rate paid as a percentage of the traded good’s value. The ‘ad-valorem’ freight rate was taken from the publicly accessible Trade and Transport dataset (UNCTAD, 2024b).

Step 6: Research of Cargo-Side Cost Assumptions

Finally, the methodology assumed three specific rates that constitute the cargo-side costs. Also taken in ‘ad-valorem’ terms per year, these assumed cost impacts include those associated with interest, depreciation and insurance. In-line with (Starcrest, 2024), a 5% cost of finance/interest and 2% cost of insurance was applied, in addition to a depreciation rate of: i) 5% for dry bulk cargo; ii) 10% for non-perishable containerised cargo; or iii) 30% for perishable cargo. Final cost impacts are then evaluated as the sum of vessel- and cargo-side cost impacts in 2030, 2040 and 2050 relative to the BAU reference case. Where no vessel speed reduction is considered (SR-0), final cost impacts are constituted from vessel-side cost impacts alone; however, where a speed reduction of 10%, 20% or 30% is assumed, final cost impacts are constituted from a combination of both vessel- and cargo-side costs.

2.3. Jamaica

Jamaica's economy is significantly reliant on exports, which showcase the country's rich natural resources, agricultural potential, and manufacturing capabilities. The principal sectors contributing to exports include petroleum products, aluminium-related products, agricultural goods, and beverages. Jamaica's international trade is almost entirely facilitated by international shipping due to its geography, and well-developed port infrastructure within the Caribbean.

Table 2.1. Top export/import commodities for Jamaica 2023

Country	Trade Direction	Commodity	Description	Key Destination	Primary Value (FOB Value\$)
Jamaica	Export	Petroleum Products*	Mineral fuels, Oils, distillation products	USA, Barbados, T&T	\$716,583,313
		Agricultural Products*	Coffee Tea and Spices	USA, Canada, Netherland, T&T, UK	\$260,027,853
		Bauxite and Alumina*	Bauxite and Alumina	USA, Netherland	\$120,011,775
		Minerals	Gypsum and Limestone	USA, UK, Canada, T&T	\$120,011,775
		Manufactured Goods	Processed foods, beverages, and light manufactured products	USA, UK, Canada, T&T, Barbados	\$66,146,495
	Import	Fuels and Petroleum Products*	Fuels and Petroleum Products	USA, T&T	\$1,208,781,681
		Cereals (Corn, Wheat, Rice)*	Cereals (Corn, Wheat, Rice)	USA, T&T, Mexico	\$701,828,357
		Vehicle*	Vehicle	Vehicle Carrier	\$352,315,628
		Chemical and Pharmaceuticals	Pharmaceutical goods, Fertilizers	USA, T&T, Japan, Mexico	\$4,074,942
		Machinery and Equipment	Pharmaceutical goods, Fertilizers	Japan, USA, China, Mexico	\$238,171,390

**Top 3 commodities for both Jamaica's exports and Imports*

The Stakeholder Assessment for Jamaica focuses on both exports and imports; for exports, petroleum products (Mineral fuels, oils. Distillation products), Agriculture products (Coffee, Tea, and Spices), and Bauxite and Alumina. For imports of

Petroleum (Mineral fuels, Oils, and distillation products), Cereals (Corn, Wheat, Rice), and Vehicles.

2.3.1. Key Export Commodities

In 2023, Jamaica's primary export commodities comprised of petroleum products, alumina, bauxite, agricultural products, and minerals. These commodities were identified based on Jamaica's steady export volumes, underscoring their significance to the national economy (UNCTAD, 2024b). Jamaica's export portfolio is characterized by a mix of minerals, fuels (Petroleum products), agricultural products, manufactured goods, and beverages. The country primarily trades with the United States, the European Union, and other regional markets. The United States accounts for approximately 60% of Jamaica's exports, with the main exports being reprocessed petroleum, Alumina, rum, coffee, and food products, and an estimated export value of US\$1.224 billion. Other key trading partners included Canada (US\$111 million), the Russian Federation (US\$101 million), the United Kingdom (US\$90 million), and the Netherlands (US\$82 million). The top three (3) primary categories of export commodities are as follows:

1. Petroleum products

In 2023, petroleum products were Jamaica's top export category, accounting for approximately 31 % of total exports having the highest primary value of USD 716 million. These exports included refined petroleum oils and gases, primarily exported markets in the United States, Canada, Trinidad and Tobago and other Caricom nations.

2. Coffee, Tea and Spices

The Agricultural Products category primarily encompasses food and beverages, which can be further categorized into segments such as fruits, coffee, vegetables, sugar, rum, and various by-products. The principal export markets for these products include the Caribbean, North America, and Europe. In 2023, this category achieved the highest primary value, approximating USD 260 million as shown Table 2.1, representing the peak during that timeframe.

3. Alumina and Bauxite

The alumina and bauxite sector constitutes a vital component of Jamaica's export revenue. This commodity primarily comprises aluminium ore concentrates, aluminium oxide, and aluminium hydroxide whereby, Aluminium oxide and aluminium ores accounts for 24% and 3.4% of export value respectively as shown Table 2.1. The principal markets for these exports include the United States, Canada, and Europe. In 2023, the total value of this commodity was approximately USD 120 million, positioning it as Jamaica's second most significant export category.

2.3.2. Key Import Commodities

The Jamaican economy is heavily reliant on the importation of goods to sustain its industries, infrastructure, and consumption. Jamaica's primary imports are Fuels and Petroleum products, Machinery and Equipment, Food and Agricultural products, Vehicles, and Chemicals and Pharmaceuticals. The major countries of import trade are the United States, China, Trinidad & Tobago, Japan, Germany, the United Kingdom, and Mexico. Table 2.1 shows the top three import commodities for Jamaica. The top three (3) primary categories of import commodities are as follows:

1. Fuels and Petroleum Products

This category comprises crude oil, refined petroleum, natural gas, mineral fuels, mineral oils, and the byproducts of their distillation, along with bituminous substances and mineral waxes. The primary sources of these imports are the United States and Trinidad and Tobago. In 2023, this community recorded a total value of approximately USD 1.2 billion, as illustrated in Table 2.6.

2. Maize, Wheat and Rice

Jamaica relies on substantial food imports to meet domestic demand and to support local agricultural production. This category encompasses a diverse range of food and beverage items, including wheat, rice, corn, meat, dairy products, and processed foods. The primary sources of these imports are the United States and Trinidad & Tobago. According to Table 2.1, the value of food imports in 2023 reached approximately USD 701 billion, making it the second-highest import value for Jamaica.

3. Vehicles

This category encompasses vehicles designated for transportation and logistics purposes. Japan, the United States, Germany, and China are the primary suppliers of these imports. Notably, this commodity ranks third highest in import value for Jamaica, approximating USD 352 million.

2.3.3. Results

Results presented here are the total expected impacts representing the sum of vessel-side and cargo-side cost impacts. Total expected impacts are given as changes to the amounts paid in transport costs as a proportion of traded value. Details of cost assumptions underpinning the vessel-side and cargo-side modelling can be found in Annexes I and II respectively. All scenarios modelled are on a WTW basis, with full details on the scenarios included in this analysis provided in Annex I.i.

2.3.1.1. Exports of Petroleum Products to the USA

Table 2.2. Scenario for each policy for the years 2030, 2040, and 2050 for Petroleum Product, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Petroleum Products to the USA	GFI Flex Only	1.04% - 1.12%	4.10% - 4.18%	5.27% - 5.35%
	Low Levy	1.37% - 1.45%	3.71% - 3.79%	5.07% - 5.15%
	High Levy	2.60% - 2.68%	4.62% - 4.70%	5.07% - 5.15%
	Feebate	1.50% - 1.58%	3.97% - 4.05%	5.33% - 5.41%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of petroleum products from Jamaica to the USA by between 1.04% to 5.41% of traded value per year, ranging from 1.04% to 2.68% in 2030, 3.71% to 4.70% in 2040 and 5.07% to 5.41% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.04% to 5.35% under a flexible GFI mechanism, 1.50% to 5.41% under a feebate mechanism and by between 1.37% to 5.15% across levy scenarios.

2.3.1.2. Exports of Coffee, Tea and Spices to the USA

Table 2.3. Scenario for each policy for the years 2030, 2040, and 2050 for Coffee, Tea and Spice, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Coffee, Tea and Spices to the USA	GFI Flex Only	0.94% - 0.97%	3.72% - 3.75%	4.78% - 4.81%
	Low Levy	1.24% - 1.27%	3.36% - 3.39%	4.60% - 4.63%
	High Levy	2.36% - 2.39%	4.19% - 4.22%	4.60% - 4.63%
	Feebate	1.36% - 1.39%	3.60% - 3.63%	4.84% - 4.87%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of coffee, tea and spices from Jamaica to the USA by between 0.94% to 4.87% of traded value per year, ranging from 0.94% to 2.39% in 2030, 3.36% to 4.22% in 2040 and 4.60% to 4.87% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 0.94% to 4.81% under a flexible GFI mechanism, 1.36% to 4.87% under a feebate mechanism and by between 1.24% to 4.63% across levy scenarios.

2.3.1.3. Exports of Bauxite and Alumina to the USA

Table 2.4. Scenario for each policy for the years 2030, 2040, and 2050 for Bauxite and Alumina, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Bauxite and Alumina to the USA	GFI Flex Only	2.54% - 2.61%	10.02% - 10.08%	12.88% - 12.95%
	Low Levy	3.34% - 3.41%	9.06% - 9.13%	12.40% - 12.47%
	High Levy	6.36% - 6.43%	11.29% - 11.36%	12.40% - 12.47%
	Feebate	3.66% - 3.72%	9.70% - 9.77%	13.06% - 13.11%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of bauxite and alumina from Jamaica to the USA by between 2.54%

to 13.11% of traded value per year, ranging from 2.54% to 6.43% in 2030, 9.06% to 11.36% in 2040 and 12.40% to 13.11% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 2.54% to 12.95% under a flexible GFI mechanism, 3.66% to 13.11% under a feebate mechanism and by between 3.34% to 12.47% across levy scenarios.

2.3.1.4. Imports of Petroleum Oils from the USA

Table 2.5. Scenario for each policy for the years 2030, 2040, and 2050 for Petroleum Oils imports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Petroleum Oils from the USA	GFI Flex Only	1.73% - 1.83%	6.80% - 6.90%	8.75% - 8.85%
	Low Levy	2.27% - 2.37%	6.16% - 6.25%	8.42% - 8.52%
	High Levy	4.32% - 4.42%	7.67% - 7.77%	8.42% - 8.52%
	Feebate	2.48% - 2.58%	6.59% - 6.69%	8.86% - 8.95%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of petroleum oils from the USA to Jamaica by between 1.73% to 8.85% of traded value per year, ranging from 1.73% to 2.58% in 2030, 6.80% to 7.77% in 2040 and 8.75% to 8.95% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.73% to 8.85% under a flexible GFI mechanism, 2.48% to 8.95% under a feebate mechanism and by between 2.27% to 8.52% across levy scenarios.

2.3.1.5. Imports of Maize, Wheat, Rice from the USA

Table 2.6. Scenario for each policy for the years 2030, 2040, and 2050 for Cereals (Maize, Wheat, Rice) imports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Cereals from the USA	GFI Flex Only	1.47% - 1.54%	5.80% - 5.86%	7.45% - 7.52%
	Low Levy	1.93% - 2.00%	5.24% - 5.31%	7.18% - 7.24%
	High Levy	3.68% - 3.75%	6.53% - 6.60%	7.18% - 7.24%
	Feebate	2.12% - 2.18%	5.61% - 5.68%	7.58% - 7.61%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of maize, wheat and rice from the USA to Jamaica by between 1.47% to 7.61% of traded value per year, ranging from 1.47% to 3.75% in 2030, 5.24% to 6.60% in 2040 and 7.18% to 7.61% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.47% to 7.52% under a flexible GFI mechanism, 2.12% to 7.61% under a feebate mechanism and by between 1.91% to 7.24% across levy scenarios.

2.3.1.6. Imports of Vehicles from Japan

Table 2.7. Scenario for each policy for the years 2030, 2040, and 2050 for Vehicles imports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Vehicles from Japan	GFI Flex Only	2.61% - 2.97%	10.27% - 10.63%	13.20% - 13.57%
	Low Levy	3.42% - 3.79%	9.29% - 9.65%	12.71% - 13.08%
	High Levy	6.52% - 6.88%	11.57% - 11.94%	12.71% - 13.08%
	Feebate	3.75% - 4.11%	9.94% - 10.31%	13.37% - 13.73%

Modelling results indicate that the introduction of midterm measures could raise the cost of imports of vehicles from Japan to Jamaica between 2.61% to 13.73% of traded value per year, ranging from 2.61% to 6.88% in 2030, 9.29% to 11.94% in 2040 and 12.71% to 13.73% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 2.61% to 13.57% under a flexible GFI mechanism, 3.75% to 13.73% under a feebate mechanism and by between 3.42% to 13.08% across levy scenarios.

2.3.4. Summary of Results

Results of the modelling undertaken in this research indicate that:

- The total cost impacts from the implementation of midterm measures on Jamaica's six most valuable import and export trades are projected to range from 0.94% to 13.73% of annual traded value between 2030 and 2050, depending on the policy scenario. Specifically, impacts are expected to range from 0.94% to 13.11% for exports and 1.47% to 13.73% for imports.
- Under the four policy scenarios modeled, total cost impacts are anticipated to be:
 - **2030:** Impacts are expected to range from 0.94% to 6.88%.
 - **2040:** Impacts are projected to range from 3.36% to 11.94%.
 - **2050:** Impacts are expected to range from 4.60% to 13.73%.
- When considering specific policy scenarios, impacts are expected to vary as follows:
 - **Under a flexible GFI scenario**, total cost impacts are projected to range between 0.94% and 13.57%.
 - **Under a feebate scenario**, impacts are projected to range from 1.36% to 13.73%.
 - **Under levy scenarios**, impacts are expected to range from 1.93% to 13.08%.
- By 2030, the highest impacts are anticipated under a high levy scenario (ranging from 2.36% to 6.88%), while the lowest impacts are expected under a flexible GFI scenario (ranging from 0.94% to 2.97%).
- By 2040, impacts remain greatest under a high levy scenario (ranging from 4.19% to 11.94%) and least under a low levy scenario (ranging from 3.36% to 9.65%).

- By 2050, the cost impacts are expected to be broadly similar across all policy scenarios.

2.3.5. Discussion

The modelling results indicate that the impact of the IMO's introduction of midterm measures on the export and import of major commodities traded between Jamaica and the United States could result in an increase in total cost impact ranging from 0.94% to 13.73% of the annual traded value during 2030, 2040, and 2050. The total cost impacts on exports are projected to range between 0.94% and 13.11%, while the cost impacts on imports are expected to range from 1.47% to 13.73%.

Specifically for export commodities, petroleum products (including mineral fuels, oils, and distillation products), agricultural products (such as coffee, tea, and spices), and bauxite and alumina are anticipated to incur cost increases of up to 5.41%, 4.87%, and 13.11%, respectively, as outlined in Tables 2, 3, and 4.

Tables 5, 6, and 7 further illustrate that imports from the United States and Japan for commodities including petroleum oils, cereals (maize, wheat, rice), and vehicles are projected to experience total cost impacts of 8.95%, 7.61%, and 13.73%, respectively, across the same time periods. The model suggests a moderate impact in 2030, estimated between 0.94% and 6.88%. However, these effects are expected to intensify as shipping regulations become increasingly stringent over time (DNV, 2024b).

The overall cost impact for 2030 is projected to remain moderate, ranging from 0.94% to 6.88% across the years 2030, 2040, and 2050. As time progresses, particularly with the enforcement of stricter shipping regulations, the effects of the midterm measures are likely to become more significant (OECD, 2024).

The IMO's introduction of mid-term measures will have repercussions for both exports and imports, where generally, imports are anticipated to encounter slightly higher cost increases compared to exports. For exports, additional shipping costs for Jamaican products destined for the United States and other foreign markets, especially those reliant on tanker and bulk shipping, such as bauxite and petroleum could jeopardize Jamaica's competitive position in global markets if such costs increase substantially over time (Alderighi et al., 2020). The total cost impacts on exports are expected to range from 0.94% to 13.11%, while imports will range from 1.47% to 13.73%. The higher impact on imports can be attributed to transportation expenses for essential goods, which are more sensitive to fluctuations in shipping costs. Such increases in import costs may exacerbate inflationary pressures within Jamaica, affecting a wide array of products including food, machinery, and vehicles (Mastromarco & Guccio, 2017; Perkins & Neumayer, 2014).

The analysis regarding commodities for exports and imports indicates that by the year 2030, the most pronounced economic impacts are anticipated under a high levy scenario, with projected costs ranging from 2.36% to 6.88%. In contrast, the least severe impacts are expected under a GFI Flex Only scenario, reflecting more moderate costs ranging from 0.94% to 2.97%. The trend is expected to persist through 2040, as the highest impacts remain associated with the high levy scenario, potentially leading to cost increases between 4.19% and 11.94%. Conversely, the lowest impacts are predicted under a low levy scenario, which may result in cost increases ranging from 3.36% to 9.65%. Furthermore, by 2050, it is anticipated that cost impacts across all policy scenarios will converge, resulting in more uniform effects that reflect long-term adjustments to the implemented policies. Hence, the GFI Flex Only is a cost-effective option for both export and import commodities for Jamaica in the short term (2030) but not in the long term for years 2040, and 2050 (IMO, 2024c).

The global shipping industry plays an essential role in international trade, and Jamaica's economy is significantly dependent on it. The introduction of the International Maritime Organization (IMO) Greenhouse Gas (GHG) Levy, which is aimed at reducing carbon emissions, is anticipated to lead to a substantial increase in shipping costs. This rise in expenses is likely to result in higher freight charges, contributing to increased prices for imported goods and further straining Jamaica's economy, which grew by only 0.5% in 2022. The Jamaican economy is heavily dependent on services, which accounts for more than 70% of GDP hence such developments could adversely affect key sectors, including tourism, consumer spending, and businesses reliant on shipping services (OECD, 2024; World Bank, 2024; Analytics, 2024). Particularly noteworthy is the potential impact on the tourism sector, which is estimated to represent approximately 6.5% of Jamaica's economy, both directly and indirectly (World Bank, 2024). As businesses adapt to these changes, Jamaica may experience prolonged delivery times and a reduction in available shipping options. Furthermore, as a critical transshipment hub in the region, the GHG levy is expected to negatively influence transshipment volumes due to route changes as a result of this levy (OECD, 2024; UNCTAD, 2021).

Conversely, the greenhouse gas (GHG) levy presents an opportunity for Jamaica to enhance its maritime infrastructure and adopt sustainable practices. By investing in environmentally friendly technologies and upgrading port facilities, Jamaica can better align itself with global sustainability objectives, thereby reinforcing its competitive advantage in the domain of environmentally conscious shipping (OECD, 2024; Miller & Hyodo, 2022). Jamaica's strategic geographic position and oil bunker supply also create a unique opportunity to alleviate the financial burden imposed on shipping companies by the IMO levy. By concentrating on competitive pricing, cleaner fuel options, and fostering regional collaboration, Jamaica could strengthen

its role as a significant maritime hub while concurrently assisting in mitigating the challenges posed by this levy on global shipping enterprises. This strategy would support the local economy and align with the environmental goals established by the IMO (Jamaica Gleaner, 2023). The findings of this study are vital for policymakers, investors, and economists in Jamaica as they seek to establish a legislative framework and develop the necessary infrastructure to support IMO initiatives while accommodating the economic fluctuations associated with this levy.

2.4. Trinidad & Tobago

The Stakeholder Assessment for Trinidad & Tobago examines both exports and imports. Trinidad & Tobago boasts a robust export-driven economy that is predominantly reliant on its energy and manufacturing sectors. The country's exports include petroleum products (such as mineral fuels, oils, and distillation products), natural gas-based products, and food and agricultural products. On the other hand, the main imports consist of manufactured goods, machinery and transport equipment, as well as food and agricultural products.

Table 2.8. Top export/import commodities for Trinidad & Tobago 2023

Country	Trade Direction	Commodity	Description	Key Destination	Primary Value (FOB Value\$)
Trinidad & Tobago	Export	Petroleum and Petroleum Products*	Petroleum oils and oils obtained from bituminous minerals; crude	USA, Spain, Guyana, Barbados, Jamaica	\$1,742,580,790
		Natural Gas-Based products*	Petroleum gases and other gaseous hydrocarbons	USA, Spain, Guyana, Barbados, Jamaica	\$919,748,689
		Food and Agricultural Products*	Cereal, flour, starch, milk preparation and products	Jamaica, Guyana, Barbados, DR, USA, Spain	\$232,382,389
		Iron and Steel Products	Iron or Steel articles	USA, Barbados, Guyana, Jamaica	\$222,206,841
		Chemical Products	Fertilizers	USA, Barbados, Guyana, Jamaica	\$187,500,017
	Import	Manufactured Goods*	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof	USA, Germany, UK, Brazil, Netherlands	\$1,122,382,395
		Food and Agricultural Products*	Cereals (Corn, Wheat, Rice), Dairy products, edible preparations, meat and edible meat	USA, Brazil, UK, Netherland	\$284,342,076
		Machinery and Transport Equipment*	Vehicles, Machinery, plant or Laboratory equipment	USA, UK, Germany, Netherland, Brazil	\$352,315,628
		Chemicals and Related products	Chemical Products	USA, Brazil, UK, Netherland	\$187,547,073

**Top 3 commodities for both Trinidad & Tobago's exports and Imports*

2.4.1. Key Export Commodities

Trinidad & Tobago, an archipelago located in the southern Caribbean, is renowned for its rich natural resources, particularly in the energy sector. As one of the largest producers of oil and natural gas in the region, the nation has developed a highly export-oriented economy, with its export commodities primarily comprising energy-related products. These exports have made Trinidad and Tobago an important player in global markets, especially in the chemicals, oil, and gas industries.

The top three (3) primary categories of export commodities are as follows:

1. Petroleum and Petroleum Products

Trinidad & Tobago are recognized as significant producers and exporters of crude oil, refined petroleum products, and lubricants. The energy sector plays a vital role in contributing to the nation's gross domestic product (GDP) and export revenues. The primary markets for these commodities include the United States, the European Union, and various Caribbean nations. In 2023, the value of exports amounted to US\$1.7bn, underscoring the importance of these high value commodities

2. Natural Gas

As one of the largest exporters of LNG in the Western Hemisphere, Trinidad & Tobago serves global markets with this essential commodity, which consists of petroleum gas and other gaseous hydrocarbons. The key markets for LNG include the United States, South America, Europe, and the Caribbean. The commodity's primary value was US\$920m in 2023.

3. Cereal, Flour, Starch, Milk Preparations and Products

Agricultural goods are also a key export market from Trinidad & Tobago, amounting to US\$232.3m in 2023.

2.4.2. Key Import Commodities

The top three (3) primary categories of import commodities are as follows:

1. Machinery

The manufactured goods sector features a wide range of products, including nuclear reactors, boilers, machinery and mechanical appliances, with imports typically sourced from the USA, Germany, UK, Brazil and the Netherlands. Commodities of this nature were valued at US\$1.1bn in 2023.

2. Cereals (Corn, Wheat, Rice)

This category addresses domestic food demand, as local agricultural production is insufficient to fully meet needs. It consists of agricultural products, as well as food and beverages. The main suppliers are the United States, Colombia, and Brazil. As shown above, this commodity accounts for US\$606m in imports. Cereals of corn, wheat and rice, as well as dairy products, edible preparations and meat are typically imported from the USA, Brazil, UK and the Netherlands. Imports of this commodity amounted to US\$284m in 2023.

3. Aircraft, Spacecraft and Parts

This category includes industrial and manufacturing machinery, motor vehicles and their components, and electrical equipment. The primary sources for these imports are the USA, UK, Germany, Netherlands and Brazil. As shown above, this accounts for the second-highest import value of US\$352m.

2.4.3. Results

Results presented here are the total expected impacts representing the sum of vessel-side and cargo-side cost impacts. Total expected impacts are given as changes to the amounts paid in transport costs as a proportion of traded value. Details of cost assumptions underpinning the vessel-side and cargo-side modelling can be found in Annexes I and II respectively. All scenarios modelled are on a WTW basis, with full details on the scenarios included in this analysis provided in Annex I.i.

2.4.3.1. Exports of Petroleum and Petroleum Products to the USA

Table 2.9. Scenario for each policy for the years 2030, 2040, and 2050 for petroleum and petroleum products exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Petroleum and Petroleum Products to the USA	GFI Flex Only	0.70% - 0.85%	2.77% - 2.92%	3.56% - 3.71%
	Low Levy	0.92% - 1.07%	2.51% - 2.66%	3.43% - 3.58%
	High Levy	1.76% - 1.91%	3.12% - 3.27%	3.43% - 3.58%
	Feebate	1.01% - 1.16%	2.68% - 2.83%	3.61% - 3.76%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of petroleum and petroleum products from Trinidad & Tobago to the USA by between 0.70% to 3.76% of traded value per year, ranging from 0.70% to 1.91% in 2030, 2.51% to 3.27% in 2040 and 3.43% to 3.76% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 0.70% to 3.71% under a flexible GFI mechanism, 1.01% to 3.76% under a feebate mechanism and by between 0.92% to 3.58% across levy scenarios.

2.4.3.2. Exports of Natural Gas to the USA

Table 2.10. Scenario for each policy for the years 2030, 2040, and 2050 for Natural Gas Based products exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Natural Gas to the USA	GFI Flex Only	2.08% - 2.18%	8.19% - 8.29%	10.53% - 10.63%
	Low Levy	2.73% - 2.83%	7.41% - 7.51%	10.14% - 10.24%
	High Levy	5.20% - 5.30%	9.23% - 9.33%	10.14% - 10.24%
	Feebate	2.99% - 3.09%	7.95% - 8.03%	10.66% - 10.76%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of natural gas from Trinidad and Tobago to the USA by between 2.08% to 10.76% of traded value per year, ranging from 2.08% to 5.30% in 2030, 7.41% to 9.33% in 2040 and 10.14% to 10.76% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 2.08% to 10.63% under a GFI Flex Only scenario, 2.99% to 10.76% under a feebate mechanism and by between 2.73% to 10.24% across levy scenarios.

2.4.3.3. Exports of Cereal, Flour, Starch, Milk Preparations and Products to Jamaica

Table 2.11. Scenario for each policy for the years 2030, 2040, and 2050 for Food and Agricultural products exports

Commodity	Scenario	2030	2040	2050
Exports of Cereal Products to Jamaica	GFI Flex Only	0.64% - 0.71%	2.52% - 2.59%	3.24% - 3.31%
	Low Levy	0.84% - 0.91%	2.28% - 2.35%	3.12% - 3.19%
	High Levy	1.60% - 1.67%	2.84% - 2.91%	3.12% - 3.19%
	Feebate	0.92% - 0.99%	2.44% - 2.51%	3.28% - 3.35%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of cereal, flour, starch, milk preparations and products from Trinidad & Tobago to Jamaica by between 0.64% to 3.35% of traded value per year, ranging from 0.64% to 1.67% in 2030, 2.52% to 2.91% in 2040 and 3.12% to 3.35% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 0.64% to 3.31% under GFI Flex Only scenario, 0.92% to 3.35% under a feebate mechanism and by between 0.84% to 3.19% across levy scenarios.

2.4.3.4. Imports of Machinery from the USA

Table 2.12. Scenario for each policy for the years 2030, 2040, and 2050 for Manufactured Goods exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Machinery from the USA	GFI Flex Only	3.18% - 3.26%	12.54% - 12.61%	16.12% - 16.19%
	Low Levy	4.18% - 4.25%	11.34% - 11.42%	15.52% - 15.60%
	High Levy	7.96% - 8.03%	14.13% - 14.20%	15.52% - 15.60%
	Feebate	4.58% - 4.65%	12.14% - 12.21%	16.32% - 16.39%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of machinery from the USA to Trinidad & Tobago by between 3.18% to 16.39% of traded value per year, ranging from 3.18% to 8.03% in 2030, 11.34% to 14.20% in 2040 and 15.52% to 16.39% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 3.18% to 16.19% under a flexible GFI mechanism, 4.58% to 16.39% under a feebate mechanism and by between 4.18% to 15.60% across levy scenarios.

2.4.3.5. Imports of Corn, Wheat and Rice from the USA

Table 2.13. Scenario for each policy for the years 2030, 2040, and 2050 for Food and Agricultural products imports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Corn, Wheat and Rice from the USA	GFI Flex Only	1.25% - 1.37%	4.91% - 5.03%	6.32% - 6.44%
	Low Levy	1.64% - 1.76%	4.45% - 4.57%	6.08% - 6.20%
	High Levy	3.12% - 3.24%	5.54% - 5.66%	6.08% - 6.20%
	Feebate	1.79% - 1.91%	4.76% - 4.88%	6.40% - 6.52%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of corn, wheat and rice from the USA to Trinidad & Tobago by

between 1.25% to 6.52% of traded value per year, ranging from 1.25% to 3.24% in 2030, 4.45% to 5.66% in 2040 and 6.08% to 6.52% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.25% to 6.44% under a flexible GFI mechanism, 1.79% to 6.52% under a feebate mechanism and by between 1.64% to 6.20% across levy scenarios.

2.4.3.6. Imports of Aircraft, Spacecraft and Parts from the USA

Table 2.14. Scenario for each policy for the years 2030, 2040, and 2050 for Machinery and Transport Equipment imports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Aircraft, Spacecraft and Parts from the USA	GFI Flex Only	1.30% - 1.35%	5.10% - 5.16%	6.56% - 6.61%
	Low Levy	1.70% - 1.75%	4.62% - 4.67%	6.32% - 6.37%
	High Levy	3.24% - 3.29%	5.75% - 5.80%	6.32% - 6.37%
	Feebate	1.86% - 1.92%	4.94% - 4.99%	6.64% - 6.69%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of aircraft, spacecraft and parts from the USA to Trinidad & Tobago by between 1.30% to 6.69% of traded value per year, ranging from 1.30% to 3.29% in 2030, 4.62% to 5.80% in 2040 and 6.32% to 6.37% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.70% to 6.37% under a flexible GFI mechanism, 1.86% to 6.69% under a feebate mechanism and by between 1.64% to 6.14% across levy scenarios.

2.4.4. Summary of Results

Across all six commodities studied, the results of this modelling suggest:

- The total cost impacts from the implementation of midterm measures on Trinidad & Tobago's six most valuable import and export trades are projected to range from 0.70% and 16.39% of annual traded value between 2030 and 2050, depending on the policy scenario. Specifically, impacts are expected to range from 0.70% to 10.76% for exports and 1.25% to 16.39% for imports.
- Under the four policy scenarios modeled, the total cost impacts are anticipated as follows:
 - ❖ **2030:** Impacts are expected to range from 0.70% to 4.65%.
 - ❖ **2040:** Impacts are projected to range from 2.52% to 12.21%.
 - ❖ **2050:** Impacts are expected to range from 3.24% to 16.39%.
- When considering specific policy scenarios, impacts are expected to vary as follows:
 - ❖ **Under a flexible GFI scenario,** total cost impacts are projected to range between 0.70% and 16.19%.
 - ❖ **Under a feebate scenario,** impacts are projected to range from 1.01% to 16.39%.
 - ❖ **Under levy scenarios,** impacts are expected to range from 0.92% to 15.60%.

- By 2030, the highest impacts are anticipated under a high levy scenario (ranging from 1.76% to 8.03%), while the lowest impacts are expected under a flexible GFI scenario (ranging from 0.70% to 3.26%).
- By 2040, the impacts remain greatest under a high levy scenario (ranging from 2.84% to 14.20%) and least under a low levy (ranging from 2.51% to 11.42%).
- By 2050, the cost impacts are expected to be broadly similar across all policy scenarios.

2.4.5. Discussion

The modeling results for Trinidad & Tobago indicate that the IMO's introduction of midterm measures will have a substantial impact on both exports and imports involving Trinidad & Tobago and its trade partners, including the United States, Spain, Barbados, and Jamaica. The total cost impact is projected to range from 0.70% to 16.39% for export and import commodities. Specifically, the cost impact for exports is anticipated to range from 0.70% to 10.76%, while the cost impact for imports may vary from 1.25% to 16.39%, as detailed in Tables 9, 10, and 11.

Notably, for export commodities, research findings indicate that Petroleum and Petroleum Products, Natural Gas, and Food and Agricultural products (including Cereal, Flour, Starch, and Milk Preparations) may peak at cost impacts of 3.76%, 10.76%, and 3.35%, respectively, based on traded value by the year 2050 (under the highest speed reduction of 30%). These costs are expected to increase gradually over the forthcoming decades, with natural gas exports facing the most considerable challenges regarding cost escalation.

In relation to import commodities, the analysis reveals that Manufactured Goods (which encompass Boilers, Nuclear Reactors, and Machinery), Food and Agricultural Products (Cereals), and Machinery and Transport Equipment (including Vehicles and Machinery) will experience cost impacts of up to 16.39%, 6.52%, and 6.69% (under the highest speed reduction of 30%), respectively, as illustrated in Tables 12, 13, and 14. Consequently, imports, particularly machinery, will undergo significant cost increases over the next few decades, reaching as high as 16.39% by 2050. Food imports and parts for aircraft and spacecraft will also experience notable cost increases but to a lesser degree.

Tables 9-14 show Trinidad & Tobago's export and import commodities. By 2030, a high levy scenario may lead to economic impacts between 1.76% and 8.03%, while the GFI Flex Only scenario may see impacts of 0.70% to 3.26%. This trend continues into 2040, with higher levies increasing costs from 3.12% to 14.20% and lower levies resulting in 2.51% to 11.42%. By 2050, cost impacts are expected to align across all scenarios, indicating balanced long-term effects. The GFI Flex Only option is cost-effective in the short term by 2030 but less so by 2040 and 2050 (IMO, 2024c).

The IMO's introduction of midterm measures has the potential to diminish the competitiveness of Trinidad & Tobago's exports, particularly within the energy sector (petroleum and natural gas) and food products. Increased shipping costs may impede the country's ability to compete with other exporters who benefit from lower shipping costs, particularly in price-sensitive markets. Additionally, escalating shipping costs associated with imported goods could adversely affect Trinidad & Tobago's industrial competitiveness, particularly in sectors that depend on imported machinery and materials. Consequently, heightened production costs may reduce the country's attractiveness as a manufacturing hub.

The introduction of the International Maritime Organization (IMO) levy may result in significant implications for Trinidad & Tobago, particularly in the form of increased shipping costs. This levy is typically implemented as fees or additional expenditures associated with compliance with international shipping regulations, including the adoption of low-sulfur fuels and emission-reduction technologies (OECD, 2024). Given that Trinidad & Tobago's economy is heavily dependent on its oil and gas sector, which constitutes approximately 40% of its Gross Domestic Product (GDP), any escalation in shipping costs arising from the IMO levy could adversely impact the transportation of crude oil, natural gas, and refined products to global markets (World Bank, 2024; OECD, 2024). Consequently, this situation may lead to elevated freight rates and result in additional financial pressures on the government, potentially diminishing export revenues and increasing operational costs for state-owned oil companies engaged in international shipping (World Bank, 2024; UNCTAD, 2024).

Trinidad & Tobago is strategically positioned as a pivotal maritime hub within the Caribbean, featuring a comprehensive port infrastructure in locations such as Port of Spain and Point Lisas. An increase in shipping costs attributable to the IMO levy could detrimentally affect the nation's maritime sector by decreasing cargo volumes and raising freight expenses (The Ministry of Industry, Investment and Commerce, 2024; Mastromarco & Guccio, 2017). Moreover, the resultant escalation in energy import prices from Trinidad & Tobago may hinder growth in other sectors across CARICOM nations. Furthermore, should regional shipping companies are not able to absorb or effectively transfer these increased costs, the supply chain may experience disruptions, leading to alterations in port traffic patterns and intensified competition from alternative suppliers (Alderighi et al., 2020).

Nonetheless, while the immediate consequences of the IMO levy present challenges, Trinidad & Tobago has the opportunity to utilize the evolving maritime landscape to diversify its economy. By investing in cleaner maritime technologies, offering sustainable fuel alternatives such as Ammonia (NH₃), which is emerging as a potential alternative fuel for ships, and enhancing port facilities to align with IMO

regulations, Trinidad & Tobago could attract vessels that seek to comply with these standards. In addition, positioning itself as a green maritime hub could enable the nation to capitalize on the growing demand for low-sulfur fuels, liquefied natural gas (LNG), and other sustainable maritime solutions, thereby establishing a green supply chain for other CARICOM countries.

2.5. Barbados

Barbados is predominantly known for its tourism and service sectors, yet it also maintains a significant export market. The principal categories of exports are refined petroleum products, rum and alcoholic beverages, clothing, chemicals, and pharmaceuticals, as shown in the table below. Barbados also imports a significant portion of its goods to sustain its economy and population.

Table 2.15. Top export/import commodities for Barbados 2023 based on merchandise trade statistics from the Comtrade platform.

Country	Trade Direction	Commodity	Description	Key Destination	Primary Value (FOB Value\$)
Barbados	Export	Petroleum and Petroleum Products*	Mineral fuels, oils, distillation products	Jamaica, USA, T&T, UK, St.Lucia	\$54,377,882.5
	Export	Rum and Alcoholic Beverage*	Beverages, spirits, and vinegar	USA, Canada, Jamaica, UK, St.Lucia	\$42,319,822.5
	Export	Food and Agricultural Products*	Animal or vegetable fats and oils and their cleavage products; prepared animal fats; animal or vegetable waxes	T&T, St.Lucia, Jamaica	\$18,822,411
	Export	Pharmaceuticals and Chemicals Products	Fertilizers, Chemical, Pharmaceutical	USA, Barbados, Guyana, Jamaica	\$15,804,398
	Import	Fuels and Petroleum Products	Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes	T&T, Canada, USA	\$391,342,472.5
	Import	Manufactured Goods	Machinery, nuclear reactors, boilers	USA, Brazil, China, Canada	\$711,096,903
	Import	Food and Agricultural Products	Beverages, spirits, and vinegar	USA, Canada, T&T, China	\$257,879,544
	Import	Machinery and Transport Equipment	Vehicles; other than railway or tramway	USA, UK, China, T&T, Canada	\$56,179,980

**Top 3 commodities for both Barbados exports and Imports*

2.5.1. Key Export Commodities

The top three (3) primary categories of export commodities are as follows

1. Petroleum and Petroleum Products

Petroleum and petroleum products were found to be the most valuable export market for Barbados, with exports typically destined for Jamaica, the USA, Trinidad and Tobago, UK and Saint Lucia. Exports of this commodity amounted to US\$54.4m in 2023.

2. Rum and Alcoholic Beverages

This category includes alcoholic beverages, spirits and vinegars for which Barbados is a significant exporter. Exports of this nature amounted to US\$42.3m from Barbados in 2023.

3. Animal, Vegetable Fats and Oils

This category includes animal and vegetable fats and oils that are exported both regionally and internationally. In 2023, the total export value of these commodities amounted to US\$18.8m.

2.5.2. Key Import Commodities

The top three (3) primary categories of import commodities are as follows:

1. Mineral Fuels, Oils and Distillation Products

This commodity supports energy needs, transportation, and industrial activities. These fuels and Petroleum Products comprise Crude oil, refined petroleum, natural gas, and Liquefied petroleum gas (LPG) for domestic and industrial use. Jamaica, Canada and the USA are major import partner countries, with imports amounting to US\$391.3m in 2023.

2. Machinery, Nuclear Reactors and Boilers

Machinery and Transport Equipment plays a critical role in infrastructure development, manufacturing, and transportation sectors. This commodity category encompasses machinery, nuclear reactors and boilers. The primary sources of imports for these items are the United States, Great Britain, and China, with imports amounting to US\$711m in 2023.

3. Beverages, Spirits and Vinegar

Imports of beverages, spirits and vinegars into Barbados are primarily sourced from the USA, Canada, Trinidad and Tobago and China. Imports of this nature amounted to US\$257.9m in 2023.

2.5.3. Results

Results presented here are the total expected impacts representing the sum of vessel-side and cargo-side cost impacts. Total expected impacts are given as changes to the amounts paid in transport costs as a proportion of traded value. Details of cost assumptions underpinning the vessel-side and cargo-side modelling can be found in Annexes I and II respectively. All scenarios modelled are on a WTW basis, with full details on the scenarios included in this analysis provided in Annex I.i.

2.5.3.1. Exports of Petroleum and Petroleum Products to Jamaica

Table 2.16. Scenario for each policy for the years 2030, 2040, and 2050 for Petroleum and Petroleum exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Petroleum and Petroleum Products to Jamaica	GFI Flex Only	0.83% - 0.90%	3.28% - 3.34%	4.21% - 4.28%
	Low Levy	1.09% - 1.16%	2.96% - 3.03%	4.06% - 4.12%
	High Levy	2.08% - 2.15%	3.69% - 3.76%	4.06% - 4.12%
	Feebate	1.20% - 1.26%	3.17% - 3.24%	4.26% - 4.33%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of petroleum and petroleum products from Barbados to Jamaica by between 0.83% to 4.33% of traded value per year, ranging from 0.83% to 2.15% in 2030, 2.96% to 3.76% in 2040 and 4.06% to 4.33% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 0.83% to 4.28% under a flexible GFI mechanism, 1.20% to 4.33% under a feebate mechanism and by between 1.09% to 4.12% across levy scenarios.

2.5.3.2. Exports of Rum and Alcoholic Beverages to the USA

Table 2.17. Scenario for each policy for the years 2030, 2040, and 2050 for Rum and Alcoholic Beverage exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Rum and Alcoholic Beverages to the USA	GFI Flex Only	0.88% - 0.95%	3.47% - 3.54%	4.46% - 4.53%
	Low Levy	1.16% - 1.23%	3.14% - 3.21%	4.29% - 4.36%
	High Levy	2.20% - 2.27%	3.91% - 3.98%	4.29% - 4.36%
	Feebate	1.27% - 1.34%	3.36% - 3.43%	4.51% - 4.58%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of rum and alcoholic beverages from Barbados to the USA by between 0.88% to 4.58% of traded value per year, ranging from 0.88% to 2.27% in 2030, 3.14% to 3.98% in 2040 and 4.29% to 4.58% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 0.88% to 4.53% under a flexible GFI mechanism, 1.27% to 4.58% under a feebate mechanism and by between 1.16% to 4.36% across levy scenarios.

2.5.3.3. Exports of Animal, Vegetable Fats and Oils to Trinidad & Tobago

Table 2.18. Scenario for each policy for the years 2030, 2040, and 2050 for Food and Agricultural Products exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Animal, Vegetable Fats and Oils to Trinidad and Tobago	GFI Flex Only	0.99% - 1.00%	3.91% - 3.92%	5.02% - 5.03%
	Low Levy	1.30% - 1.31%	3.53% - 3.55%	4.84% - 4.85%
	High Levy	2.48% - 2.49%	4.40% - 4.41%	4.84% - 4.85%
	Feebate	1.43% - 1.44%	3.78% - 3.79%	5.08% - 5.10%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of animal, vegetable fats and oils from Barbados to Trinidad & Tobago by between 0.99% to 5.10% of traded value per year, ranging from 0.99% to 2.49%

in 2030, 3.53% to 4.41% in 2040 and 4.84% to 5.10% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 0.99% to 5.03% under a flexible GFI mechanism, 1.43% to 5.10% under a feebate mechanism and by between 1.30% to 4.85% across levy scenarios.

2.5.3.4. Imports of Mineral Fuels, Oils and Distillation Products from Trinidad Tobago

Table 2.19. Scenario for each policy for the years 2030, 2040, and 2050 for Fuel and Petroleum Products imports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Mineral Fuels, Oils and Distillation Products from Trinidad and Tobago	GFI Flex Only	0.99% - 1.00%	3.91% - 3.92%	5.02% - 5.03%
	Low Levy	1.30% - 1.31%	3.53% - 3.55%	4.84% - 4.85%
	High Levy	2.48% - 2.49%	4.40% - 4.41%	4.84% - 4.85%
	Feebate	1.43% - 1.44%	3.78% - 3.79%	5.08% - 5.10%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of mineral fuels, oils and distillation products from Trinidad & Tobago to Barbados by between 0.99% to 5.10% of traded value per year, ranging from 0.99% to 2.49% in 2030, 3.53% to 4.41% in 2040 and 4.84% to 5.10% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 0.99% to 5.03% under a flexible GFI mechanism, 1.43% to 5.10% under a feebate mechanism and by between 1.30% to 4.85% across levy scenarios.

2.5.3.5. Imports of Machinery, Nuclear Reactors and Boilers from the USA

Table 2.20. Scenario for each policy for the years 2030, 2040, and 2050 for Manufactured Goods imports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Machinery, Nuclear Reactors and Boilers from the USA	GFI Flex Only	3.44% - 3.52%	13.55% - 13.63%	17.42% - 17.50%
	Low Levy	4.52% - 4.60%	12.26% - 12.34%	16.77% - 16.85%
	High Levy	8.60% - 8.68%	15.27% - 15.35%	16.77% - 16.85%
	Feebate	4.95% - 5.03%	13.12% - 13.20%	17.63% - 17.71%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of machinery, nuclear reactors and boilers from the USA to Barbados by between 3.44% to 17.71% of traded value per year, ranging from 3.44% to 8.68% in 2030, 12.26% to 15.35% in 2040 and 16.77% to 17.71% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 3.44% to 17.5% under a flexible GFI mechanism, 4.95% to 17.71% under a feebate mechanism and by between 4.52% to 16.85% across levy scenarios.

2.5.3.6. Imports of Beverages, Spirits and Vinegar from Trinidad and Tobago

Table 2.21. Scenario for each policy for the years 2030, 2040, and 2050 for Food and Agricultural Products imports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Beverages, Spirits and Vinegar from Trinidad and Tobago	GFI Flex Only	1.36% - 1.44%	5.36% - 5.44%	6.89% - 6.97%
	Low Levy	1.79% - 1.87%	4.85% - 4.93%	6.63% - 6.71%
	High Levy	3.40% - 3.48%	6.04% - 6.12%	6.63% - 6.71%
	Feebate	1.96% - 2.04%	5.19% - 5.27%	6.97% - 7.05%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of beverages, spirits and vinegar by between 1.36% to 7.05% of traded value per year, ranging from 1.36% to 3.48% in 2030, 4.85% to 6.12% in 2040 and 6.63% to 7.05% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.36% to 6.97% under a flexible GFI mechanism, 1.96% to 7.05% under a feebate mechanism and by between 1.79% to 6.71% across levy scenarios.

2.5.4. Summary of Results

- Across all six commodities studied, the results of this modelling suggest:
- The total cost impacts from the implementation of midterm measures on Barbados' six most valuable import and export trades are projected to range from 0.83% and 17.71% of annual traded value between 2030 and 2050, depending on the policy scenario. Specifically, impacts are expected to range from 0.83% to 5.10% for exports and 0.99% to 17.71% for imports.
- Under the four policy scenarios modelled, the total cost impacts are anticipated as follows:
 - ❖ **2030:** Impacts are expected to range from 0.83% to 5.03%.
 - ❖ **2040:** Impacts are projected to range from 3.28% to 13.2%.
 - ❖ **2050:** Impacts are expected to range from 4.21% to 17.71%.
- When considering specific policy scenarios, impacts are expected to vary as follows:
 - ❖ **Under a flexible GFI scenario,** total cost impacts are projected to range between 0.83% and 17.5%.
 - ❖ **Under a feebate scenario,** impacts are projected to range from 1.20% to 17.71%.
 - ❖ **Under levy scenarios,** impacts are expected to range from 1.09% to 16.85%.
- By 2030, the highest impacts are anticipated under a high levy scenario (ranging from 2.08% to 8.68%), while the lowest impacts are expected under a flexible GFI scenario (ranging from 0.83% to 3.52%).
- By 2040, the impacts remain greatest under a high levy scenario (ranging from 3.91% to 15.35%) and least under a low levy scenario (ranging from 2.96% to 12.34%).

- By 2050, the cost impacts are expected to be broadly similar across all policy scenarios.

2.5.5. Discussion

The model results for Barbados indicate that the overall cost impact of the IMO's introduction of mid-term measures will range from 0.83% to 17.71% of the annual traded value for both exports and imports of commodities between 2030 and 2050. Specifically, the cost impact for exports is projected to range from 0.83% to 5.10%, while imports are expected to range from 0.99% to 17.71%. This information is detailed in Tables 16, 17, and 18.

For export commodities, the peak cost impacts for 2050 are expected to be as follows: Petroleum and petroleum products to Jamaica at 4.33%, Rum and alcoholic beverages to the USA at 4.58%, and agricultural products to Trinidad and Tobago at 5.10%. For imports, the highest cost impacts projected in 2050 are: Petroleum products (mineral fuels, oils, and distillation products) from Trinidad & Tobago at 5.20%, manufactured goods (machinery, nuclear reactors, boilers) from the USA at 12.3%, and food and agricultural products (beverages, spirits, and vinegar) from Trinidad & Tobago at 5.01%, as shown in Tables 19, 20, and 21.

Therefore, petroleum and petroleum products shipped to Jamaica are expected to have the highest export cost, with a potential impact of 4.33% in 2050. Conversely, the machinery, nuclear reactors, and boiler sector from the USA will experience the highest import impact, estimated at 17.71% in 2050.

The GFI Flex Only would be considered the most cost-effective option for Barbados' import and export commodities in the short term (2030), ranging from 0.83% to 3.52%, while a high levy scenario is expected to have the highest economic impact, with costs ranging from 2.08% to 8.68%. As the timeline progresses to 2040, the trend remains consistent, with the highest impacts continuing to be observed under the high levy scenario, where costs could increase from 3.69% to 15.35%. Conversely, the lowest impacts are now anticipated under a low levy scenario, with costs ranging from 2.96% to 12.34%. By 2050, however, the cost impacts across all policy scenarios are expected to converge, with the differences becoming less pronounced and impact leveling out across the various approaches. Nonetheless, the short- and long-term effects of all four scenarios could negatively impact Barbados's major trade relations with the U.S. and other markets, as businesses may face difficulties absorbing price increases linked to rising shipping costs (Mastromarco & Guccio, 2017; Perkins & Neumayer, 2014).

The introduction of midterm measures by the International Maritime Organization (IMO) is vital for enhancing sustainability in shipping through the reduction of carbon emissions. In the long run, Barbados stands to gain from the adoption of more

sustainable shipping practices, such as utilizing cleaner fuels and more efficient vessels. Furthermore, the IMO's measures could generate revenue for Barbados, enabling reinvestment in sustainable port infrastructure and green shipping technologies (Koenig et al., 2021; OECD, 2024). However, it is essential to recognize that the Barbadian economy is largely fueled by the services sector, which constitutes 88.7% of its GDP, with tourism serving as the primary economic driver, accounting for 17% of GDP. As a result, the IMO's midterm measures may affect tourist arrivals due to increased transcosts, potentially leading to a decline in tourism-related jobs and wages (Scott & Becken, 2014).

Additionally, Barbados is a key player in the maritime supply chain within the Caribbean region. The implementation of the IMO levy could have negative repercussions for trade, as the resulting higher shipping costs may disrupt local supply chains by inflating prices for goods and causing shipment delays. Companies might face challenges in absorbing these increased shipping fees and may pass those costs onto consumers, which could result in price inflation within the island's economy (Alderighi et al., 2020).

2.6. Antigua & Barbuda

Antigua and Barbuda's economy is predominantly reliant on tourism; however, the jurisdiction also engages in three principal export commodities: petroleum products (re-exports), manufactured goods, and agricultural products. Due to its limited natural resources, Antigua and Barbuda depends on imports to fulfill most of its domestic requirements. The major categories of imported commodities are Food and beverage products, Machinery and Transport Equipment, Petroleum Products, Pharmaceuticals and Chemicals, and Clothing and Textiles.

Table 2.22. Top export/import commodities Antigua & Barbuda 2023

Country	Trade Direction	Commodity	Description	Key Destination	Primary Value (FOB Value\$)
Antigua and Barbuda	Export	Petroleum and Petroleum Products*	Petroleum oils and oils from bituminous minerals, not crude	Saint Maarten, USA	\$4,858,036
		Machinery and Transport Equipment	Yachts and other vessels	UK, USA	\$858,867
		Food and Beverage Products	Beverages, spirits and vinegar	USA, UK, Barbados	\$184,041
	Import	Food and Beverage Products	Meat and edible meal offal, Cereals, Fruits and Vegetables	T&T, Canada, USA	\$34,897,602
		Fuels and Petroleum Products	Mineral fuels, oils and distillation products.	USA, UK, Barbados	\$7,531,461
		Machinery and Transport Equipment	Vehicles	USA, Canada, T&T, China	\$3,957,165

**Top 3 commodities for both Antigua & Barbuda's exports and Imports*

2.6.1. Key Export Commodities

The top three (3) primary categories of export commodities are as follows:

1. Petroleum and Petroleum Products

Antigua and Barbuda imports refined petroleum (reexport), which is subsequently re-exported to other nations, benefiting from the country's strategic logistical position. The primary markets for these re-exports include the United States and nearby Caribbean islands such as Saint Maarten. The components of this commodity encompass mineral fuels, bituminous substances, and mineral waxes. The table above reveals that in 2023, this commodity had the highest primary value at approximately US\$4.8m.

2. Yachts and Other Vessels

The manufactured goods sector comprises a diverse array of products, including machinery, electrical equipment, electronic components, tools, iron and steel articles, furniture, and artwork. The principal markets for these commodities are predominantly regional. In 2023, this sector was ranked as the second highest in primary value, with an approximate valuation of US\$859,000, as indicated above.

3. Beverages, Spirits and Vinegar

The agricultural products sector comprises small-scale exports of vegetables, fruits, seafood, and processed food items. Alongside the USA and UK, markets for these agricultural commodities are primarily regional. As indicated above, export commodities of this nature amounted to US\$184,000 in 2023.

2.6.2. Key Import Commodities

The top three (3) primary categories of import commodities are as follows:

1. Meat and Edible Offal

These commodities are essential for meeting the food demands of the local population and the tourism sector. Major imports in this category come from Trinidad & Tobago, the USA and UK. In 2023, commodities of this nature amounted to US\$34.9bn.

2. Mineral Fuels, Oils and Distillates

These imports are crucial for transportation, electricity generation, and other industrial uses. This category includes diesel, gasoline, and liquefied petroleum gas (LPG), with major imports originating from the USA, the UK and Barbados. In 2023, imports of this nature amounted to US\$7.5m.

3. Vehicles

This category encompasses industrial and manufacturing machinery, motor vehicles and their components, and electrical equipment. It includes items such as motor vehicles, construction machinery, electrical and electronic equipment, and industrial equipment, typically sourced from the USA, Canada and Trinidad and Tobago. In 2023, imports of this nature totalled US\$4.0m.

2.6.3. Results

Results presented here are the total expected impacts representing the sum of vessel-side and cargo-side cost impacts. Total expected impacts are given as changes to the amounts paid in transport costs as a proportion of traded value. Details of cost assumptions underpinning the vessel-side and cargo-side modelling can be found in Annexes I and II respectively. All scenarios modelled are on a WTW basis, with full details on the scenarios included in this analysis provided in Annex I.i.

2.6.3.1. Exports of Petroleum and Petroleum Products to Saint Martin

Table 2.23. Scenario for each policy for the years 2030, 2040, and 2050 for Petroleum and Petroleum Products exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Petroleum and Petroleum Products to Saint Martin	GFI Flex Only	1.01% - 1.01%	3.97% - 3.97%	5.10% - 5.11%
	Low Levy	1.32% - 1.33%	3.59% - 3.60%	4.91% - 4.92%
	High Levy	2.52% - 2.53%	4.47% - 4.48%	4.91% - 4.92%
	Feebate	1.45% - 1.45%	3.84% - 3.85%	5.17% - 5.17%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of petroleum and petroleum products from Antigua and Barbuda to Saint Martin by between 1.01% to 5.17% of traded value per year, ranging from 1.01% to 1.45% in 2030, 3.59% to 4.48% in 2040 and 4.91% to 5.17% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.01% to 5.11% under a flexible GFI mechanism, 1.45% to 5.17% under a feebate mechanism and by between 1.32% to 4.92% across levy scenarios.

2.6.3.2. Exports of Yachts and Other Vessels to the UK

Table 2.24. Scenario for each policy for the years 2030, 2040, and 2050 for Machinery and Transport Equipment exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Yachts and Other Vessels to the UK	GFI Flex Only	1.84% - 2.00%	7.25% - 7.41%	9.32% - 9.48%
	Low Levy	2.42% - 2.58%	6.56% - 6.72%	8.97% - 9.13%
	High Levy	4.60% - 4.76%	8.17% - 8.33%	8.97% - 9.13%
	Feebate	2.65% - 2.81%	7.02% - 7.18%	9.43% - 9.59%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of yachts and other vessels from Antigua and Barbuda to the UK by between 1.84% to 9.59% of traded value per year, ranging from 1.84% to 4.70% in 2030, 6.56% to 8.33% in 2040 and 8.97% to 9.59% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.84% to 9.48% under a flexible GFI mechanism, 2.65% to 9.59% under a feebate mechanism and by between 2.42% to 9.13% across levy scenarios.

2.6.3.3. Exports of Beverages, Spirits and Vinegar to the USA

Table 2.25. Scenario for each policy for the years 2030, 2040, and 2050 for Food and Beverages Products exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Beverages, Spirits and Vinegar to the USA	GFI Flex Only	0.43% - 0.47%	1.70% - 1.74%	2.19% - 2.23%
	Low Levy	0.57% - 0.61%	1.54% - 1.58%	2.11% - 2.15%
	High Levy	1.08% - 1.12%	1.92% - 1.96%	2.11% - 2.15%
	Feebate	0.62% - 0.66%	1.65% - 1.69%	2.21% - 2.26%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of beverages, spirits and vinegar from Antigua and Barbuda to the USA by between 0.43% to 2.26% of traded value per year, ranging from 0.43% to 1.12% in 2030, 1.54% to 1.96% in 2040 and 2.11% to 2.26% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 0.43% to 2.23% under a flexible GFI mechanism, 0.62% to 2.26% under a feebate mechanism and by between 0.57% to 2.15% across levy scenarios.

2.6.3.4. Imports of Meat and Edible Offal from the USA

Table 2.26. : Scenario for each policy for the years 2030, 2040, and 2050 for Food and Beverages Products imports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Meat and Edible Offal from the USA	GFI Flex Only	0.69% - 0.74%	2.71% - 2.76%	3.48% - 3.53%
	Low Levy	0.90% - 0.95%	2.45% - 2.50%	3.35% - 3.40%
	High Levy	1.72% - 1.77%	3.05% - 3.10%	3.35% - 3.40%
	Feebate	0.99% - 1.04%	2.62% - 2.67%	3.53% - 3.57%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of meat and edible offal from the USA to Antigua and Barbuda by between 0.69% to 3.57% of traded value per year, ranging from 0.69% to 1.77% in 2030, 2.45% to 3.10% in 2040 and 3.35% to 3.57% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 0.69% to 3.53% under a flexible GFI mechanism, 0.99% to 3.57% under a feebate mechanism and by between 0.90% to 3.40% across levy scenarios.

2.6.3.5. Imports of Mineral Fuels, Oils and Distillates from the USA

Table 2.27. Scenario for each policy for the years 2030, 2040, and 2050 for Petroleum and Petroleum Products imports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Mineral Fuels, Oils and Distillates from the USA	GFI Flex Only	1.25% - 1.36%	4.91% - 5.02%	6.32% - 6.43%
	Low Levy	1.64% - 1.75%	4.45% - 4.56%	6.08% - 6.19%
	High Levy	3.12% - 3.23%	5.54% - 5.65%	6.08% - 6.19%
	Feebate	1.79% - 1.90%	4.76% - 4.87%	6.40% - 6.51%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of mineral fuels, oils and distillates from the USA to Antigua and Barbuda by between 1.25% to 6.51% of traded value per year, ranging from 1.25% to 1.90% in 2030, 4.45% to 5.65% in 2040 and 6.08% to 6.51% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging

between 1.25% to 6.43% under a flexible GFI mechanism, 1.79% to 6.51% under a feebate mechanism and by between 1.64% to 6.19% across levy scenarios.

2.6.3.6. Imports of Vehicles from the USA

Table 2.28. Scenario for each policy for the years 2030, 2040, and 2050 for Machinery and Transport Equipment exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Vehicles from the USA	GFI Flex Only	1.58% - 1.72%	6.24% - 6.38%	8.02% - 8.16%
	Low Levy	2.08% - 2.22%	5.64% - 5.78%	7.72% - 7.86%
	High Levy	3.96% - 4.10%	7.03% - 7.17%	7.72% - 7.86%
	Feebate	2.28% - 2.42%	6.04% - 6.18%	8.12% - 8.26%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of vehicles from the USA to Antigua and Barbuda by between 1.58% to 8.26% of traded value per year, ranging from 1.58% to 4.10% in 2030, 5.64% to 7.17% in 2040 and 7.72% to 8.26% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.58% to 8.16% under a flexible GFI mechanism, 2.28% to 8.20% under a feebate mechanism and by between 2.08% to 7.86% across levy scenarios.

2.6.4. Summary of Results

Across all six commodities studied, the results of this modelling suggest:

- The total cost impacts from the implementation of midterm measures on Antigua and Barbuda's six most valuable import and export trades are projected to range from 0.43% and 9.59% of annual traded value between 2030 and 2050, depending on the policy scenario. Specifically, impacts are expected to range from 0.43% to 9.59% for exports and 0.69% to 8.26% for imports.
- Under the four policy scenarios modeled, the total cost impacts are anticipated as follows:
 - ❖ **2030:** Impacts are expected to range from 0.43% to 2.81%.
 - ❖ **2040:** Impacts are projected to range from 1.70% to 7.18%.
 - ❖ **2050:** Impacts are expected to range from 2.19% to 9.59%.
- When considering specific policy scenarios, impacts are expected to vary as follows:
 - ❖ **Under a flexible GFI scenario,** total cost impacts are projected to range between 0.43% and 9.48%.
 - ❖ **Under a feebate scenario,** impacts are projected to range from 0.62% to 9.59%.
 - ❖ **Under levy scenarios,** impacts are expected to range from 0.57% to 9.13%.

- By 2030, the highest impacts are anticipated under a high levy scenario (ranging from 1.08% to 4.76%), while the lowest impacts are expected under a flexible GFI scenario (ranging from 0.43% to 1.72%).
- By 2040, the impacts remain greatest under a high levy scenario (ranging from 1.92% to 8.33%) and least under a low levy scenario (ranging from 1.54% to 5.78%).
- By 2050, the cost impacts are expected to be broadly similar across all policy scenarios.

2.6.5. Discussion

The Model results for Antigua & Barbuda indicate that total cost impacts are projected to range from 0.43% to 9.59% of the annual traded value during the period from 2030 to 2050. Specifically, the anticipated impact on exports is assessed to be between 0.43% and 9.59%, while the effect on imports is expected to vary from 0.69% to 8.26%. This anticipated increase in the cost of traded commodities underscores the significant influence that the IMO's introduction of midterm measures will exert on shipping expenses and overall trade costs (Mastromarco & Guccio, 2017). The results indicate that the IMO's introduction of midterm measures will result in increasing impacts each decade. This observation indicates that the longer these measures are implemented, the more they will reshape trade patterns between Antigua & Barbuda and its trading partners, as shown in Tables 23, 24, and 25.

For import commodities costs are expected to peak in 2050 for Meat and Edible Offal from the United States at 3.57%, Mineral Fuels, Oils, and Distillates from the United States at 6.51%, and Vehicles from the United States at 8.26%. Overall, all categories are expected to exhibit an increase in impact over time, with the most significant effects typically observed under feebate or levy mechanisms (Alderighi et al., 2020).

The findings of the model revealed yachts and vessels exports to the United Kingdom will experience the highest percentage impacts, particularly by 2040 and 2050, ranging from 9.43% to 9.59% in 2050. In contrast, petroleum exports to Saint Martin and beverages to the United States will encounter smaller yet substantial impacts, with the greatest effects expected in 2050 for both categories. Imports of Mineral Fuels, Oils, and Distillates will experience the highest impacts, particularly by 2050, ranging from 6.40% to 6.51%. Vehicle imports will also experience significant impacts, reaching 8.12% to 8.26% in 2050, and Meat and edible offal imports will face moderate impacts, peaking between 3.53% to 3.57% in 2050.

For Antigua & Barbuda, the GFI Flexible mechanism represents the most cost-effective policy option for both exports and imports for 2030, with cost increases projected to range between 0.43% and 1.72%. The most substantial economic

impacts are anticipated under a high levy scenario, where costs are expected to persist within this range of 1.08% to 4.76%. By the year 2040, this trend is likely to continue, with the highest impacts remaining associated with the high levy scenario, which may result in cost increases ranging from 1.92% to 6.13%. In contrast, the lowest impacts are projected under a low levy scenario, with estimated costs ranging from 1.92% to 8.33%. Nonetheless, by 2050, it is anticipated that the cost impacts across all policy scenarios will converge, leading to a reduction in the differences between scenarios and resulting in more uniform impacts across the various approaches as shown in tables 23-28.

Overall, the IMO's introduction of midterm measures will likely lead to higher export costs, reducing the competitiveness of high-value exports such as petroleum products, yachts, and beverages. Hence, yacht exports could see a steep decline as shipping costs increase, while petroleum exports might face reduced market share due to higher transport prices. If yacht exports from Antigua & Barbuda become comparatively less competitive than yacht exports from other countries, or from production in the UK. The former case would only take place if the price of yacht exports from Antigua & Barbuda increases more than the price of yacht exports from other countries, which would also however be subject to the mid-term measures as shown in Table 2.24. Likewise, the cost of imports will rise significantly, particularly for essential goods like fuels and vehicles. This could increase the cost of living and affect industries reliant on imported goods. Energy-intensive industries could be particularly affected by higher fuel prices (Mastromarco & Guccio, 2017).

Antigua & Barbuda is recognized as a premier destination for cruise ships in the Caribbean, drawing thousands of tourists annually. In 2022, tourism constituted 60% of the country's Gross Domestic Product (GDP) (World Bank, 2024; UNCTAD, 2024). As is the case with other Caribbean nations, the tourism sector is instrumental in significantly contributing to GDP and facilitating job creation. Nevertheless, the implementation of midterm measures by the International Maritime Organization (IMO) presents potential challenges to the economy of Antigua & Barbuda (Scott & Becken, 2014). Increased shipping costs for both imports and exports, possible disruptions in the shipping industry, and elevated expenses associated with tourism-related goods may adversely affect the economy (Alderighi et al., 2020).

Despite these challenges, Antigua & Barbuda possesses opportunities for adaptation. By investing in green technologies, enhancing port infrastructure, and exploring new export markets, the nation can mitigate the impacts of the IMO levy. Furthermore, by fostering environmentally sustainable practices, Antigua & Barbuda can reduce its reliance on traditional fuels, thereby ensuring its maritime sector's long-term competitiveness while minimizing its environmental footprint. Such considerations are critical for the policymakers of Antigua & Barbuda.

2.7. St. Lucia

The economy of Saint Lucia is primarily driven by the tourism sector, while also featuring a modest export market. The principal categories of export commodities include agricultural products, food and beverages, as well as manufactured goods. As indicated in Table 2.32, the prominent goods produced on the island comprise agricultural products, particularly bananas, clothing and textiles, processed food and beverages, seafood, manufactured items, and minerals. Saint Lucia imports a wide range of goods essential for sustaining its economy and serving its population. The principal categories of imports encompass petroleum products, machinery, and transport equipment, manufactured goods, pharmaceuticals and chemicals, clothing and textiles, and food and agricultural products.

Table 2.29. Top export/import commodities for St. Lucia 2023

Country	Trade Direction	Commodity	Description	Key Destination	Primary Value (FOB Value\$)
St. Lucia	Export	Processed Food and Beverages	Beverages, spirits, and vinegar, process food	Saint Maarten, USA, Barbados	13,204,270.88
		Agricultural	Banana	USA, Barbados, Dominica	5,022,960.74
		Clothing and Manufactured Goods	T-shirts, singlets and other vests; knitted or crocheted	USA, United Kingdom, Barbados	264,762.32
	Import	Fuels and Petroleum Products	Petroleum oils and oils from bituminous minerals, Products	T&T, China, USA, UK	60,600,823.41
		Food and Beverage Products	Beverages, spirits, and vinegar	USA, UK, T&T	8,253,537.51
		Manufactured Goods	Electrical Machinery and Equipment	USA, Canada, China, France	25,604,221.01

2.7.1. Key Export Commodities

The top three (3) primary categories of export commodities are as follows:

1. Beverages, Spirits and Vinegar

This category encompasses a diverse array of products, including beer, rum, cocoa-based items, and vinegar. The principal export markets for these goods are predominantly situated in the Caribbean region and North America. In 2023, commodities of this nature amounted to US\$13.2m.

2. Bananas

Bananas represent the country's foremost agricultural export and are integral to its economic framework. Furthermore, the country exports a variety of agricultural products, including fruits, nuts, citrus, and melons. The primary markets for these exports are the USA, Barbados and Dominica. Commodities of this nature amounted to US\$5.0m in 2023.

3. Textiles and Clothing

Exports within this sector consist of garments and select manufactured items, such as textiles, fabrics, furniture, electronics, and various other manufactured products.

The primary export destinations for these goods are typically the USA, UK and Barbados, with commodities of this nature amounting to US\$265,000 in 2023.

2.7.2. Key Import Commodities

The top three (3) primary categories of import commodities are as follows:

1. Fuels and Petroleum Products

These products are essential for electricity generation, transportation, and domestic energy needs in Saint Lucia and include gasoline, diesel, kerosene, and liquefied petroleum gas (LPG). Trinidad and Tobago, China and the USA are the primary sources of these imports, with commodities of this nature amounting to US\$60.6m in 2023.

2. Beverages, Spirits and Vinegars

Imports of beverages, spirits and vinegars are necessary to meet domestic food demand, as local agricultural production is limited for certain items. Commodities of this nature into Saint Lucia are typically sourced from the USA, UK and Trinidad and Tobago, and in 2023 amounted for US\$8.3m.

3. Electrical Machinery and Equipment

This category supports industrial activities in Saint Lucia, with major suppliers including the USA, Canada and Trinidad and Tobago. Commodities of this nature amounted to US\$25.6m in 2023.

2.7.3. Results

Results presented here are the total expected impacts representing the sum of vessel-side and cargo-side cost impacts. Total expected impacts are given as changes to the amounts paid in transport costs as a proportion of traded value. Details of cost assumptions underpinning the vessel-side and cargo-side modelling can be found in Annexes I and II respectively. All scenarios modelled are on a WTW basis, with full details on the scenarios included in this analysis provided in Annex I.i.

2.7.3.1. Exports of Beverages, Spirits and Vinegar to Trinidad & Tobago

Table 2.30. Scenario for each policy for the years 2030, 2040, and 2050 for Processed Food and Beverages exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Beverages, Spirits and Vinegar to Trinidad and Tobago	GFI Flex Only	1.71% - 1.72%	6.74% - 6.75%	8.67% - 8.67%
	Low Levy	2.25% - 2.25%	6.10% - 6.11%	8.35% - 8.35%
	High Levy	4.28% - 4.29%	7.60% - 7.60%	8.35% - 8.35%
	Feebate	2.46% - 2.47%	6.53% - 6.53%	8.77% - 8.78%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of beverages, spirits and vinegar from Saint Lucia to Trinidad and Tobago by between 1.71% to 8.78% of traded value per year, ranging from 1.71% to 4.29% in 2030, 6.10% to 7.60% in 2040 and 8.35% to 8.78% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.71% to 8.67% under a flexible GFI mechanism, 2.46% to 8.78% under a feebate mechanism and by between 2.25% to 8.35% across levy scenarios.

2.7.3.2. Exports of Bananas to the USA

Table 2.31. Scenario for each policy for the years 2030, 2040, and 2050 for Agricultural Products exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Bananas to the USA	GFI Flex Only	1.60% - 1.66%	6.30% - 6.36%	8.10% - 8.16%
	Low Levy	2.10% - 2.16%	5.70% - 5.76%	7.80% - 7.86%
	High Levy	4.00% - 4.06%	7.10% - 7.16%	7.80% - 7.86%
	Feebate	2.30% - 2.36%	6.10% - 6.16%	8.20% - 8.26%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of bananas from Saint Lucia to the USA by between 1.60% to 8.26% of traded value per year, ranging from 1.60% to 4.06% in 2030, 5.70% to 7.16% in 2040 and 7.80% to 8.20% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.60% to 8.16% under a flexible GFI mechanism, 2.30% to 8.20% under a feebate mechanism and by between 2.10% to 7.86% across levy scenarios.

2.7.3.3. Exports of Textiles and Clothing to the USA

Table 2.32. Scenario for each policy for the years 2030, 2040, and 2050 for Clothing and Manufacturing Goods exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Exports of Textiles and Clothing to the USA	GFI Flex Only	1.84% - 1.89%	7.25% - 7.29%	9.32% - 9.36%
	Low Levy	2.42% - 2.46%	6.56% - 6.60%	8.97% - 9.02%
	High Levy	4.60% - 4.65%	8.17% - 8.21%	8.97% - 9.02%
	Feebate	2.65% - 2.69%	7.02% - 7.06%	9.43% - 9.48%

Modelling results indicate that the introduction of midterm measures may raise the cost of exports of textiles and clothing by between 1.84% to 9.48% of traded value per year, ranging from 1.84% to 4.65% in 2030, 6.56% to 8.21% in 2040 and 8.97% to 9.48% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.84% to 9.36% under a flexible GFI mechanism, 2.65% to 9.48% under a feebate mechanism and by between 2.42% to 9.02% across levy scenarios.

2.7.3.4. Imports of Fuels and Petroleum Products from Trinidad and Tobago

Table 2.33. Scenario for each policy for the years 2030, 2040, and 2050 for Fuels and Petroleum imports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Fuels and Petroleum Products from Trinidad and Tobago	GFI Flex Only	0.91% - 0.92%	3.59% - 3.60%	4.62% - 4.63%
	Low Levy	1.20% - 1.21%	3.25% - 3.26%	4.45% - 4.46%
	High Levy	2.28% - 2.29%	4.05% - 4.06%	4.45% - 4.46%
	Feebate	1.31% - 1.32%	3.48% - 3.49%	4.67% - 4.69%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of fuels and petroleum products from Trinidad and Tobago to Saint Lucia by between 0.91% to 4.69% of traded value per year, ranging from 0.91% to 2.29% in 2030, 3.25% to 4.06% in 2040 and 4.45% to 4.69% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 0.91% to 4.63% under a flexible GFI mechanism, 1.31% to 4.69% under a feebate mechanism and by between 1.20% to 4.46% across levy scenarios.

2.7.3.5. Imports of Beverages from Trinidad and Tobago

Table 2.34. Scenario for each policy for the years 2030, 2040, and 2050 for Food and Beverage Products exports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Beverages from Trinidad and Tobago	GFI Flex Only	1.60% - 1.61%	6.30% - 6.31%	8.10% - 8.11%
	Low Levy	2.10% - 2.11%	5.70% - 5.71%	7.80% - 7.81%
	High Levy	4.00% - 4.01%	7.10% - 7.11%	7.80% - 7.81%
	Feebate	2.30% - 2.31%	6.10% - 6.11%	8.20% - 8.21%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of beverages from Trinidad and Tobago to Saint Lucia by between 1.60% to 8.21% of traded value per year, ranging from 1.60% to 4.01% in 2030, 5.70% to 7.11% in 2040 and 7.80% to 8.21% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 1.60% to 8.11% under a flexible GFI mechanism, 2.30% to 8.21% under a feebate mechanism and by between 2.10% to 7.81% across levy scenarios.

2.7.3.6. Imports of Electrical Machinery and Equipment from the USA

Table 2.35. Scenario for each policy for the years 2030, 2040, and 2050 for Machinery and Transport Equipment imports, across 0-30% speed reduction scenarios.

Commodity	Scenario	2030	2040	2050
Imports of Electrical Machinery and Equipment from the USA	GFI Flex Only	5.10% - 5.17%	20.10% - 20.16%	25.84% - 25.90%
	Low Levy	6.70% - 6.76%	18.18% - 18.25%	24.88% - 24.94%
	High Levy	12.76% - 12.82%	22.65% - 22.71%	24.88% - 24.94%
	Feebate	7.34% - 7.40%	19.46% - 19.52%	26.16% - 26.22%

Modelling results indicate that the introduction of midterm measures may raise the cost of imports of Electrical Machinery and equipment from the USA to Saint Lucia by between 5.10% to 26.22% of traded value per year, ranging from 5.10% to

12.82% in 2030, 18.18% to 22.71% in 2040 and 24.88% to 26.22% in 2050. Impacts are expected to vary depending on the final basket of midterm measures, ranging between 5.10% to 25.90% under a flexible GFI mechanism, 7.34% to 26.22% under a feebate mechanism and by between 6.70% to 24.94% across levy scenarios.

2.7.4. Summary of Results

Across all six commodities studied, the results of this modelling suggest:

- The total cost impacts from the implementation of midterm measures on Saint Lucia's six most valuable import and export trades are projected to range from 0.91% and 26.22% of annual traded value between 2030 and 2050, depending on the policy scenario. Specifically, impacts are expected to range from 1.60% to 9.48% for exports and 0.91% to 26.22% for imports.
- Under the four policy scenarios modelled, the total cost impacts are anticipated as follows:
 - ❖ **2030:** Impacts are expected to range from 0.91% to 7.40%.
 - ❖ **2040:** Impacts are projected to range from 3.59% to 19.52%.
 - ❖ **2050:** Impacts are expected to range from 8.10% to 26.22%
- When considering specific policy scenarios, impacts are expected to vary as follows:
 - ❖ **Under a flexible GFI scenario,** total cost impacts are projected to range between 0.91% and 25.90%.
 - ❖ **Under a feebate scenario,** impacts are projected to range from 1.31% to 26.22%.
 - ❖ **Under levy scenarios,** impacts are expected to range from 1.20% to 24.9%.
- By 2030, the highest impacts are anticipated under a high levy scenario (ranging from 2.28% to 12.82%), while the lowest impacts are expected under a flexible GFI scenario (ranging from 0.91% to 5.71%).
- By 2040, the impacts remain greatest under a high levy scenario (ranging from 4.05% to 22.71%) and least under a low levy scenario (ranging from 3.82% to 18.25%).
- By 2050, impacts are expected to be broadly similar regardless of policy scenario.

2.7.5. Discussion

Modelling results for Saint Lucia indicate that the overall cost impact of the IMO's introduction of midterm measures will range from 0.91% to 26.22% of the annual traded value for both exports and imports of commodities between 2030 to 2050. Specifically, for exports, the range is between 1.60% to 9.48%, and for imports, the range is from 0.91% to 26.22%.

For export commodities of Beverage, Spirit and Vinegar to Trinidad and Tobago, Bananas to the USA and Textiles and Clothing to the USA. For the years 2030, 2040 and 2050, the impact ranges from 1.71% to 8.78%, 1.60% to 8.26% and 1.84% to 9.48% of traded value per year as outlined in Tables 30, 31, and 32. For imports commodities of Fuel and Petroleum products from Trinidad and Tobago, Cereals from Trinidad and Tobago, and Manufactured Goods from the USA; the impact ranges from 0.91% to 4.69%, 1.60% to 8.21% and 5.10% to 26.22% as outlined in Tables 33, 34, and 35. Overall, the model revealed that for exports, that of all categories of goods, the impacts of the midterm measures are expected to increase over time (from 2030 to 2050), with the most significant effects occurring by 2050. In addition, all categories show a gradual increase in impacts over time, with the highest effects typically observed under feebate or levy mechanisms.

Increased shipping costs could make Saint Lucia's products less competitive in international markets, particularly for price-sensitive items like bananas or textiles. This could potentially reduce the volume of exports, as foreign buyers might look for cheaper alternatives (Alderighi et al., 2020). The IMO's introduction of midterm measures, which targets carbon emissions from shipping, would likely lead to higher shipping costs for Saint Lucia's exports. As shipping is a critical mode of transport for goods like beverages, spirits, textiles, bananas, and other products, these increased costs could make Saint Lucia's products less competitive on the global market. For example, bananas (a perishable product) could see a reduction in demand, particularly in markets like the USA, if the added shipping costs make them more expensive compared to competitors like those from Ecuador or Costa Rica (Mastromarco & Guccio, 2017). Just as exports are affected, imports to Saint Lucia will also become more expensive due to the IMO's introduction of midterm measures. Saint Lucia imports a variety of goods, including fuel, machinery, cereals, and electronics, from countries like Trinidad and Tobago and the USA. The IMO's introduction of mid-term measures is expected to increase both export and import costs for Saint Lucia due to higher shipping costs (Scott & Becken, 2014). Imports of fuels, machinery, and bulk goods are likely to rise in price, putting pressure on Saint Lucia's trade balance and domestic prices (Dominioni et al., 2023).

The International Maritime Organization (IMO) levy is anticipated to have a variety of economic repercussions for Saint Lucia, an island nation that is significantly dependent on maritime trade and tourism. In 2022, the services sector constituted approximately 74.11% of the nation's Gross Domestic Product (GDP), with tourism accounting for around 65% of GDP during the same year (World Bank, 2024). This trend is reflective of broader economic patterns observed in many Caribbean nations, including those within the CARICOM framework, suggesting that the IMO levy may exert considerable influence on Saint Lucia's economy (Scott & Becken, 2014). Saint Lucia imports a diverse array of commodities, from fuel to food products. The implementation of the IMO levy is likely to result in increased

operational costs for shipping companies, costs that may subsequently be transmitted to consumers through heightened prices for imported goods as shown in Tables 33, 34, and 35.

This scenario poses particular challenges for essential commodities that the island imports in significant volumes. Furthermore, the levy is expected to directly affect fuel prices, thereby influencing both the operational costs for shipping entities and the utility rates within the local economy, ultimately leading to an escalation in prices for basic goods and services (UNCTAD, 2021). However, the IMO's introduction of mid-term measures has the potential to serve as a catalyst for Saint Lucia to invest in environmentally sustainable shipping practices, greener ports, establishment of sustainable infrastructure necessary for facilitating green shipping, and to explore more sustainable transportation options (Smith et al., 2024).

2.8. Conclusion

Key findings from this research include that:

1. Negative Impacts Across All Commodity Flows:

- The research indicates that negative impacts are expected for all 30 modelled commodity flows, regardless of the policy frameworks or future years considered.
- Impacts relative to a Business As Usual (BAU) scenario are predicted to increase over time across all policy architectures, meaning that over the years, the detrimental effects will likely grow as the IMO midterm measures are implemented.

2. Diverging Impacts in the Short-Term (2030) vs. Long-Term (2050):

- 2030: There is a high likelihood of greater impacts in a scenario with a high levy compared to scenarios involving a GFI Flex Only or Feebate mechanisms. However, it is important to note that the study does not account for the redistribution of the revenue raised under levy scenarios, which could potentially offset some of the negative impacts.
- 2040 and 2050: The impacts across different policy architectures are expected to align by 2050, suggesting that, over the long term, all policy frameworks might produce similar results. However, significant divergence is anticipated in the 2030s and especially in 2040, where policy variations will lead to considerable differences in outcomes.

3. Greater Impacts for Smaller, Less Integrated Caribbean Countries:

- The Caribbean region is particularly vulnerable due to its reliance on shipping for trade and tourism. The study highlights that smaller Caribbean countries, like Saint Lucia and Antigua and Barbuda, which are less integrated into the global transport network, will likely face greater impacts from the levy.
- These impacts are particularly noticeable where transport costs make up a larger proportion of final prices. Countries with higher ad-valorem freight rates will be more sensitive to increased shipping costs due to the levy.

4. Impact on Imports and Exports:

- **Imports:** For essential commodities like food and agricultural products, which typically have higher transport costs as a proportion of total costs, the IMO levy could exacerbate the financial burden on both businesses and consumers. These goods may become more expensive as shipping costs rise, affecting the cost of living in the Caribbean.
- **Exports:** For Caribbean economies reliant on export trades (e.g., agricultural products and manufactured goods), higher shipping costs could make their exports uncompetitive in international markets, leading to a decline in trade and potential economic losses in the long run.

5. Negative Impact on Caribbean Economies (Jamaica, Trinidad and Tobago, Barbados, Antigua and Barbuda, Saint Lucia):

- The midterm measures of the IMO levy, including carbon taxes or emissions pricing, are expected to have significant detrimental effects on the economies of the Caribbean, particularly for the CARICOM countries of Jamaica, Trinidad and Tobago, Barbados, Antigua and Barbuda, and Saint Lucia.
- These economies are particularly vulnerable in terms of shipping costs, tourism, and trade, all of which are critical to their economic stability and growth.

6. Potential for Mitigation Strategies:

- **Green Shipping Initiatives:** A levy-based mechanism offers the Caribbean the opportunity to position itself as a leader in sustainable maritime practices. By investing in green technologies, such as alternative fuels, energy-efficient shipping, and eco-friendly infrastructure at ports, a levy would enable Caribbean states to mitigate some of the negative impacts of the midterm measures.
- **Regional Collaboration:** Working together regionally to implement shared green technologies and develop sustainable maritime policies can help reduce the impact of the midterm measures. By collaborating on investments in renewable energy and clean shipping technologies, the Caribbean can strengthen its position in global maritime trade while also reducing the environmental footprint of the industry.

The implementation of the International Maritime Organization's (IMO) midterm measures will result in both positive and negative consequences for Caribbean states, particularly concerning shipping costs, tourism, and trade. The midterm measures are anticipated to raise costs associated with imported goods, diminish the competitiveness of exports, and potentially influence cruise tourism adversely. Nonetheless, a levy-based architecture presents a significant opportunity for the region to take a leadership role in sustainable maritime practices. By embracing green shipping technologies, investing in environmentally friendly infrastructure, and fostering regional collaboration, Caribbean nations can effectively adapt to the introduction of midterm measures, thereby promoting long-term economic resilience and environmental sustainability. These findings bear considerable implications for governments, maritime stakeholders, economists, professionals, policymakers, and investors.

2.8.1. Short-Term and Long-Term Impacts

2.8.1.1. Short-Term Impacts (2030)

In the short term, the IMO levy is expected to impose varying degrees of economic strain on Caribbean economies, particularly on export and import activities. Countries such as Jamaica, Trinidad & Tobago, Barbados, Antigua & Barbuda, and St. Lucia will be affected as shown in Figure 1.1. Under the high levy scenario, substantial cost increases for imports and exports are anticipated across these nations. Specifically:

Jamaica: The impacts under the high levy scenario range from 2.36% to 6.88%. The bauxite industry will experience the greatest impact, with costs increasing between 2.54% and 6.43%. The vehicle imports will also face significant increases in import costs, ranging from 2.61% to 6.88%. In contrast, the GFI Flex Only scenario presents lower impacts, ranging from 0.94% to 2.97%.

Trinidad & Tobago: Under the high levy scenario, the impacts range from 1.60% to 8.03%. The export of Natural Gas to the USA will encounter the most significant effects between 2.08% to 5.30%, while imports of Machinery from the USA will see the highest impact, of the three import commodities ranging from 3.18% to 8.03%. Again, the GFI Flex Only scenario shows lower impacts, ranging from 0.70% to 3.26%.

Barbados: The high levy scenario indicates an impact of 2.20% to 6.04%. Exports, particularly Animals, Vegetable fats and oils to T&T, will face the highest impacts among three export commodities between 0.99% to 2.49%. Conversely, imports, specially manufactured goods (Machinery, boiler etc), will be most affected, ranging from 3.44% to 8.68%. The GFI Flex Only scenario ranges from 0.83% to 3.52%.

Antigua & Barbuda: The high levy impact ranges from 1.08% to 4.76%. Machinery and transport equipment (e.g., yachts and other vessels) will bear the highest impact on exports ranging from 1.84% to 4.76%, while Mineral fuels, oil and distillates from

the USA will face the highest import impacts ranging from 1.25% to 3.23%. Under the GFI Flex Only scenario, impacts are lower, ranging from 0.43% to 2.00%.

St. Lucia: The high levy scenario will have a significant impact, ranging from 2.28% to 12.82%. Exports like clothing and manufactured goods will be most affected (1.84% to 4.65%), while Electrical machinery and equipment imports from the USA will have the greatest impact among the 3 import commodities, ranging from 5.10% to 12.82%. The GFI Flex Only scenario, while still impactful, will result in lower increases, ranging from 0.91% to 5.17%.

Short-term cost increases are anticipated to have a significant impact on the prices of 30 commodities exchanged among Caricom nations and their principal trading partners, including the United States, Europe, and regional markets. The escalation of shipping costs may create challenges for sectors such as tourism, petroleum, manufacturing, mining, and agriculture, potentially resulting in higher consumer prices and diminished export demand (Mastromarco & Guccio, 2017). Analysis of the GFI Flex scenarios indicates that the increase in transportation costs by 2030 will be the least pronounced in comparison to the Feebate, Low Levy, and High Levy scenarios. However, by 2050, the High and Low Levy scenarios are projected to exhibit the least long-term effect, with minimal variation relative to the GFI Flex Only and Feebate scenarios.

2.8.1.2. Long-Term Impacts (2040 and 2050)

Looking ahead to 2040 and 2050, the long-term effects of the IMO levy are anticipated to become more significant across all policy scenarios. Projected cost increases for Caribbean exports and imports range from 1.54% to 26.22%, imposing substantial financial burdens on key sectors such as tourism, manufacturing, mining, and agriculture, which significantly depend on global trade (UNCTAD, 2023).

By 2040, the low levy scenario shows impacts ranging from 1.54% to 15.60%, which are more manageable compared to High Levy, GFI Flex only, and Feebate policy scenarios. However, DNV (2024) states that a low levy policy won't sufficiently address the economic and climate challenges of Small Island Developing States (SIDS). Rising food import costs due to IMO's midterm measures could worsen food insecurity (DNV, 2024).

By 2050, the cost impacts across all policy scenarios are expected to converge. The differences between high, low, and flexible levy scenarios will likely diminish as industries adjust to the new regulatory environment (Scott & Becken, 2014). This convergence suggests that, over the long term, Caribbean nations may experience stabilization of trade costs as they adapt to the long-term impacts of the IMO levy (IMO, 2024). The ability to mitigate financial burdens will depend on how quickly businesses and governments can implement adaptive strategies such as improving fuel efficiency, enhancing infrastructure, and exploring alternative trade solutions (Dominioni et al., 2023).

While the IMO levy presents significant short-term challenges for Caricom economies, particularly for sectors reliant on imports and exports, with proper strategic adjustments and long-term planning, the region can stabilize its trade costs by 2050. This approach will ensure continued competitiveness in the global market while minimizing economic burdens (Smith et al., 2024).

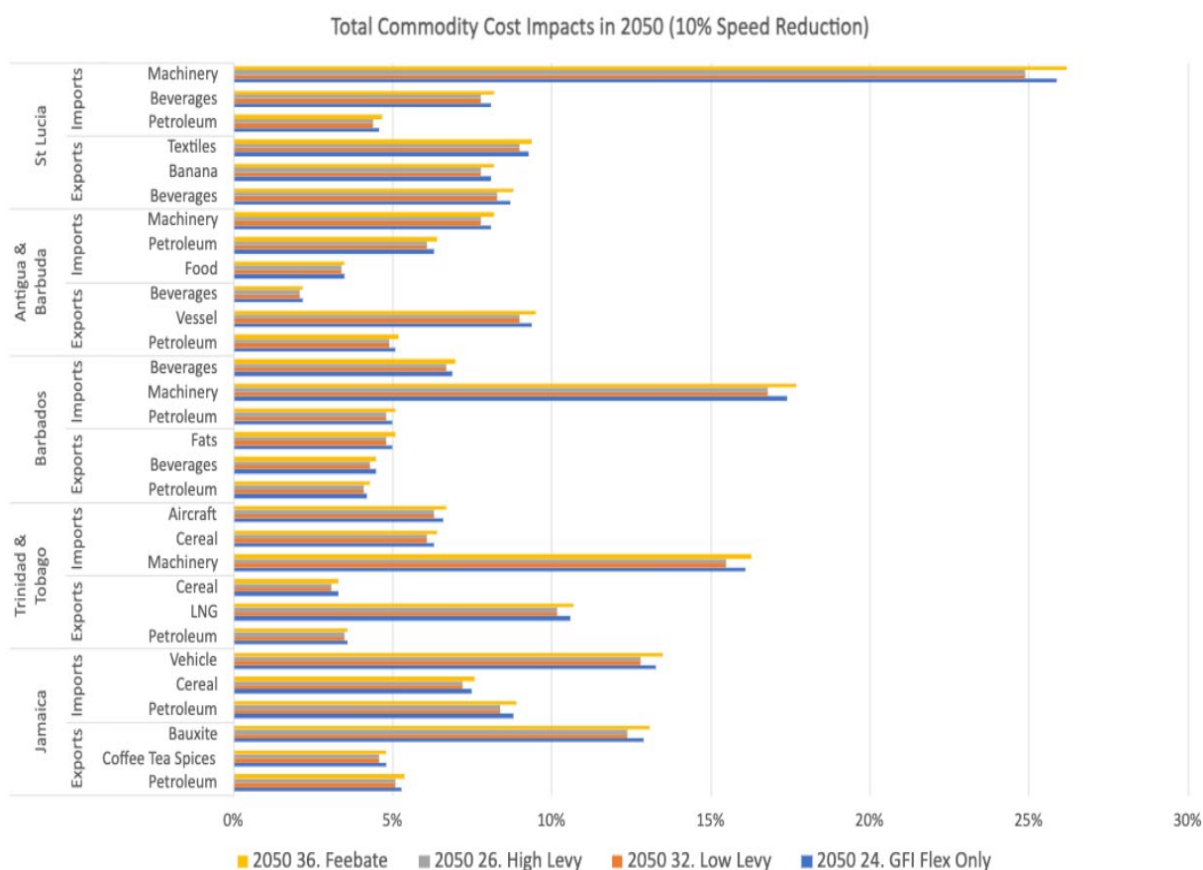


Figure 2.1. Summary of Total Impacts Across all 30 modelled commodities.

2.8.2. Impact on CARICOM Economies

The IMO’s introduction of midterm measures is likely to negatively affect CARICOM countries more significantly due to their existing high transport costs and heavy reliance on tourism which accounts for a significant portion of GDP in many CARICOM countries (Smith et al., 2022). As smaller, less integrated economies within the global shipping network, CARICOM nations often face substantial transport costs relative to the value of their traded goods. For example, CARICOM countries such as Antigua & Barbuda, Barbados, Jamaica, and St. Lucia have historically been exposed to higher transport cost rates, which make their exports less competitive and imports more expensive. The introduction of midterm measures will only amplify this existing vulnerability, with the increased shipping costs disproportionately affecting lower-value goods, such as food and agricultural

products, which already account for a large portion of trade in the region (Mastromarco & Guccio, 2017).

In particular, the modeling suggests that essential goods and agricultural products comprise a significant portion of CARICOM exports and will see greater price increases (OECD, 2024). As these products often have relatively low intrinsic value, the increase in transport costs will constitute a higher proportion of the final price, making them less competitive in global markets. Additionally, imports of these products will become more expensive for domestic consumers, contributing to inflationary pressure and potentially exacerbating regional food insecurity (DNV, 2024b; Smith et al., 2024; FAO, 2021). Conversely, export commodities like Jamaica's Bauxite and Alumina, which rely heavily on global transport systems, could face reduced market share due to the rising transport costs. These mercantile goods may become less competitive due to higher shipping prices, harming export volumes and tourism (Koenig et al., 2021).

2.8.3. Impact on Specific Commodities

The IMO's introduction of midterm measures is expected to have differentiated impacts depending on the nature of the commodity type in question. Commodities that are less valuable, such as food products and essential goods, tend to have higher transport cost rates as a proportion of their total price. This will make the cost impact of the midterm measures greater for these products. The increased transport costs are likely to result in higher prices for imported goods, further straining the purchasing power of local consumers. This is a significant concern for CARICOM countries that rely on imports for essential goods like Cereal (wheat, corn, rice), Agricultural products, and Petroleum products. The levy will increase these costs, potentially leading to higher energy prices and increasing operational costs for industries that depend on imported machinery, manufactured goods, and land transportation.

On the other hand, higher-value mercantile commodities where transport costs represent a smaller proportion of overall prices paid exhibit greater resistance to midterm measures impact as the proportion of the transport costs relative to total price is comparatively smaller. Nonetheless, these commodities will still be subject to negative impacts and may encounter challenges with competitiveness in international markets in particular. This scenario could adversely affect the overall trade performance of the region, as industries reliant on bulk exports may become less competitive on a global scale, potentially resulting in increased unemployment and a decline in economic performance.

2.8.4. Redistributed Revenue and Policy Considerations

One important factor not accounted for in the modelling is the potential impact of redistributed revenues generated under low and high levy scenarios. If the revenue

raised from a levy is redistributed to support sectors adversely affected by the increased shipping costs, this could potentially mitigate some of the negative impacts of the levy. Such redistribution could be directed towards the most vulnerable industries or invested in developing green technologies to reduce the long-term costs associated with shipping. However, the absence of this factor in the modelling means that the full scope of the levy's effects remains uncertain, as the redistribution of funds could alleviate some of the economic burdens placed on countries in the sample. The reader is instead pointed towards the Section 3 analysis for a more detailed understanding of the impacts of levy revenues on mitigating midterm measures impact.

The IMO's introduction of midterm measures is expected to result in substantial cost impacts for exports and imports across all CARICOM countries included in this research, with smaller economies in particular exhibiting greater vulnerability due to their higher transport costs. In the short term, high levy scenarios will lead to the most significant impacts, particularly for perishable goods like Cereal (Wheat, Rice, Maize), bananas, agricultural products, and essential imports such as Petroleum, Manufactured goods, and machinery, and transport. However, by 2040 and 2050 in particular, impacts across policy architectures relative to a BAU scenario are likely to align. The redistribution of levy revenues could potentially offset some of the negative impact, for example through investment into green shipping technologies, however these effects have been unable to be included in the modelling presented as part of this research. Ultimately, while the IMO levy will introduce higher costs in the short term, it may also contribute to long-term sustainability in global trade if countries can adapt effectively.

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ANNEX I - VESSEL-SIDE COST ASSUMPTIONS AND IMPACTS

AI.i. DNV Task 2 Cost Intensities

Table 2.AI.1. DNV Task 2 Cost Intensities

Scenario ID	Scenario Desc.	Traj.	Trade Growth	Policy Combination						Cost Intensity		
				GFI Flex			Levy		Feebate	2030	2040	2050
				Scope	RU% of price	SU% of price	Levy, USD/tCO ₂ eq	Reward, % of cost gap	Reward, % of cost gap			
BAULG	BAU	Base	Low	None	None	None	None	None	None	1.00	1.00	1.00
24	GFI Flex Only	Base	Low	WtW	120%	80%	No Levy	No Levy	No Feebate	1.16	1.63	1.81
32	Low Levy	Base	Low	WtW	120%	80%	30-120	105% to 2040	No Feebate	1.21	1.57	1.78
26	High Levy	Base	Low	WtW	No flexibility		150-300	90 to 60% to 2040	No Feebate	1.40	1.71	1.78
36	Feebate	Base	Low	WtW	120%	80%	No Levy	No Levy.	105% to 2040	1.23	1.61	1.82

Task 2 cost intensities were sourced from DNV’s draft final report (DNV, 2024a). Four scenarios were considered representing each of the three main policy architectures being considered for adoption at the IMO. The cost intensities presented here are aggregated across all vessel types and size groups. Detailed cost intensity changes were not able to be introduced to the modelling in time, however an informal comparison of results derived using aggregated versus specific Task 2 cost intensities revealed broadly the same trends between alternative sets of results were.

AI.ii. Ad-valorem Transport Cost Rates

Transport cost rates (referred to as ‘Ad-Valorem Freight Rate, %’) are used to express typical costs paid for transportation of a good as a proportion (or percentage) of the trade’s value. These rates were sourced from UNCTAD’s Trade-and-Transport database (UNCTAD, 2024b) and are presented below for each of the 6 commodities selected for analysis across all 5 Caribbean countries.

Attempts are made to map the most specific freight rate as possible to the individual commodity flow, however where this isn’t possible, the commodity description has been broadened until a suitable rate is found. Ad-valorem transport costs recorded in the database across similar trade flows are also presented for reference. Observed values are denoted below with an asterisk (*), the value is categorised as ‘experimental’ in the database rather than ‘observed’ and is therefore an estimate based on the methodology described in (UNCTAD, 2022).

Table 2.AI.2. Ad-valorem Transport Cost Rate for 5 Caricom Countries

Country	Origin	Destination	HS	Product	Mode	Year	Value, FOE	Transport Cost	Ad-val. FR
Jamaica	Jamaica	USA	2709	Petroleum oils and oils from bituminous minerals, not crude	Sea	2021	94357786	6152902	6.50%
	Jamaica	USA	9	Coffee, tea, mate and spices	Sea	2021	9448570	558,663	5.90%
	Jamaica	USA	2606	Aluminium ores and concentrates	Sea	2021	694549	110185	15.90%
	USA	Jamaica	27	Mineral fuels, mineral oils and products of their distillation; bitumin	Sea	2021	607739000	65442154	10.80%
	USA	Jamaica	10	Cereals	Sea	2021	71856813	6583365	9.20%
	Japan	Jamaica	8703	Motor cars and other vehicles; principally designed for the transport	Sea	2021	87371523	14275537	16.30%
Trinidad & Tobago	Trinidad & Tobago	USA	2709	Petroleum oils and oils from bituminous minerals, not crude	Sea	2021	912766303	40086725	4.40%
	Trinidad & Tobago	USA	2711	Petroleum gases and other gaseous hydrocarbons	Sea	2021	683975755	89256095	13.00%
	Trinidad & Tobago	Jamaica	10	Cereals	Sea	2021	2631	107	4.00%
	USA	Trinidad & Tobago	84	Nuclear reactors, boilers, machinery and mechanical appliances; p	Sea	2021	274943524	54665080	19.90%
	USA	Trinidad & Tobago	10	Cereals	Sea	2021	57490031	4483099	7.80%
	USA	Trinidad & Tobago	87	Vehicles; other than railway or tramway rolling stock, and parts anc	Sea	2021	17572565	1419022	8.10%
Barbados	Barbados	Jamaica	2709	Petroleum oils and oils from bituminous minerals, not crude	Sea	2021	9277444	478378	5.20%
	Barbados	USA	22	Beverages, spirits, and vinegar	Sea	2021	17606586	971534	5.50%
	Barbados	Trinidad & Tobago	15	Animal, vegetable or microbial fats and oils and their cleavage prod	Sea	2021	4534938	279983	6.20%
	Trinidad & Tobago	Barbados	27	Mineral fuels, mineral oils and products of their distillation; bitumin	Sea	2021	112242429	6909407	6.20%
	USA	Barbados	84	Nuclear reactors, boilers, machinery and mechanical appliances; p	Sea	2021	77706265	17743936	21.50%
	Trinidad & Tobago	Barbados	22	Beverages, spirits, and vinegar	Sea	2021	8976134	767336	8.50%
Antigua & Barbuda	Antigua & Barbuda	Caribbean	27	Mineral fuels, mineral oils and products of their distillation; bitumin	Sea	2021	46874182	2971413	6.30%
	Caribbean	Europe	89	Ships, boats and floating structures	Sea	2021	1.898E+09	218218326	11.50%
	Antigua & Barbuda	USA	22	Beverages, spirits, and vinegar	Sea	2020	37665	1021	2.70%
	USA	Antigua & Barbuda	2	Meat and edible offal	Sea	2021	10149068	434291	4.30%
	USA	Antigua & Barbuda	27	Mineral fuels, mineral oils and products of their distillation; bitumin	Sea	2021	5345783	416671	7.80%
	USA	Antigua & Barbuda	8703	Motor cars and other vehicles; principally designed for the transport	Sea	2021	3828514	377188	9.90%
Saint Lucia	Saint Lucia	Trinidad & Tobago	22	Beverages, spirits, and vinegar	Sea	2021	3085515	330414	10.70%
	Caribbean	USA	803	Bananas, including plantains; fresh or dried	Sea	2021	1407754	140682	10.00%
	Caribbean	USA	61	Apparel and clothing accessories; knitted or crocheted	Sea	2021	463839256	53190300	11.50%
	Trinidad & Tobago	Saint Lucia	2709	Petroleum oils and oils from bituminous minerals, not crude	Sea	2021	28682467	1646793	5.70%
	Trinidad & Tobago	Saint Lucia	22	Beverages, spirits, and vinegar	Sea	2021	2197458	219543	10.00%
	USA	Saint Lucia	85	Electrical machinery and equipment and parts thereof, sound recor	Sea	2021	8826793	2816551	31.90%

ANNEX II - CARGO-SIDE COST ASSUMPTIONS

All.i Route and Vessel Assumptions

The website 'vesselfinder.com' was utilized to determine the common routes for each of the six (6) commodity flows outlined in Sections 1.2 and 1.3. The distances between the identified ports were subsequently calculated using the sea-distances.org website. The tables below outline the vessels and routes designated to facilitate each of the six identified commodity flows. Details were first research for all relevant vessel classes and routes, with the most prominent vessel class and route pair assumed to facilitate the entirety of each trade, details of which are presented below.

Table 2. All.1 Jamaica – Fleet characteristics, by case study

	Category	Commodity	Vessel Type	Avg. Build	Route Distance, nm	Average Speed, knots
Jamaica	Export to USA	Mineral fuels, oils, distillation products	Tanker 5,000 - 10,000 DWT	2014	1,249	12.9
	Export to USA	Coffee Tea and Spices	Container 1,000-3000 TEU	2017	747	21.1
	Export to USA	Bauxite and Alumina	Bulk Carrier 60,000- 80,000 DWT	2013	1,138	14.1
	Import from USA	Mineral fuels, oils, distillation products	Tanker 5,000 - 10,000 DWT	2009	1,299	11.1
	Import from USA	Maize, Wheat and Rice	Bulk Carrier 10,000 - 40,000 DWT	2003	1,155	14.3
	Import from Japan	Vehicle	Vehicle Carrier: 3000 - 4000	2008	8,281	19.0

Table 2.All.2 Trinidad and Tobago – Fleet characteristics, by case study

	Category	Commodity	Vessel Type	Avg. Build	Route Distance, nm	Average Speed, knots
Trinidad & Tobago	Export to USA	Mineral fuels, oils, distillation products	Tanker 5,000 - 10,000 DWT	2013	2,195	12.1
	Export to USA	Fuel (LNG)	LNG Carrier 150,000-180,000	2020	2,185	19.0
	Export to Jamaica	Cereal, flour, starch, milk preparation and products	Bulk Carrier 60,000- 80,000 DWT	2013	1,296	14.4
	Import from USA	Machinery, nuclear reactors, boilers	Container 3,000-5000 TEU	Multiple	2,065	23.1
	Import from USA	Cereals (Corn, Wheat, Rice)	Bulk Carrier 60,000 - 99,999 DWT	Multiple	2,065	14.4
	Import from USA	Aircraft, spacecraft and parts	Container 1,000-3000 TEU	2010	1,456	23.1

Table 2.All.3 Barbados – Fleet characteristics, by case study

	Category	Commodity	Vessel Type	Avg. Build	Route Distance, nm	Average Speed, knots
Barbados	Export to Jamaica	Petroleum and Petroleum Products	Tanker 10,000 - 24,999 DWT	2008	1,045	12.9
	Export to USA	Rum and Alcoholic Beverage	Container 1,000-3000 TEU	2018	1,825	21.1
	Export to T-and-T	Food and Agricultural Products	General Cargo 10,000- 40,000 DWT	2010	203	15.0
	Import from T-and-T	Fuels and Petroleum Products	Tanker 10,000 - 24,999 DWT	2008	203	14.8
	Import from USA	Manufactured Goods	Container 1,000-3000 TEU	2009	2,045	21.1
	Import from T-and-T	Food and Agricultural Products	Container 1,000-3000 TEU	2010	203	21.1

Table 2.All.4. Antigua and Barbuda – Fleet characteristics, by case study

	Category	Commodity	Vessel Type	Avg. Build	Route Distance, nm	Average Speed, knots
Antigua & Barbuda	Export to Saint Martin	Petroleum Products (Re-Export)	Tanker 10,000 - 24,999 DWT	2010	90	14.8
	Export to UK	Machinery and Transport Equipment	Vessel Carrier 1,000-3000 TEU	2018	3,394	17.3
	Export to USA	Food and Beverages Products	Container 1,000-3000 TEU	2010	1,174	23.1
	Import from USA	Food and Beverage Products	Refrigerated Cargo 5,000 - 10,000 DWT	2002	1,174	20.2
	Import from USA	Fuels and Petroleum Products	Tanker 10,000 - 24,999 DWT	2010	1,889	14.8
	Import from USA	Machinery and Transport Equipment	Vehicle Carrier : 1000- 3000	2010	1,889	11.2

Table 2.All.5 Saint Lucia – Fleet characteristics, by case study

	Category	Commodity	Vessel Type	Avg. Build	Route Distance, nm	Average Speed, knots
St. Lucia	Export to T-and-T	Beverages, spirits, and vinegar	Container 1,000-3000 TEU	2010	222	23.1
	Export to USA	Banana	Vessel Carrier 1,000-3000 TEU	2018	1,744	23.1
	Export to USA	Textiles and Clothing	Container 1,000-3000 TEU	2010	1,322	23.1
	Import from T-and-T	Fuels and Petroleum Products	Tanker 10,000 - 24,999 DWT	2005	222	14.9
	Import from T-and-T	Beverages, spirits, and vinegar	Container 1,000-3000 TEU	2006	222	23.1
	Import from USA	Machinery and Transport Equipment	Container 1,000-3000 TEU	2010	1,744	23.1

ANNEX III - JUSTIFICATION OF METHODOLOGY

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

AIII.i Official CIA Task 4 Methodology

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

Commodity, Route and Vessel Selection

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

Vessel-side Cost Calculations

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

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

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

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

Cargo-side Cost Calculations

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

1. **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. **Value_{Trade, CIF}** - Annually traded value of the commodity associated with the specific route. Unit: US\$.
3. **C_{int}** - 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. **C_{dep}** - 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. **C_{ins}** - 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 (Starcrest, 2019) demonstrates that cargo-side cost per day of delay is evaluated in alignment with Equation O2a below.

$$\text{Commodity-side Task 4 TCCIsr Change, \% (daily)} = \text{Delay}_{10|20|30} * \text{Value}_{\text{Trade, CIF}} * (\text{C}_{\text{int}} + \text{C}_{\text{dep}} + \text{C}_{\text{ins}}) / 365.25 \quad [\text{O2a}]$$

Multiplication of Equation O2a by the projected time delay (in days), Delay_{10|20|30}, results in Equations O2b and O2c representing the total expected cargo-side cost change.

$$\text{Commodity-side Task 4 TCCIsr Change, \% (total)} = \text{Delay}_{10|20|30} * \text{Commodity-side Task 4 TCCIsr Change, \% (daily)} \quad [\text{O2b}]$$

$$\text{Commodity-side Task 4 TCCIsr Change, \% (total)} = (\text{Delay}_{10|20|30})^2 * \text{Value}_{\text{Trade, CIF}} * (\text{C}_{\text{int}} + \text{C}_{\text{dep}} + \text{C}_{\text{ins}}) / 365.25 \quad [\text{O2c}]$$

Total Cost Calculation

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

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

$$\begin{aligned} & \textit{Total Expected Cost Intensity Change, TCCI} = \\ & \textit{Ship-side Task 2 Freight-Rate Adjusted Commodity Cost Intensity (FRACCI)} + \\ & \textit{Commodity-side Task 4 TCCI}_{sr} \textit{ Change, \% (total)} \quad [O3] \end{aligned}$$

AIII.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.

$$\begin{aligned} & \textit{Ship-side Task 2 Freight-Rate Adjusted Commodity Cost Intensity (FRACCI)} = \\ & \textit{Ship-side Task 2 CI Change, \%} \times \textit{Ad-valorem Freight Rate, \%} \quad [U1] \end{aligned}$$

Cargo-side Cost Calculations

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

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. **Value_{Trade, CIF}** - Annually traded value of the commodity associated with the specific route. Unit: US\$.
3. **C_{int}** - 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. **C_{dep}** - 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. **C_{ins}** - Cost of insurance, as a percentage of cargo value per day of delay. A value of 2% is typically assumed. Unit: Per day.

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

$$\text{Commodity-side Task 4 TCCIsr Change, \% (daily)} = \text{Value}_{\text{Trade, CIF}} * (\text{C}_{\text{int}} + \text{C}_{\text{dep}} + \text{C}_{\text{ins}}) / 365.25 \quad [\text{U2a}]$$

Multiplication of Equation U2a by the projected time delay (in days), Delay_{10|20|30}, results in Equation U2b representing the total expected cargo-side change.

$$\text{Commodity-side Task 4 TCCIsr Change, \% (total)} = \text{Delay}_{10|20|30} * \text{Value}_{\text{Trade, CIF}} * (\text{C}_{\text{int}} + \text{C}_{\text{dep}} + \text{C}_{\text{ins}}) / 365.25 \quad [\text{U2b}]$$

Total Cost Calculation

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

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

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

AIII.iii Discussion

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

Commodity, Route and Vessel Selection

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

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

Vessel-side Cost Calculations

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

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

DNV's disaggregated data of modelled **Ship-side Task 2 CI Change, %** across details vessel classes was made available to the UCL team, facilitating application of differentiated **Ship-side Task 2 CI Changes, %** by vessel type, size class and

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

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

Calculation of the **Ad-valorem Freight Rate, %** was conducted by UNCTAD and is documented in (UNCTAD, 2022). These rates have been primarily based on CIF-FOB margins recorded in the Comtrade database, specifically featuring infilling of FOB values they are missing, using modelling trained on other areas of presenting data. In this sense, the majority of the ad-valorem rates featured in the Trade-and-Transport database are therefore estimated 'synthetic' data.

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

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 (DNVa, 2024). The **Ad-valorem Freight Rate, %** is defined by the total costs paid for transportation of the goods compared with the value of the goods themselves, where both cost and value are provided in US\$. Therefore, the dimensionless units of the former are (US\$/tonne-mile) / (US\$/tonne-mile), whilst the latter are (US\$/US\$).

The discrepancy is magnified when considering what each entity represents. The **Ship-side Task 2 CI Change, %** considers vessel-side costs such as those associated with required investments into energy efficiency and propulsive technologies, retrofits and compliance. The **Ad-valorem Freight Rate, %** is defined in the official Task 4 methodology as 'the transportation cost percentage of a commodity's total cost', i.e. the CIF-FOB margin divided by the CIF value. These values are sourced from UNCTAD's Trade-and-Transport Dataset (UNCTAD, 2024c) who's underpinning methodological note (UNCTAD, 2022) describes the application of CIF-FOB margins to derive transport cost projections. The CIF-FOB margin captures all cost elements along the transport supply-chain between exporter (FOB-valued) and importer (CIF-valued), accounting for more costs exogenous to

those considered in DNV's Task 2 analysis such as port dues, fees and profit margins, cargo handling charges, customs duties etc. Referring to this transport cost rate as the **Ad-valorem Freight Rate, %** is therefore inaccurate as it implies that the rate represents freight charges alone.

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

In addition, UNCTAD typically refers to ad-valorem rates as the division of the CIF-FOB margin by the FOB value, whereas the changes in 'commodity cost' imply a change in relation to a good's CIF value. There is therefore the potential for uncertainty when quoting the modelling results of an order of magnitude roughly equal to the 'ad-valorem' transport cost rate itself (i.e. for an ad-valorem rate of 6%, the uncertainty would be around 0.5% if 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 ($\text{Transit Time}_{\text{GSA-X}} = \text{Distance} \# / \text{Speed}_{\text{GSA-X}}$). Time delay is dependent on vessel speed assumptions; any changes in GSA will automatically modify the voyage time. Changes in speed are to be made in Module 1 – GHG Impacts, tab “Analysis Matrices”, column D”, rows 15 to 23.
- **GDP impact:** the reduction of product exports is measured as an impact on total economy Gross Domestic Product (GDP) ($\text{GDP Impact} = \text{Commodity Total Export Value} / \text{Economy GDP}$). An economy's GDP is labelled blue; thus, the user can update and modify it.
- **Interest cost:** the financial cost of capital invested in inventory over time. This measures the impact of each hour or day of delay in the cost of the product due to cost of money or interest rate. (here assumed to be 5%) ($\text{Interest Cost} = (\text{Export Value} \times \text{Interest Rate}) \times (\text{Time Delay}/365.25)$). Interest rate is labelled in blue font; thus, the user can modify it.
- **Depreciation cost:** is defined as the cost allocation of a product over its useful life. (for this economic analysis, it is assumed as 10% for containerized cargo, 30% for fresh perishable products, and 5% for dry bulk cargo) ($\text{Depreciation Cost} = (\text{Export Value} \times \text{Depreciation Rate}) \times (\text{Time Delay}/365.25)$). The depreciation rate is labelled in blue font; thus, the user can modify it.
- **Insurance cost:** a cost paid by the shippers to protect their goods while in transit. (the percentage used in the economic analysis is 2%) ($\text{Insurance Cost} = (\text{Export Value} \times \text{Insurance Rate}) \times (\text{Time Delay}/365.25)$). The insurance rate is labelled in blue font; thus, the user can modify it.

Figure 2.AIII.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:

$$\text{Commodity-side Task 4 TCCLsr Change, \% (daily)} = \text{Value}_{\text{Trade, CIF}} * (C_{\text{int}} + C_{\text{dep}} + C_{\text{ins}}) / 365.25$$

Multiplication by the projected time delay (in days), $\text{Delay}_{10|20|30}$, therefore results in the following expression for the total expected cargo-side change:

$$\text{Commodity-side Task 4 TCCLsr Change, \% (total)} = \text{Delay}_{10|20|30} * \text{Value}_{\text{Trade, CIF}} * (C_{\text{int}} + C_{\text{dep}} + C_{\text{ins}}) / 365.25$$

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

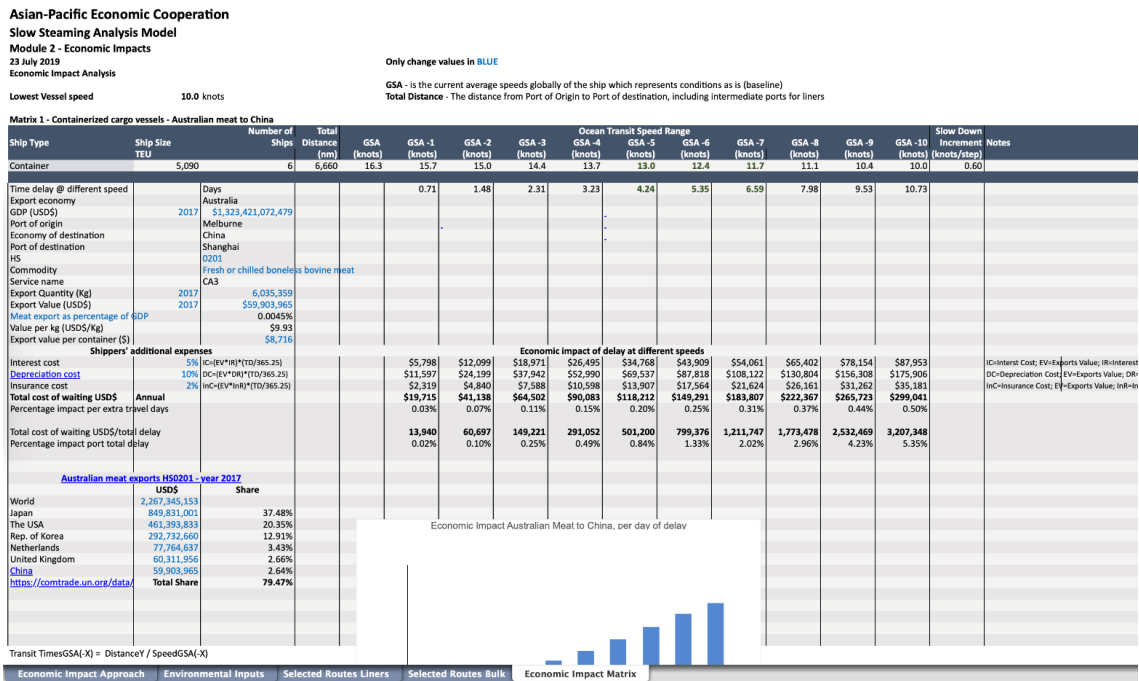


Figure 2.AIII.2. Screenshot of the Economic Impact Matrix model for Australian Meat to China from (APEC, 2019).

As presented above, the 'daily cost during the transit or during any extra voyage days', TCCIsr, is scaled by the delay term, Delay_{10|20|30}, therefore resulting in the following equation:

$$\text{Commodity-side Task 4 TCCIsr Change, \% (daily)} = \text{Delay}_{10|20|30} * \text{Value}_{\text{Trade, CIF}} * (C_{int} + C_{dep} + C_{ins}) / 365.25$$

Multiplication by the projected time delay (in days), Delay_{10|20|30}, would therefore result in the following expression representing the total expected cargo-side change:

$$\begin{aligned} \text{Commodity-side Task 4 TCCIsr Change, \% (total)} &= \text{Delay}_{10|20|30} * \text{Delay}_{10|20|30} * \text{Value}_{\text{Trade, CIF}} * (C_{int} + C_{dep} + C_{ins}) / 365.25 \\ \text{Commodity-side Task 4 TCCIsr Change, \% (total)} &= (\text{Delay}_{10|20|30})^2 * \text{Value}_{\text{Trade, CIF}} * (C_{int} + C_{dep} + C_{ins}) / 365.25 \end{aligned}$$

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			Ocean Transit Speed Range										Slow Down		
Ship Type	Ship Size	Number of Ships	Total Distance (nm)	GSA (knots)	GSA -1 (knots)	GSA -2 (knots)	GSA -3 (knots)	GSA -4 (knots)	GSA -5 (knots)	GSA -6 (knots)	GSA -7 (knots)	GSA -8 (knots)	GSA -9 (knots)	GSA -10 (knots)	Increment (knots/step)
Container	5,090 TEU	6	6,660	20.0	19.0	18.0	17.0	16.0	15.0	14.0	13.0	12.0	11.0	10.0	0.60
Time delay @ different speed		Days			0.73	1.54	2.45	3.47	4.63	5.95	7.47	9.25	11.35	13.88	
Export economy	Australia														
GDP (USD\$)	2017	\$1,323,421,072,479													
Port of origin	Melbourne														
Economy of destination	China														
Port of destination	Shanghai														
HS	0201														
Commodity	Fresh or chilled boneless bovine meat														
Service name	CA3														
Export Quantity (Kg)	2017	6,035,359													
Export Value (USD\$)	2017	\$59,903,965													
Meat export as percentage of GDP		0.0045%													
Value per kg (USD\$/Kg)		\$9.93													
Export value per container (\$)		\$8,716													
Shippers' additional expenses				Economic impact of delay at different speeds											
Interest cost	5%	$IC=(EV*IR)*(TD/365.25)$	\$5,988	\$12,642	\$20,079	\$28,445	\$37,927	\$48,763	\$61,266	\$75,854	\$93,093	\$113,781			
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	\$186,186	\$227,561			
Insurance cost	2%	$INC=(EV*IR)*(TD/365.25)$	\$2,395	\$5,057	\$8,032	\$11,378	\$15,171	\$19,905	\$24,507	\$30,342	\$37,237	\$45,512			
Total cost of waiting USD\$ Annual			\$20,361	\$42,984	\$68,268	\$96,714	\$128,951	\$165,795	\$208,306	\$257,903	\$316,517	\$386,854			
Percentage impact per extra travel days			0.03%	0.07%	0.11%	0.16%	0.22%	0.28%	0.35%	0.43%	0.53%	0.65%			
Australian meat exports HS0201 - year 2017															
	USD\$														
World	2,267,345,153														
Japan	849,831,001	37.48%													
USA	461,393,833	20.35%													
Rep. of Korea	292,732,660	12.91%													
Netherlands	77,764,637	3.43%													
United Kingdom	60,311,956	2.66%													
China	59,903,965	2.64%													
https://comtrade.un.org/data/	Total Share	79.47%													

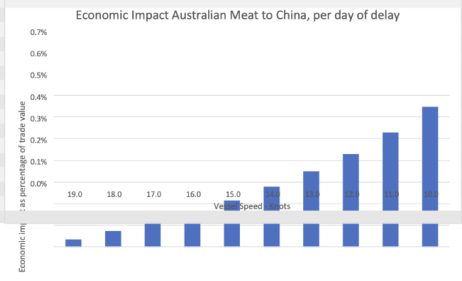


Figure 2.AIII.3. Alternative screenshot of the Economic Impact Matrix model for Australian Meat to China presented unreferenced as the penultimate page of Appendix B in (APEC, 2019).

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

SECTION 3

REVIEWING ANALYSIS OF THE IMPACT OF THE IMO MID-TERM MEASURES ON CARIBBEAN ECONOMIES



REVIEWING ANALYSIS OF THE IMPACT OF THE IMO MID-TERM MEASURES ON CARIBBEAN ECONOMIES

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EXECUTIVE SUMMARY

- **IMO Mid-Term Measures:** The International Maritime Organization's (IMO) mid-term measures aim to achieve net-zero greenhouse gas (GHG) emissions in international shipping by 2050. These measures, combining fuel standards and carbon levies, are pivotal for global decarbonization but pose significant economic challenges for small and vulnerable economies, including CARICOM states.
- **Approach and methods:** In this report, we assess the economic impact of the mid-term measures on CARICOM countries. To do so, we conduct a literature review of the existing work estimating the impact of an increase in transport cost on countries' economies and extract the results relevant to CARICOM countries.
- **Impact on GDP:** The literature reveals that increased transport costs result in regressive economic effects, particularly impacting small and import-dependent economies, including SIDS, disproportionately. The report identifies greater GDP impacts on Caribbean Community (CARICOM) countries than the world average, averaging -0.1% to -1.3%, depending on the model and scenario. This wide range highlights methodological differences across studies and underscores the need for caution when interpreting the results.
- **Inflation and consumer prices:** An increase in transport costs creates inflationary pressures on the prices of goods imported to the Caribbean (the average increase across CARICOM countries ranges from 0.03% to 1.8%, depending on the study and scenario). Additionally, the redistribution of carbon levy revenues boosts household purchasing power, which can further drive price increases. For CARICOM countries, the IMO's CIA suggests this effect could add up to 0.6% to consumer price index increases by 2050 in high-levy scenarios.
- **CIA evidence is:** most of the key findings from the CIA relevant to the Caribbean region are reinforced by the Section 2 of this compilation and wider literature review. In particular these common/reinforced findings include:
 - ❖ That negative impacts arise from both measures (fuel standard and carbon price), predominantly because of transport cost increases due to the adoption of new technology and fuels
 - ❖ That negative impacts are regressive (GDP impacts are higher in lowest income countries)
 - ❖ However, individual country results vary from country to country, so they should be taken with caution.
- **Food security concerns:** CARICOM countries are very dependent on food imports. The implementation of the mid-term measures is likely to result in an increase in the prices of imported food and a decrease in the quantity of imported food.
- **Mitigation of negative impacts:** If shipping mitigation measures include a revenue-raising mechanism, such as a carbon tax, the redistribution of the revenue to Caribbean countries can partially offset the negative effects on food imports and GDP. The modelling shows that to which extend the revenue offsets the negative

impact of the increase in transport costs depends 1/ on the total amount of revenue raised by the levy and 2/ which share of the total revenue CARICOM countries can access. The positive impact on GDP from revenue distribution fully offsets the negative impacts in the high levy scenario when revenue is only distributed to SIDS to LDCs. If the level of the levy is low and/or the revenue is distributed to all emerging economies, then the distribution of revenue only partially offsets the negative impact (on average -0.2% GDP decrease across CARICOM countries in 2050, compared to -0.3% in the absence of revenue distribution). Distribution of revenue is likely to be most effective if it is tailored to country-specific economic structures and vulnerabilities, such as infrastructure improvements of investments to reduce dependency on imports for critical commodities such as food commodities. Without a levy and revenue distribution, another option for mitigation is an exemption, which can only postpone, not reduce, the ultimate impact, as the exempted routes will eventually have to move to net zero by 2050.

3.1. Introduction

The International Maritime Organization's (IMO) 2023 strategy on greenhouse gas (GHG) emissions reduction represents a pivotal shift in the global shipping sector's trajectory toward decarbonisation. The strategy sets a target to achieve net-zero GHG emissions by around 2050. Milestone goals for reducing emissions in international maritime transport are outlined as follows: by 2030, a 20% reduction is targeted, striving to reach 30%, compared to 2008 levels; by 2040, the aim is a 70% reduction, with a strive goal of 80%.

Negotiations are ongoing at the IMO to adopt a new set of legally binding and globally enforceable policies, known as mid-term measures, that will complement existing policies to achieve the GHG reduction goals outlined in the 2023 strategy. These measures are expected to include both a technical component, such as a fuel standard, and an economic element. A common feature of all proposals is a fuel standard that sets progressively stricter limits on the GHG intensity of marine fuels, propelling sector-wide decarbonisation towards the net-zero goal by 2050. However, certain aspects of the policy, particularly the design of the economic measure, remain under discussion:

- Whether to allow credit trading between over- and under-performing ships, referred to as a “flexibility mechanism”.
- Whether a GHG price should apply only to emissions exceeding the fuel standard’s limits (e.g., for underperforming ships) or to all emissions, effectively creating a “universal” GHG price or “carbon tax/levy” applicable to compliant and non-compliant ships alike.
- Whether the scope of emissions measurement should be Take-to-Wake (TTW) or Well-to-Wake (WTW), and whether the fuel standard’s trajectory should align with the base or strive trajectory.
- How revenue generated from these measures should be distributed, including the appropriate mechanisms, beneficiary countries, and projects, which are not addressed in detail in this note, but are discussed in the 4th report of this project.

While the proposed mid-term measures aim to curb emissions through fuel standards and a carbon pricing mechanism, their economic impacts remain uneven, particularly for import-dependent small island developing states (SIDS) like those in the Caribbean. This report critically evaluates the potential economic implications of the IMO's mid-term measures on Caribbean States and compares the results to those of Section 2 of this compilation, with a particular focus on GDP impacts and price effects. While existing literature provides valuable insights into the global impacts of increased transport costs, its applicability to the unique socioeconomic contexts of Caribbean nations remains uncertain. By assessing the robustness of global models and interpreting their implications for the Caribbean, this report aims to contextualise the findings and offer recommendations that are tailored to regional vulnerabilities and

opportunities. The scope of this article is limited to Caribbean Community (CARICOM) countries¹. The report is organised as follows:

- The next section discusses the specific vulnerabilities of the Caribbean States linked to an increase in transport costs, as highlighted in the literature.
- Section 3 then lists the articles which have looked globally at the impact of shipping mitigation measures on States' economies and critically compares their respective methods.
- Sections 4, 5 and 6 review the findings of the studies identified in Section 3 for the CARICOM countries related to changes in GDP, prices and food security, respectively.
- Section 7 discusses those results in relation to those of task 2.
- Section 8 concludes.

¹ Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Jamaica, Grenada, Guyana, Haiti, Monserrat, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Saint Lucia, Suriname and Trinidad and Tobago

3.2. Vulnerability of Caribbean States to increases in transport cost

While global models provide valuable trends, Caribbean states face unique vulnerabilities and opportunities due to their small size, high import dependency, and reliance on tourism. Regional studies offer critical insights into these dynamics.

The Caribbean relies on imports for 70%-100% of key staples like wheat, rice, and maize (FAO, 2022), making it particularly sensitive to transport cost increases. Historical food price spikes, such as those between 2006-2008, significantly impacted welfare and consumption patterns, underscoring the potential for adverse effects under carbon pricing policies. Furthermore, the region's small shipment sizes and lack of economies of scale, highlighted by (Lewis et al., 2021), amplify transport costs, with limited capacity to absorb shocks, further challenging trade competitiveness.

Additionally, tourism accounts for over 15% of GDP in many Caribbean states (World Travel & Tourism Council, 2022). Increasing shipping costs could hinder cruise activity, with Johnson et al., 2023) warning of reduced itineraries and economic losses. Nevertheless, investments in green port infrastructure and low-emission technologies could mitigate these risks and boost regional competitiveness.

Given the region's inelastic import demand, food security is also a primary concern. Rising import prices for agricultural products could exacerbate food insecurity, particularly in vulnerable states like Haiti, Jamaica, and the Dominican Republic. Investments in agricultural innovation, such as hydroponics and aquaponics (Allayne et al., 2020), could help offset these risks.

This all requires an effective governance for Caribbean states to absorb redistributed revenues. The Caribbean Development Bank (2021) emphasises the importance of regional cooperation through CARICOM frameworks to pool resources and finance shared infrastructure projects, such as renewable energy systems and resilient port facilities (Caribbean Development Bank, 2021).

Finally, for resource-exporting states like Trinidad & Tobago, carbon levies pose dual challenges of rising transport costs and declining global fossil fuel demand. (United Nations Development Programme (UNDP), 2022) advocates for diversification into renewable energy exports, such as green hydrogen, to maintain trade competitiveness.

Table 3.1. Overview of the literature relevant to the impact of shipping climate mitigation on Caribbean States

Study	Model	Method	Period	Policy	Redistribution of revenue
FAO, 2022	Food balance data	Statistical analysis	2010-2021	No direct policy analysis; focus on Caribbean food import dependency	Not addressed

Study	Model	Method	Period	Policy	Redistribution of revenue
Lewis et al., 2021	Policy paper	Mixed methods	Not specified	Analysis of the impact of high transport costs on Caribbean SIDS	Discussion on indirect redistribution impacts through regional trade policies
Johnson et al., 2023	Tourism-specific models	Mixed methods	2020-2035	Decarbonisation of cruise shipping (carbon pricing impacts and green port strategies)	Revenue redistribution assumed indirectly through green investments
Alleyne et al., 2020	Regional economic analysis	Qualitative analysis	Not specified	Revenue redistribution and investment strategies in the Caribbean	Focuses on pooling carbon levy revenues through CARICOM for shared green infrastructure
UNDP, 2022	Policy analysis	Mixed methods	2020-2050	Focus on transitioning fossil-fuel-exporting countries like Trinidad & Tobago to green hydrogen and renewable exports	No redistribution mechanism; emphasis on reinvestment in sustainable industries

3.3. Methods to Assess the Global Impact of Shipping Climate Mitigation on States' Economies

There is a growing body of global literature on the impact of rising transport costs on GDP, summarised in Table 3.2. Key studies include Sheng et al. (2018), Pereda et al. (2023), Black et al. (2024), Dequiedt et al. (2024), Ogbugo et al. (2024), and the IMO's Comprehensive Impact Assessment (CIA), which analyze various carbon pricing scenarios and redistribution mechanisms (Black et al., 2024; Dequiedt et al., 2024; Ogbugo et al., 2024; Pereda et al., 2024; Sheng et al., 2018; UNCTAD, 2024). This section summarises the main methodological assumptions underpinning these studies: the shipping mitigation policies they model (subsection 3.1), the modelling approach they utilise for fleet and GDP evolution (subsection 3.2), the modelling of inflationary effects (subsection 3.3), and finally discusses the limitations of certain assumptions made in this global literature to represent Caribbean countries.

3.3.1. Policies modelled

Sheng et al. (2018) assess the impact of an \$18/tonne CO₂ from 2010 to 2030, examining its effects on exports and GDP when redistributing revenue towards all or only developing countries, based on their trade share (only the latter is reported in this document). Pereda et al. (2023) consider the implementation of a \$50/tonne CO₂-eq carbon tax and disregard the distribution of this revenue—indicating that the carbon

tax is simply excluded from the economy. Dequiedt et al. assess the impact of implementing a \$40/tonne CO₂ in 2018 on countries' welfare, also without redistributing the revenue and limited to a single year. The IMO's comprehensive impact assessment (CIA) of the mid-term measures (DNV, 2024; UNCTAD, 2024) reviews the impact of various policy designs on exports, GDP, and prices in 2030, 2040, and 2050, and evaluates the impact of redistributing the revenue from a carbon tax to countries proportionally to the scale of negative impact and population. Black et al. (2024) explore the impact of implementing both a high and a moderate carbon tax from 2015 to 2050, and qualitatively discusses the redistribution of the revenue. Finally, Ogbugo et al. (2024) assesses the impact of enforcing a \$100/tonne CO₂-eq on the GDP, exports, imports, and selected prices of commodities across 13 countries, with a focus on African countries.

3.3.2. Modelling approach and consideration of the fleet evolution

These studies employ various models to quantify the impact of a global maritime policy. Firstly, they differ in how they model the policy shock (Table 3.2): Sheng et al. (2018), Pereda et al. (2023), and Dequiedt et al. (2024) directly incorporate the carbon tax into the operational cost for each trade link, while Ogbugo et al. (2024) apply the shock to the maritime transportation sector, which is divided across countries in the CGE model, and whose outputs serve as a production input for other sectors. All four studies utilise static models to assess the direct effects of carbon pricing on trade and GDP. This assessment is static within a single year, meaning that the transport cost is implemented in one year and the fleet does not adjust (specifically, it does not decarbonise). In contrast, the IMO's CIA and Black et al. (2024) employ dynamic models that account for fleet evolution, improvements in energy efficiency, and changes in the fuel mix over time. They therefore model the evolution of the fleet following the implementation of a policy shock, using the resulting increase in transport costs (for instance, due to rising transport costs, alongside changes in the fuel mix, speed, etc.). These models offer more nuanced insights but rely heavily on assumptions about future policy implementation and technological adoption.

The literature on the economic impacts of maritime decarbonisation policies typically employs computational general equilibrium (CGE) models or partial equilibrium models to simulate the effects of increased transport costs and carbon levies. However, all studies use fairly comparable methods to derive their impact on the economy (Table 3.2): all but Black et al. (2024) use a computational general equilibrium model (CGE) to estimate the impact on the change in exports economy, while Black et al. (2024) employs a partial equilibrium model. Nevertheless, the specific CGE used in the different studies differs, with the IMO's CIA, Pereda et al. (2024) and Ogbugo et al. (2024) utilising GTAP, while the other studies adopt different CGEs.

3.3.3. Inflationary effects on consumer prices

The inflationary impacts of mid-term measures are another area of focus, with studies identifying two primary channels:

- The increase in transport costs leads to an increase in imported commodity costs, which in turn leads to an increase in price in the economy.
- The distribution of revenue, because it increases the purchasing power of the recipient countries' households, leads to an increase in prices, which partly offsets the increase in GDP (this effect is already factored in the results in real GDP change, reported above).

Under the direct price effects, increased transport costs raise the prices of imported goods, particularly those consumed in trade-dependent economies. All studies reported in Table 3.2 model this inflationary effect. The second channel is only modelled in studies that consider the distribution of revenue and is only separately reported in the IMO's CIA (UNCTAD, 2024)

Table 3.2. Overview of the literature assessing global impact of shipping climate mitigation on States' economies

Study	Model	Method	Period	Evolution of the fleet	Policy	Redistribution of revenue
Sheng et al, 2018	GTEM	CGE	2010-2030	No evolution	Carbon tax of \$18/tonne CO ₂	Revenue distributed to developing economies according to their trade shares (further scenarios are reported but are not covered in this report)
Pereda et al, 2023	GTAP, with the shock applied to trade links	CGE	2014	No evolution	Carbon tax of \$50/tonne CO ₂ -eq	The revenue is removed from the economy.
Dequiedt et al, 2024	Econometric model of exports and CGE		2018	No evolution	Carbon tax of \$40/tonne CO ₂	The revenue is removed from the economy.
IMO's comprehensive impact assessment of the mid-term measures (DNV + UNCTAD)	DNV GHG pathway model + GTAP, with the shock applied to trade links	CGE	2027-2050	Energy efficiency and fuel (in DNV)	"Flexibility": Fuel standard + flexibility mechanism; WTW, base trajectory (sc. 24)	The revenue is removed from the economy, but limited revenue is raised.
					"Low levy + flexibility": Fuel standard + feebate to hydrogen-base fuels + flexibility mechanism + carbon tax \$30 increasing to 120/tonne CO ₂ -eq; WTW, base trajectory (sc. 32)	To all developing economies according to their population and the level of negative impact on their GDP in the absence of revenue distribution (further distribution are modelled in the IMO's CIA but are not covered in this report)
					"High levy": Fuel standard + feebate to hydrogen-base fuels + carbon tax \$150 increasing to 300/tonne CO ₂ -eq; WTW, base trajectory (sc. 26)	
Further scenarios covering TTW emissions, strive trajectory and the inclusion of the feebate are not covered in this report						

Study	Model	Method	Period	Evolution of the fleet	Policy	Redistribution of revenue
Black et al, 2024	Model developed in (Keen et al., 2013)	Partial equilibrium	2015-2050	Energy efficiency and fuel (no retrofitting)	<p>Net zero pathway: carbon tax from \$20/tonne CO2 in 2028 to \$170 in 2035 to \$500 in 2050</p> <hr/> <p>Net zero pathway + feebate to ships more efficient than average</p> <hr/> <p>Moderate pathway: carbon tax from \$10/tonne CO2 in 2028 to \$250 in 2050</p> <hr/> <p>Moderate pathway + feebate to ships more efficient than average</p>	Qualitative discussion on the distribution of revenue, but quantitatively it is simply removed from the economy.
Ogbugo et al, 2024	GTAP, with the shock distributed to countries' maritime transport sector	CGE	2017	No fleet evolution	\$100/tonne CO2-eq	Redistributed in-sector only and revenue raised in countries is distributed to the country that levies it (no active redistribution to targeted countries)

3.3.4. Relevance and limitations for Caribbean countries

The literature reviewed above is global in nature (although Ogbugo et al. (2024) focuses on several African countries) and does not specifically focus on Caribbean countries. This section reviews some methodological assumptions made globally that have limitations for Caribbean States.

Some models assume that the global shipping fleet, including vessels serving Caribbean states, will adopt energy-efficient technologies or low-carbon fuels by 2030 (Black et al., 2024; DNV, 2024). However, regional realities, such as limited port infrastructure for green fuels, may delay this transition, amplifying short-term GDP impacts. This results in a discrepancy, as models like the IMO's CIA that account for gradual fleet evolution would likely show lower GDP impacts in the long term, whereas static models (e.g., Dequiedt et al., 2024) assume no fleet adjustments, leading to higher cost estimates. Nevertheless, in the short term, a similar policy shock would likely have a comparable impact on economies.

Additionally, models that capture the Caribbean's trade dependency might show higher GDP impacts compared to global averages. All models reviewed in Table 3.2 reflect trade dependency through shipping flows to and from the countries, as well as transport costs as a proportion of the prices of imported goods. However, models that categorise Caribbean countries alongside broader developing economies may dilute these effects: all SIDS are grouped in Pereda et al., 2023, while the IMO's CIA groups Belize, Guyana, Suriname, the Falkland Islands, and South Georgia & South Sandwich Islands under "Other American SIDS". Anguilla, Antigua & Barbuda, Aruba, the Bahamas, Barbados, the British Virgin Islands, the Cayman Islands, Cuba, Curaçao, Dominica, Grenada, Haiti, Jamaica, Montserrat, St Kitts & Nevis, St Lucia, St Vincent, Turks & Caicos, and the US Virgin Islands are placed under "Rest of Caribbean." Meanwhile, the Dominican Republic and Trinidad and Tobago are modelled separately, and Sheng et al. (2018) and Ogbugo et al. (2024) do not report SIDS or Caribbean-specific results. In contrast, Dequiedt et al. (2024) and Black et al. (2024) both provide individual results for most Caribbean countries.

Furthermore, Caribbean economies are highly diverse, with resource-exporting nations like Trinidad & Tobago responding differently to carbon pricing than tourism-reliant states like Jamaica or Barbados. Models that aggregate Caribbean states may fail to capture these nuances. For example, assumptions concerning sectoral GDP contributions (e.g., energy, tourism, agriculture) can lead to significant variability in results, and models that disaggregate resource exports from other types of cargo and individual Caribbean countries (e.g., Black et al., 2024; Dequiedt et al., 2023) may reveal more severe impacts for energy-dependent economies. Energy-dependent economies, such as Trinidad and Tobago, are particularly vulnerable to the effects of mid-term measures for several reasons that extend beyond the vulnerabilities of trade-dependent economies in general. They face simultaneous challenges: declining global demand for fossil fuels, rising shipping costs for energy exports, the risks of stranded assets, and amplified economic ripple effects due to sectoral concentration. Models

that focus on these structural dynamics, like Black et al. (2024), tend to indicate more severe impacts for energy-dependent economies compared to trade-dependent economies with more diverse export profiles.

Additionally, the Caribbean's limited infrastructure for green shipping fuels or retrofitted fleets may lead to higher costs for complying with decarbonisation policies. Models that assume uniform global infrastructure readiness underestimate the region's challenges and, therefore, short-term impacts, as all the studies considered in Table 3.2 do.

It is also important to remain mindful that the Caribbean has primarily inelastic demand for imports. Models based on global elasticity assumptions may underestimate the Caribbean's vulnerability to price shocks. Models that account for high elasticity in essential imports report lower GDP impacts compared to those that use lower global elasticity assumptions. For example, Sheng et al. (2018) assume global elasticities for food and commodity imports, which do not accurately reflect the Caribbean economies' high dependency on essential imports. Pereda et al. (2023) do not differentiate between elastic and inelastic goods, and the model assumes uniform substitution across economies. In the Caribbean, where food and energy are critical imports with few substitutes, this assumption may distort the scale of the economic impact. Dequiedt et al. (2024) incorporate country-specific elasticities, reflecting the reality that essential imports such as food and fuel have low substitution potential in regions like the Caribbean. Black et al. (2024) employ partial equilibrium modelling with differentiated elasticities for energy exports and essential imports, which illustrates the limited ability of Caribbean economies to adapt to price shocks.

This also has implications, given the region's exchange rates and currency volatility. Any carbon tax may increase shipping costs in USD, which could exacerbate price increases in Caribbean countries with weaker currencies or high levels of currency volatility. Models that incorporate exchange rate fluctuations and pass-through effects show higher GDP impacts, particularly for smaller, import-dependent Caribbean economies.

The impacts of increasing transport costs due to carbon pricing have been extensively studied in global literature, which we have just reviewed, yielding insights into GDP, consumer prices, trade competitiveness, and welfare. However, their specific implications for Caribbean states remain less explored. The next three sections synthesise findings from the global literature while incorporating Caribbean-specific insights to contextualise the unique vulnerabilities and opportunities for the region. The following section summarises the impacts of shipping climate mitigation on GDP. Then, Section 5 summarises the impact on prices, and Section 6 addresses food security.

3.4. Impact of the Mid-Term Measures on Caribbean States' GDP

3.4.1 Impact of an increase in transport cost on GDP

Let us first examine the evidence of changes in GDP resulting from the increase in transport costs following a shipping policy shock, assuming one overlooks the impact of revenue distribution.

Global evidence robustly demonstrates that increases in transport costs lead to a decline in GDP, which is regressive in the absence of revenue distribution. This means that lower-income countries (in general, not only SIDS) are, on average, more negatively impacted than higher-income countries (Figure 3.1). The correlation between GNI per capita and the change in GDP ranges from 7 to 35% depending on the article. Furthermore, CARICOM countries are more negatively impacted than the global average, although less severely than other SIDS (Figure 3.1. Impact on GDP, in selected comparable scenarios

and Table 3.3. Detailed impact on GDP for the CARICOM countries, in comparable scenarios). This regressive effect is likely particularly acute due to their dependence on imports, higher shipping costs, and geographical remoteness from major trade flows. Additionally, a larger carbon tax leads to a stronger short-term effect on CARICOM countries and others (Figure 3.1. Impact on GDP, in selected comparable scenarios

), but this result can be misleading as it overlooks the distribution of revenue and will be discussed in the following section.

3.4.2. Comparative average impact across models

The scale of GDP reduction varies significantly among models and should therefore be approached with caution. Firstly, the extent of the impact differs considerably in each study, with the average impact across CARICOM countries ranging from -0.1% to -1.3% depending on the study, and from -0.1% to -0.7% across all countries (see Figure 3.1. Impact on GDP, in selected comparable scenarios

and Table 3.3. Detailed impact on GDP for the CARICOM countries, in comparable scenarios). This discrepancy occurs even when the scale of the policy shock is of the same order of magnitude – that is, when comparing the high levy scenarios without revenue distribution from IMO's CIA, as analysed by Black et al. (2024) and Ogbugo et al. (2024), as well as the low levy scenario without redistribution from IMO's CIA, as examined by Black et al. (2024), Dequiedt et al. (2024), and Sheng et al. (2018).

In particular, the IMO's CIA, Pereda et al. (2024), and Sheng et al. (2018) find that the impact of a carbon tax ~\$20-50/tonne-CO₂-eq on the world economy is around -0.05%

(with results ranging from -0.04% to -0.08%), while the IMO’s CIA reports a negative impact on the CARICOM countries of roughly -0.09%. Conversely, Dequiedt et al. (2024) find that under similar carbon pricing scenarios, the average negative impact of - 0.7% across all countries worldwide and -1.3% across CARICOM countries, which is an order of magnitude higher. The results of Black et al. (2024) fall in between, showing an average impact of -0.1% and -0.2% for CARICOM countries. Similarly, the IMO’s CIA, Ogbugo et al. (2024), and Black et al. (2024) report significantly different results for a high carbon tax (\$100-170/tonne CO₂), with the IMO’s CIA finding that GDP decreases on average by 0.16% across all countries and by 0.17% for CARICOM countries in 2030; Ogbugo et al. (2024) do not report an average impact for the world but find that impacts in various countries range from -0.12% to +0.15%; meanwhile, Black et al. (2024) find that GDP decreases on average by 0.5% for countries and by 0.9% for CARICOM countries.

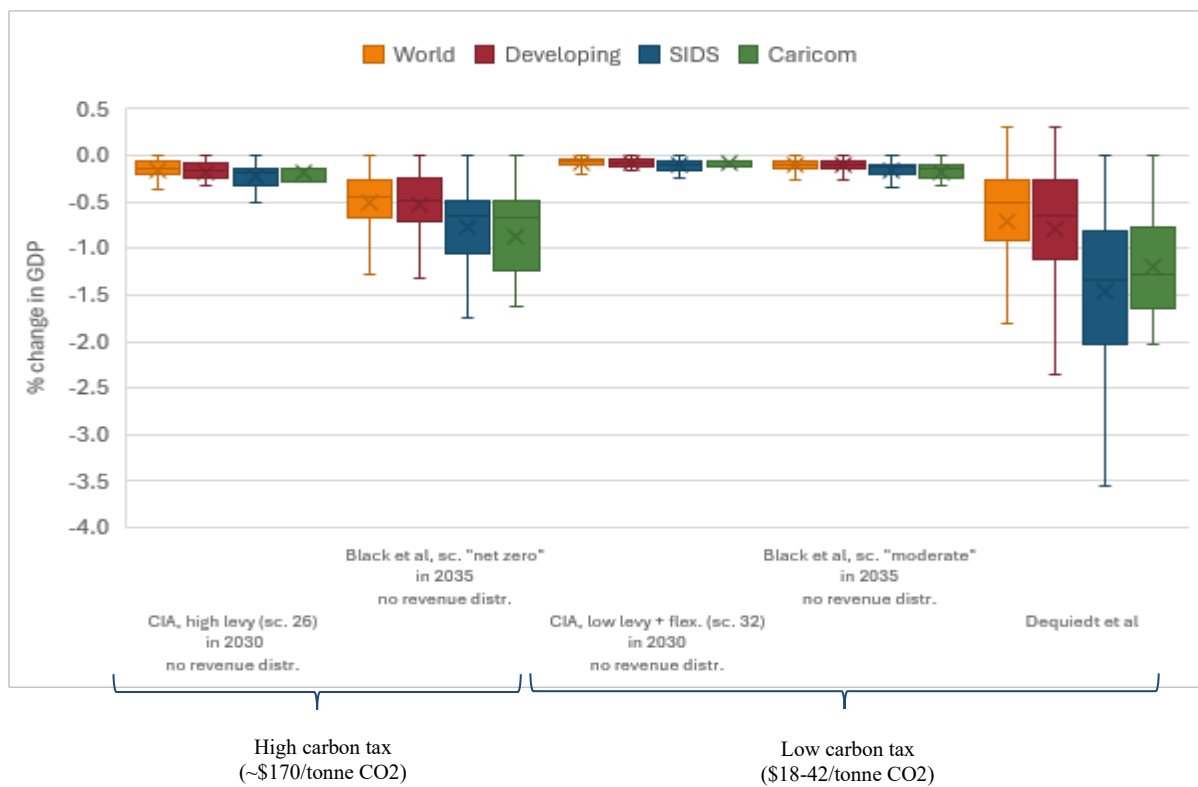


Figure 3. SEQ Figure_3. * ARABIC 1. Impact on GDP, in selected comparable scenarios

**The policy scenarios and years were selected for the shock to be as comparable as possible.
 **Sheng et al (2018), Pereda et al (2023) and Ogbugo et al (2024)'s results are not reported, as the country level results in the Caribbeans are not reported.*

Heterogeneous impacts among Caribbean States

Between countries, impacts vary substantially, and the way individual countries compare to the world average impact differs across various studies. Consequently, the changes in GDP for individual countries are, on average, positively but only slightly correlated among the various studies, with the exception of Ogbugo et al. (2024), which reports individual results for only 13 countries (Table 3.4). This means that while the overall and aggregated trends described above are robust across models, the results for individual countries are not and should be interpreted with caution. All models indicate that individual CARICOM countries are unequally affected, with the most impacted country experiencing a GDP reduction of up to 2-3 times that of the least affected nation. This shows that the results for individual CARICOM countries are inconsistent across different models (Table 3.3):

- In all models, Belize is found to be more negatively impacted than the world average due to its greater vulnerability to transport cost increases and reliance on exports.
- Guyana, Suriname, and Trinidad and Tobago show contrasting results across studies, with some models indicating significant GDP reductions, possibly due to their reliance on resource exports (IMO's CIA and Black et al., 2024). However, Guyana performs better than the world average according to Pereda et al. (2023) and Dequiedt et al. (2023)
- All other countries are more impacted than the world average in Dequiedt et al (2023), but Grenada, Antigua & Barbuda, St Lucia, St Kitts and Nevis and St Vincent & the Grenadines see particularly large impacts (> 1.5% GDP reduction), which is not the case in the Pereda et al (2023), the IMO's CIA, nor Black et al (2024).

Table 3.3. Detailed impact on GDP for the CARICOM countries, in comparable scenarios

	CIA, high levy	Black et al, high levy	CIA, low levy	Black et al, low levy	Dequiedt et al	Pereda et al, 2023
	GFS + \$170/tonne CO ₂ -e in 2030 (sc. 26), no revenue distr.	\$170/tonne CO ₂ in 2035, no revenue distr.	GFS + \$42/tonne CO ₂ -e in 2030 (sc. 32), no revenue distr.	\$32/tonne CO ₂ in 2030, no revenue distr.	\$40/tonne CO ₂	\$50/tonne CO ₂
Antigua & Barbuda	-0.142	-0.705	-0.069	-0.140	-1.930	
Bahamas	-0.142	-0.458	-0.069	-0.091	-0.800	
Barbados	-0.142	-0.609	-0.069	-0.121	-1.130	
Belize	-0.276	-1.272	-0.129	-0.252	-0.860	-0.05% to -1%
Dominica	-0.142	-0.822	-0.069	-0.163	-1.260	
Grenada	-0.142	-0.700	-0.069	-0.139	-2.020	
Guyana	-0.276	-1.616	-0.129	-0.320	-0.570	-0.025% to -0.05%
Haiti	-0.142		-0.069		-1.300	0 to 0.025%

	CIA, high levy	Black et al, high levy	CIA, low levy	Black et al, low levy	Dequiedt et al	Pereda et al, 2023
Jamaica	-0.142	-0.607	-0.069	-0.120	-1.330	
St Kitts & Nevis	-0.142	-0.653	-0.069	-0.130	-1.620	
St Lucia	-0.142	-0.483	-0.069	-0.096	-1.750	
St Vincent & the Grenadines	-0.142	-0.464	-0.069	-0.092	-1.480	
Suriname	-0.28	-2.49	-0.13	-0.49	-0.7	-0.025% to -0.05%
Trinidad and Tobago	-0.288	-1.223	-0.129	-0.242		
Caricom	-0.181	-0.931	-0.086	-0.185	-1.289	
SIDS	-0.234	-0.857	-0.112	-0.170	-1.498	-0.007
World average	-0.165	-0.539	-0.082	-0.107	-0.728	-0.040

**Results are identical for most CARICOM countries as they are grouped in a “Rest of the Caribbean” region. Belize, Guyana and Suriname are grouped in the “Rest of American SIDS” region, which further includes the Falkland Islands and South Georgia & South Sandwich Islands.*

***Country results for Pereda et al. (2023) were read from Figure 3.5, but most CARICOM countries were not visible.*

Table 3.4. Correlation matrix of countries' change in GDP (one point = one country)

	CIA, high levy	CIA low levy	Dequiedt et al	Black et al, high levy	Black et al; low levy	Ogbugo et al, 2024
CIA, high levy	100%					
CIA low levy	100%	100%				
Dequiedt et al	32%	32%	100%			
Black et al, high levy	36%	35%	22%	100%		
Black et al, low levy	36%	35%	22%	100%	100%	
Ogbugo et al, 2024	-8%	-9%	50%	17%	17%	100%

3.4.3. Impact of revenue distribution on GDP

Let us now look at the effect of various policy scenarios on GDP when considering the impact of revenue distribution. The IMO’s CIA and Sheng et al. (2018) both assess the impact of revenue distribution, but only the IMO’s CIA reports country-level results for the Caribbean. Both demonstrate that redistributing revenue from the carbon tax can alleviate some negative impacts associated with rising transport costs, and, if aimed at more vulnerable countries, can reduce or even reverse the regressivity of the tax. In the IMO’s CIA, the distribution of revenue to all developing economies results in less inequality post-distribution than if no mid-term measures had been implemented at all – practically, the correlation between the impact on GDP and GNI per capita becomes negative once revenue is distributed to all economies in the high levy scenario only.

In particular, CARICOM countries and SIDS experience, on average, a smaller reduction in GDP when revenue is distributed to all countries than when no revenue is distributed (in the scenario where the carbon tax revenue is simply removed from the

economy, and in the scenario where the mid-term measures lead to an increase in transport costs but not to significant revenue, e.g., scenario 24 of the IMO's CIA; Figure 3.3). Whether a higher carbon tax results in a greater impact on CARICOM countries largely depends on 1/ the amount of revenue raised and 2/ on which share of the total revenue CARICOM countries can access: in 2050, according to the IMO's CIA, a higher levy leads to a smaller impact on CARICOM countries if revenue is distributed to all emerging economies, whereas the opposite occurs in 2030 (Figure 3.3). The positive impact on GDP from revenue distribution fully offsets the negative impacts in the high levy scenario when revenue is only distributed to SIDS to LDCs. However, if the level of the levy is low and/or the revenue is distributed to all emerging economies, then the distribution of revenue only partially offsets the negative impact (on average - 0.2% GDP across CARICOM countries in 2050 in scenarios 32 and 26, compared to - 0.3% in the absence of revenue distribution). On the contrary, the high levy scenario fully offsets on average the negative impact on CARICOM countries due to the increase in transport cost, when it is distributed to SIDS and LDCs only (Figure 3.3). This raises the question of how revenue should be distributed among countries so that the most vulnerable, in this case the Caribbean States, would significantly benefit from it.

It is worth noting, however, that all scenarios assume that revenue is distributed to consumers. The extent of the impact of revenue distribution would likely depend not only on the sums received but also on how the revenue is distributed in Caribbean countries and whether it is invested in strategic development projects. These projects would positively impact the economy and create benefits for the consumers, who will likely bear the cost of the increase in transport costs.

Regional disparities in GDP impacts, therefore, underscore the need for tailored policy responses that consider country-specific economic structures and vulnerabilities. As Alleyne et al. (2020) suggest redistributed revenues could be directed toward infrastructure improvements (e.g., green ports, renewable energy systems), and agricultural innovations (e.g., hydroponics, and aquaponics). These investments would reduce dependency on imports and improve food security, mitigating long-term economic impacts.

However, while the mid-term measures pose significant challenges for the Caribbean, particularly in terms of GDP losses and increased transport costs, strategic policy responses and effective use of redistributed revenues can help mitigate these effects and foster long-term resilience. The combination of global insights and region-specific analysis emphasises the need for targeted interventions tailored to the Caribbean's unique context. Pooling resources through CARICOM or similar frameworks can facilitate shared investments in resilient infrastructure, benefiting the region as a whole. This highlights the need for Caribbean countries to advocate for equitable redistribution mechanisms that prioritise vulnerable economies, ensuring that the region gains tangible benefits from global decarbonisation efforts.

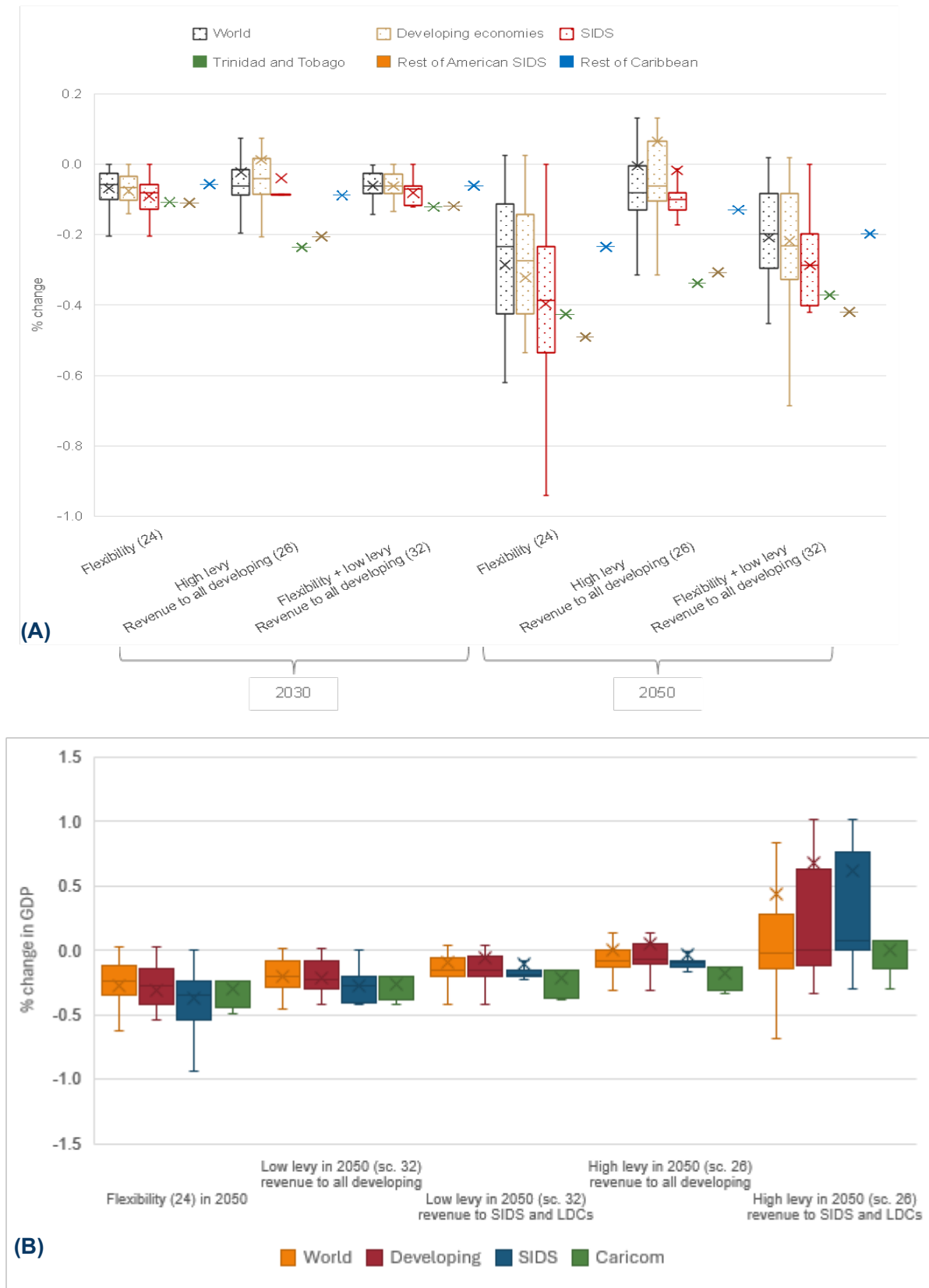


Figure 3. 2. (A)(B): Change in GDP in 2030 and 2050, in a selection of scenarios in the IMO's CIA

3.5. Impact of the Mid-Term Measures on Caribbean States' Consumer Prices

Let us now examine the proposed mid-term measures' impact on prices. The IMO's CIA and Dequiedt et al. (2024) provide detailed results per country on the change in the consumer price index. As explained in section 3.3, the implementation of the mid-term measures leads to inflationary pressures through two main channels: a direct increase in imported goods prices due to an increase in transport costs and an indirect increase in consumption prices due to an increase in purchasing power.

3.5.1. Inflationary effects from increased transport costs

The results significantly differ between Dequiedt et al. (2024) and the IMO's CIA. Dequiedt et al. (2024) find that SIDS, particularly CARICOM countries, experience an increase in the consumer index by 1.8% (1.6% for all SIDS), compared to a world average increase of 1.1% when a \$40/tonne CO₂ tax is implemented (Figure 3.4). This reflects the Caribbean's dependence on maritime imports and high freight costs. Conversely, the IMO's CIA reports a modest average increase of 0.03% in consumer price index for CARICOM countries by 2030 with a \$42/tonne CO₂-eq implemented (alongside a fuel standard). This is lower than the global average increase of 0.1% (Figure 3.4). By 2050, transport-cost-driven inflation for Caribbean states is expected to stabilise at an average of 0.07%, compared to 0.3% globally (Figure 3.4). The discrepancy between these findings underscores key differences in modelling assumptions. For Caribbean states, which face higher transport costs due to smaller shipment volumes and limited economies of scale, the actual inflationary impact is likely to fall between these estimates. Only the CIA enables comparison of results across various policy options, demonstrating that the scale of this inflationary pressure is similar across all scenarios in 2050.

3.5.2. Inflationary effects from revenue redistribution

Revenue redistribution plays a significant role in offsetting some of the inflationary effects of increased transport costs. This is only estimated in the IMO's CIA, so the results cannot be validated against the wider literature. This estimate highlights the potential effect of revenue distribution in exacerbating consumer price index increases through demand-driven inflation. The IMO's CIA finds that this channel can have a much larger effect in magnitude than the impact of an increase in transport costs, especially in recipient countries. CARICOM countries experience, on average, a further increase in the consumer price index of 0.6% through this channel, particularly in a high levy scenario with revenue distributed to all developing economies (scenario 26, Figure 3.5).

Furthermore, the combined effect of inflation from transport costs and revenue redistribution is expected to lead to a total CPI increase of 0.6% by 2050 for Caribbean states. The impacts vary significantly across countries. For example, Trinidad & Tobago shows a modest increase of 0.25%, likely due to its higher share of domestic production, whereas Belize, Guyana, and Suriname—along with several others in the

region classified as the 'rest of American SIDS'—experience a larger increase of up to 0.7%, potentially driven by a greater reliance on imported goods and limited economic diversification (Figure 3.5).

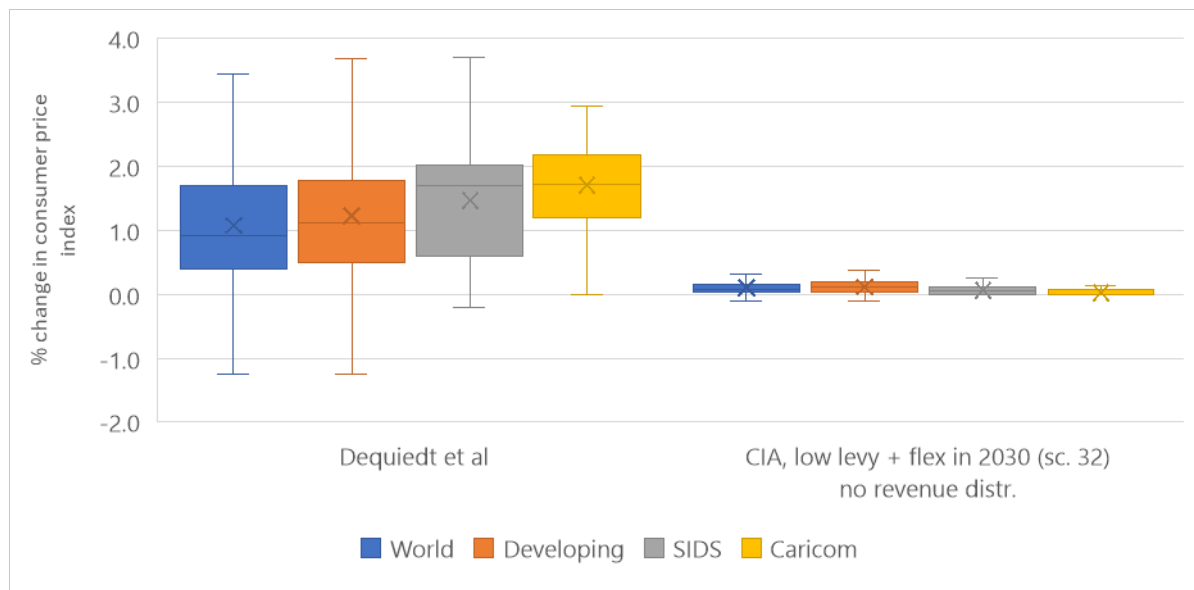


Figure 3.3. Change in consumer price index, in a set of comparable scenarios
 *Scenarios and years were chosen to be broadly comparable (low carbon tax -\$40-42/tonne CO₂)

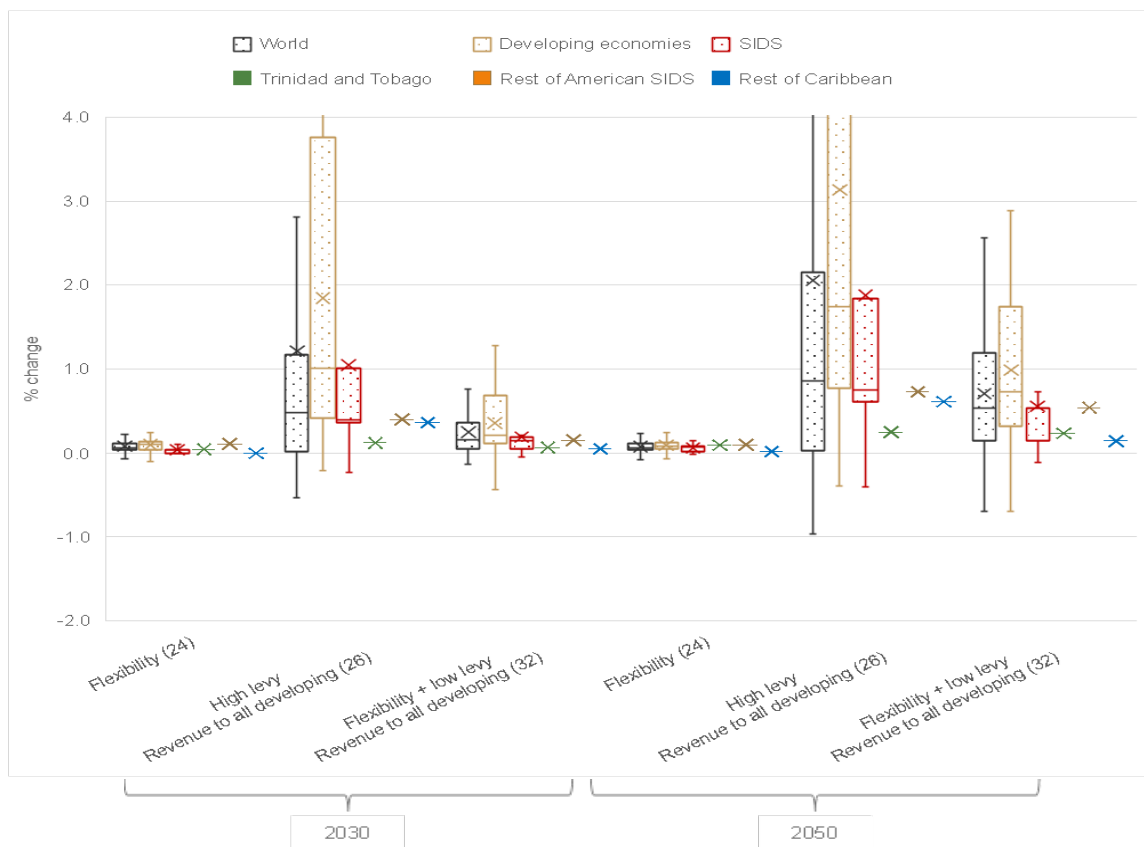


Figure 3.4. Change in consumer price index in 2030 and 2040, in a selection of scenarios in the IMO's CIA

**Results are not plotted for 2050 in scenario 24, as results in certain scenarios including scenario 24 is not consistent with the results in the report (tables 17 and 21) and is lower than 2030 and 2040, which raises doubts on whether reported results are correct.*

***The y-axis is cut for readability, but the upper whisker of developing countries reaches nearly 15% increase in 2040 in the high levy scenario (26).*

3.5.3. Policy implications

The mid-term measures are expected to moderately increase consumer prices in the CARICOM countries, with impacts varying significantly across states, possibly due to their high dependency on imports and reliance on specific industries, such as agriculture. This could result in inflationary disparities throughout the region.

The Caribbean's high dependency on imports exposes it to many potential unintended consequences, which cannot be ignored. Caribbean states import 70%-100% of their cereals, energy, and consumer goods. Inflationary pressures from increased transport costs are expected to disproportionately affect essential goods such as food and fuel, which are key drivers of household expenditures. Historical data from the FAO (2022) shows that past global food price shocks (e.g., 2008 and 2010) led to significant welfare losses and increased food insecurity in the region.

Additionally, the region relies heavily on tourism, and rising prices for imported goods and services, including fuel and consumer goods, could indirectly impact the sector. Increased operational costs for the hospitality industry may diminish its global competitiveness, leading to a multiplier effect that contributes to unemployment and a decline in GDP.

It is also important to recognise the heterogeneous nature of Caribbean economies, which can result in unequal impacts. Countries with high levels of resource exports, like Trinidad and Tobago, may experience milder inflation due to revenue from energy exports cushioning import costs. On the other hand, tourism-dependent economies such as Barbados and the Bahamas and agriculture-reliant nations like Belize are likely to face higher inflation due to their reliance on imports and limited economic diversification.

Effective governance and strategic policy interventions, combined with effective revenue redistribution, can alleviate these effects while fostering long-term economic resilience. This approach necessitates regional cooperation and the strategic use of revenue distribution. For example, revenues from carbon levies should be reinvested in local agricultural production, renewable energy, green port infrastructure, and transport efficiencies to diminish dependency on imports and lessen long-term inflation. Additionally, pooling resources through CARICOM could facilitate economies of scale in developing shared green infrastructure and reducing transportation costs. The social network is also a key variable in this transition. Regional governments

should implement targeted subsidies and social safety nets to protect low-income populations from short-term price increases.

3.6. Impact of the Mid-Term Measures on Caribbean States' Food Security

3.6.1. Dependence to food-security products

CARICOM countries import a variety of food-related products. On average, they import \$100/capita/year of animal-derived products and around \$36/capita/year of cereals (Figure 3.5). However, there is some variability between CARICOM countries in the distribution of imports, with Antigua & Barbuda, Barbados, Dominica, Saint Lucia, and Trinidad and Tobago importing, for example, much more meat and generally much more food (in value) than the others.

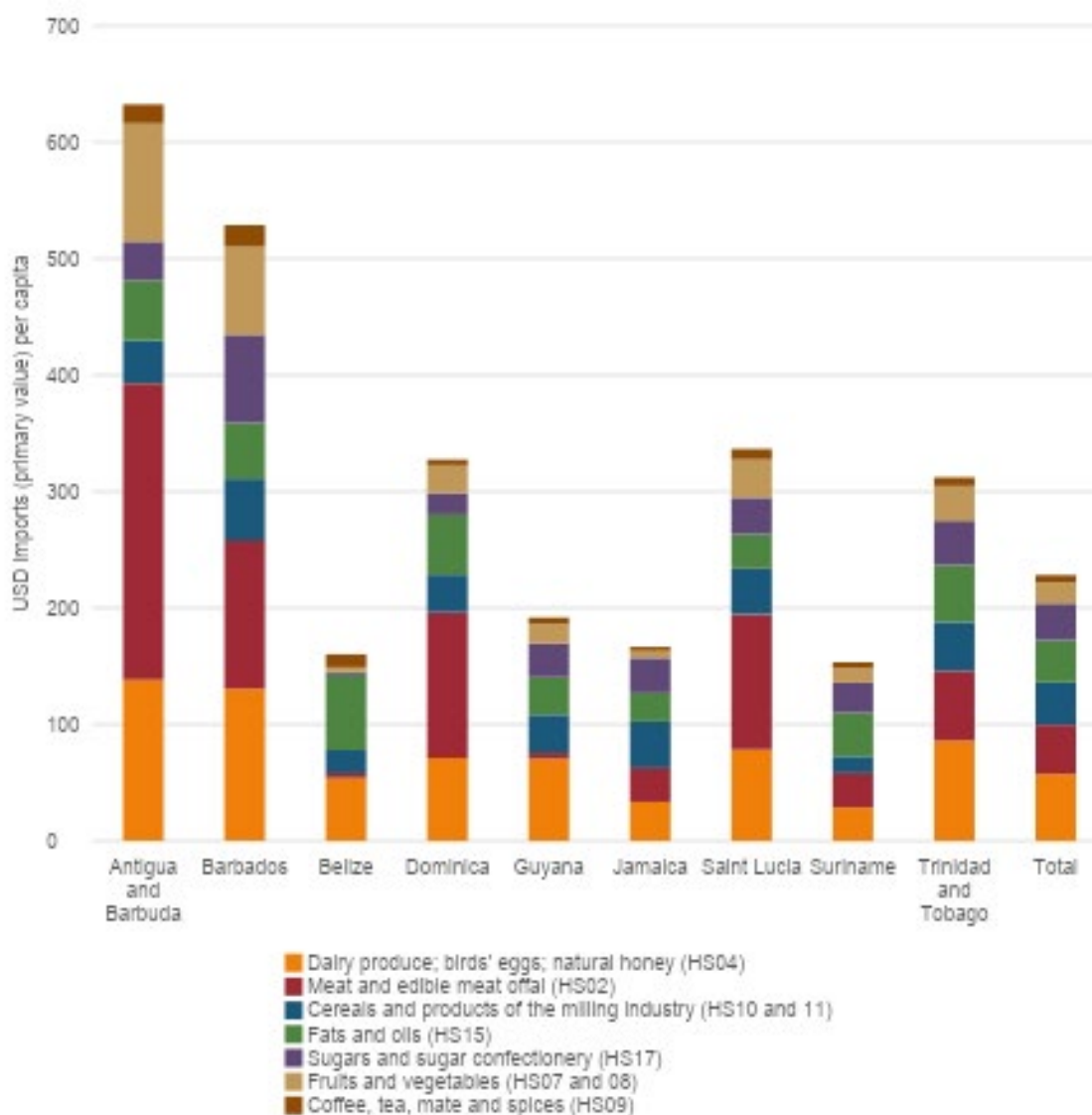


Figure 3.5. Imports in selected food-related HS categories

CARICOM countries, like other SIDS, are highly dependent on imports for their consumption of cereals (maize, rice, and wheat) and soybeans, four commodities generally regarded as critical to food security (Table 3.5). They import over 70% of these commodities, with nearly all their wheat imports, which is significantly higher than the world average, apart from soybeans. There is some variability among the CARICOM countries, with Belize being a net exporter of maize, rice, and soybeans, while Guyana and Suriname primarily export rice. Some states (Guyana, Haiti, Saint Vincent and the Grenadines, and Trinidad and Tobago) produce the majority of their maize, rice, and/or soybeans (see details in Table 3.5). This reliance on imports may render CARICOM countries vulnerable to increases in transport costs affecting their food security, especially in those with an existing prevalence of food insecurity (Haiti, Jamaica, and to a lesser extent, Saint Vincent and the Grenadines and Trinidad and Tobago; see details in Table 3.5).

Table 3.5. Dependency on imports for maize, rice, soyabeans and wheat in the CARICOM countries and in the world (calculated using FAO food balances)

	Dependency on imports (2010-2021)				Prevalence of severe food insecurity in population (3-year average)
	Maize and products	Rice and products	Soyabeans	Wheat and products	
Antigua and Barbuda	100%	84%		99%	7%
Bahamas	72%	101%		101%	3%
Barbados	99%	104%	100%	100%	7%
Belize	-12%	-4%	0%	104%	6%
Dominica	100%	92%		100%	6%
Grenada	100%	100%		99%	6%
Guyana	90%	-14%	34%	128%	5%
Haiti	17%	77%		110%	42%
Montserrat	-	-	-	-	-
Jamaica	99%	110%	100%	102%	27%
Saint Kitts and Nevis	100%	100%		97%	6%
Saint Lucia	74%	102%		105%	5%
Saint Vincent and the Grenadines	84%	36%	93%	102%	10%
Suriname	100%	-59%		103%	7%
Trinidad and Tobago	96%	96%	46%	90%	10%
Caricom	80%	66%	62%	103%	10%
SIDS	68%	80%	80%	99%	9%
World	39%	62%	74%	55%	10%

*Dependency on imports is calculated as $\frac{\text{imports} - \text{exports}}{\text{imports} + \text{production} + \text{change in stock} - \text{exports}}$, as reported in the FAO food balances

3.6.2. Change in prices and import quantities

The IMO's CIA and global studies, such as those by Sheng et al. (2018) and Pereda et al. (2023) provide insights into the potential impacts of mid-term measures on food import prices and quantities in the Caribbean.

Before moving to the results, several limitations are worth highlighting. First, this exercise is limited to examining two dimensions of food security (access and availability), whereas food security is generally understood in the literature to also encompass stability and utilisation (the diversity of nutrient intake). This framing arises from the data available in the literature, notably the IMO's CIA (UNCTAD, 2024), which focuses on prices and the level of imports, and from the fact that an increase in transport costs may be more naturally linked to those dimensions of food security. Second, the CIA provides results for only one type of commodity: agricultural products, which include all non-processed agricultural items, such as cereals, seeds, and vegetables. However, it does not address flour, dairy, meat, and other processed foods, including animal-based products, even though Figure 3.5 indicates that a significant portion of food imports consists of processed food commodities. Moreover, it is impossible to isolate the impact of specific commodities that are particularly critical to food security, such as wheat or maize. Third, this work assesses the impact on the average price of imports, while most of the volatility in food prices is driven by fluctuations in food markets, which are linked to the balance between the supply and demand of food commodities and is therefore overlooked in this analysis. However, it remains unclear whether the mid-term measures would influence this volatility through an increase in transport costs. On the other hand, the heightened demand for shipping due to biofuels may also affect this volatility. Finally, focusing solely on imports disregards the resilience of domestic production and the potential increase in food security that could arise if the country were to become less dependent on imports for its own food needs.

Any policy design, in the absence of revenue distribution, leads to a decrease in the import quantities of agricultural products for most countries. The IMO's CIA finds an average decrease in agricultural products by 1.6% across all countries globally by 2050, assuming no revenue distribution (Figure 3.6). This figure does not vary significantly depending on the policy design. Meanwhile, Pereda et al. identify wheat and processed rice exports as two of the top 10 affected commodities, with global exports declining by 0.8%. The IMO's CIA estimates a decline of 0.3%-0.9% in agricultural product imports for Caribbean states by 2030 and 1.2%-3.9% by 2050, assuming no revenue redistribution. This decline is attributed to the increased cost of transporting goods to the region (Figure 3.6). Generally, revenue distribution compensates for this impact for developing countries and for SIDS overall. However, the group labelled "rest of American SIDS", which includes Belize, Guyana and Suriname among others, actually experiences a larger reduction when revenue distribution is considered, while the others do not see a significant change after redistribution (Figure 3.6). This suggests that redistribution mechanisms may not fully mitigate supply-side constraints or structural economic vulnerabilities in these nations.

Therefore, as discussed in Section 2.2, the results for each country should be interpreted with caution; it appears that agricultural product imports in the Caribbean region generally do not benefit significantly from revenue distribution.

Furthermore, the mid-term measures create inflationary pressure on agricultural products through two avenues:

- The increase in transport costs per se leads to a direct rise in the costs of imported commodities costs: the IMO's CIA finds that this effect is somewhat more limited in 2030 in the non-levy scenarios but remains similar across all scenarios in 2050, with the average import price increasing by 1.9% in 2050 across all countries and 2.7% to 3.3% across CARICOM countries (Figure 3. 7). This is significantly higher than the estimates in other studies, with Sheng et al. (2018) finding that food and crop import prices increase by 0.2%, which models a less ambitious policy (\$18/tonne CO₂); and Ogbugo et al. (2024) estimating an average increase in agricultural prices of 0.011% and processed food of 0.013% for a high levy scenario (\$100/tonne CO₂-eq).
- The distribution of revenue leads to a slight further increase in the imported commodity cost, so that the IMO's CIA finds that the price of imported agricultural products in CARICOM countries will increase from 2.8 to 3.4% by 2050 in the high levy scenario, where revenue is distributed to all developing countries (Figure 3. 7, scenario 26).

Comparatively, Sheng et al. (2018) model less ambitious policies (\$18/tonne CO₂) and find only a 0.2% increase in food and crop import prices, underscoring the sensitivity of results to policy assumptions. To put these figures into perspective, the increase in the prices of cereals and meat and seafood in the Caribbean between 2006 and 2008 was 77% and 17% respectively, 16% and 12% respectively between 2010 and 2011, and 15% and 16% respectively in the first year of the Covid pandemic (Forgenie et al., 2024). These episodes demonstrated the inelasticity of demand for staples while revealing reductions in the consumption of higher-cost proteins such as meat and seafood. This led to a significant decline in welfare and an increase in food insecurity, but the consumption of cereals and staples remained inelastic, whereas the consumption of meat and seafood, as well as dairy and eggs, decreased (Forgenie et al., 2024).

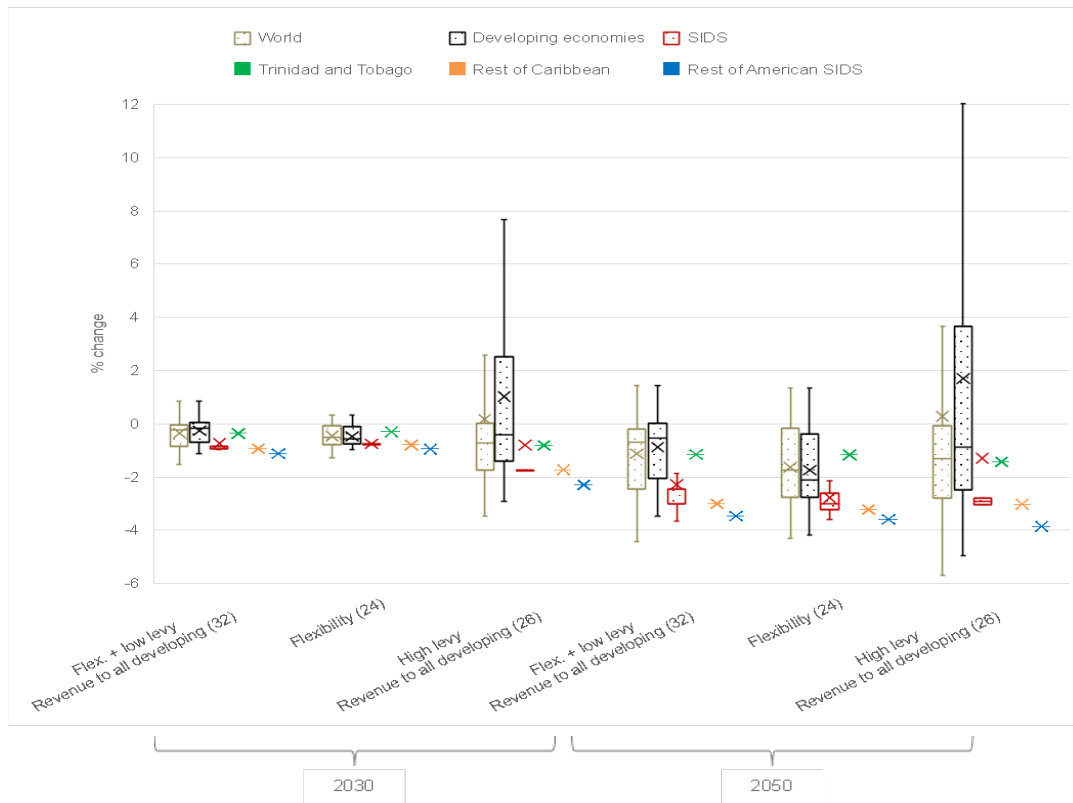


Figure 3. 6. Change in imported quantity of agricultural products. From (UNCTAD, 2024)

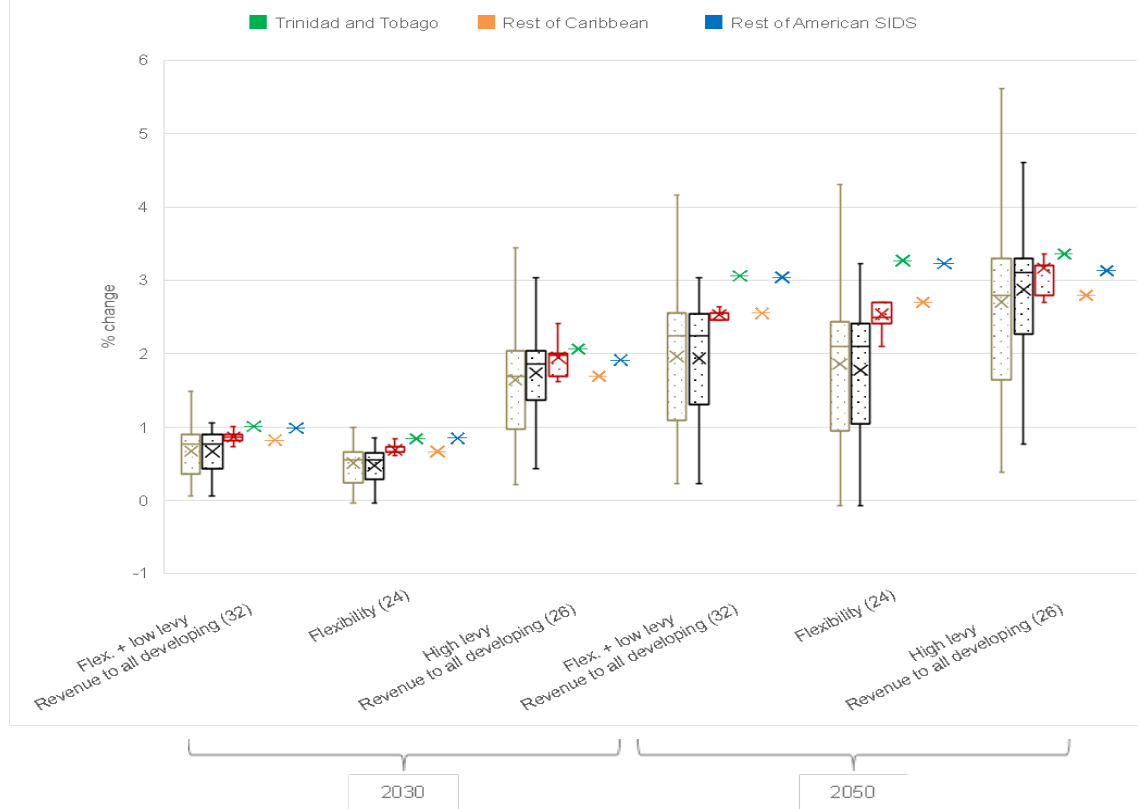


Figure 3. 7. Change in import price of agricultural products. From (UNCTAD, 2024)

While the mid-term measures' projected increases in food prices are lower than these historical spikes, they still pose significant risks, particularly for low-income households in Haiti, Jamaica, and other vulnerable states. The increase in transport costs will directly affect the affordability of key staples, particularly for countries like Jamaica, where food imports constitute a significant share of GDP. Revenue redistribution can partially offset these costs but must be complemented by targeted investments to improve food affordability for low-income populations.

Additionally, Caribbean countries already contend with volatile food prices due to external supply shocks and climatic events (Rhiney & Barker, 2018). Increases in transport costs will further destabilise local food markets unless mitigated by policy interventions such as subsidies or price stabilisation funds. There are wider social implications as rising food prices are likely to disproportionately impact diet quality, leading households to shift towards cheaper, calorie-dense foods to offset higher staple costs. This could worsen public health challenges related to malnutrition and non-communicable diseases in the region.

3.6.3. Policy Implications and Recommendations

Given the projected impacts of the mid-term measures on food security, Caribbean governments and regional organisations should consider a number of key policy responses. For example, investments in sustainable agriculture, such as hydroponics and aquaponics (Beckford & Rhiney, 2016), can diminish reliance on imports and bolster food security. Countries like Belize and Guyana, which already boast robust agricultural sectors, could assume a regional role by exporting staples to other Caribbean nations, thereby reducing dependency on extra-regional imports.

Additionally, carbon levy revenues should be directed toward reducing the cost of food imports through subsidies or investments in efficient transportation and logistics systems. Regional governments ought to prioritise infrastructure that alleviates bottlenecks in the food supply chain, such as modernised ports and storage facilities. Furthermore, regional cooperation is vital for pooling resources. Through institutions like CARICOM, the Caribbean can support regional food security initiatives, such as joint investments in agricultural research and development, and the strengthening of intra-regional trade agreements, which could facilitate the distribution of locally produced staples throughout the Caribbean.

As the region prepares for the impacts of the IMO's mid-term measures, social protection programs will become increasingly needed. Governments will need to consider expanding food assistance programs for vulnerable populations, which can help mitigate the immediate effects of food price increases. Nutrition education initiatives can also help households maintain diet quality despite rising costs.

3.7. CONCLUSION

This report examines the potential impacts of the IMO's mid-term measures on the economies of CARICOM countries by conducting a literature review of the economic assessments of increased transport costs in these countries' economies. The IMO's mid-term measures, designed to reduce GHG emissions in international shipping, are expected to introduce both technical and economic components, such as fuel standards and a carbon levy. However, the economic impacts are unevenly distributed, with SIDS particularly vulnerable due to their dependency on imports, geographic isolation, and reliance on sectors like tourism.

In particular, the economic impacts on the Caribbean Community highlight significant vulnerabilities due to their structural characteristics, including a high dependency on imports, reliance on tourism, and limited economies of scale in shipping. Our results indicate that increased shipping costs could reduce CARICOM GDP by an estimated 0.1% to 1.3%, depending on the model and scenario. The resulting inflationary pressure on consumer prices ranges from 0.03% to 1.8%. Food security remains a pressing issue, as the region relies heavily on imports for critical commodities like wheat and maize. These measures are expected to raise food import prices by up to 3.4% by 2050, further straining households that are already vulnerable to economic shocks.

Despite these challenges, the redistribution of carbon levy revenues offers opportunities for CARICOM countries to mitigate negative impacts. Strategic use of these revenues, combined with targeted investments in renewable energy, green port infrastructure, sustainable agriculture, and regional trade integration, could enhance resilience and long-term economic competitiveness. This, therefore, provides an impetus for transformative investments in building regional resilience and sustainability. This will require crucial proactive and regionally coordinated policy responses to ensure that the region not only mitigates the negative impacts but also seizes the opportunities to build a more diversified and sustainable economic future.

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An aerial photograph of a port area. On the left, a large white cruise ship with a yellow funnel is docked. In the center, a container ship is docked at a pier with several yellow gantry cranes. The water is a clear blue-green, and the sky is bright blue with a few wispy clouds. The text 'SECTION 4' is overlaid in the center of the image.

SECTION 4

DISTRIBUTING SHIPPING CARBON REVENUE IN THE CARIBBEAN SMALL ISLAND DEVELOPING STATES

DISTRIBUTING SHIPPING CARBON REVENUE IN THE CARIBBEAN SMALL ISLAND DEVELOPING STATES

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List of Abbreviations

AIS	Automatic Identification System
CARICOM	Caribbean Community and Common Market
CCCCC	Caribbean Community Climate Change Centre
CCREEE	Caribbean Centre for Renewable Energy and Energy Efficiency
CIA	Comprehensive Impact Assessment
CMU	Caribbean Maritime University
CO₂	Carbon Dioxide
DAN	Disproportionately Affected Nation
DNV	Det Norske Veritas
EE	Energy Efficiency
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
GCF	Green Climate Fund
GHG	Greenhouse Gas
ICE	Internal Combustion Engines
IMO	International Maritime Organization
IRENA	International Renewable Energy Agency
LDCs	Least Developed Countries
LNG	Liquefied Natural Gas
LSHFO	Low-Sulphur Heavy Fuel Oil
NO_x	Nitrogen Oxides
OECD	Organization for Economic Cooperation and Development
PM	Particulate Matter
RD&D	Research, Development, and Deployment
SIDS	Small Island Developing States
SO₂	Sulphur Dioxide
SDG	Sustainable Development Goal
UNFCCC	United Nations Framework Convention on Climate Change
UNTAD	UN Trade and Development
USD	US Dollar
UWI	University of the West Indies
WFR	World Fleet Register

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EXECUTIVE SUMMARY

This report examines the decarbonisation of the Caribbean maritime sector within the framework of the International Maritime Organization's (IMO) mid-term measures to reduce greenhouse gas (GHG) emissions. It highlights the challenges and opportunities for Caribbean Small Island Developing States (SIDS), particularly CARICOM nations, in accessing and utilising revenues generated from global carbon pricing mechanisms. Given the region's heavy reliance on shipping for trade, tourism, and energy exports, a just and equitable transition is critical to ensuring economic resilience and sustainability.

The Caribbean's maritime emissions are shaped by its unique economic structure, with cruise tourism, container trade, and energy exports playing pivotal roles. Cruise tourism, a major economic driver, contributes significantly to emissions due to the high energy demands of passenger vessels. Similarly, CARICOM's dependence on imports results in inefficient cargo flows, increasing per-ton emissions. Additionally, energy exports—particularly from Trinidad and Tobago and Guyana—add to the region's carbon footprint, necessitating a strategic approach to decarbonisation that balances economic imperatives with environmental sustainability.

In response to these challenges, the IMO's mid-term measures, including carbon levies and emissions trading, are expected to generate between \$500 billion and \$1.72 trillion globally by 2050. However, the effectiveness of these measures for the Caribbean depends on how revenues are distributed. Without targeted support, regional shipping operators, many of whom rely on older, less efficient vessels, may face financial disadvantages, making the transition to low-carbon shipping more costly and difficult.

Two potential revenue scenarios are evaluated:

- a) a low levy scenario, generating approximately \$500 billion by 2050, which would provide limited funding for maritime decarbonisation in SIDS, and
- b) a high levy scenario, generating up to \$1.72 trillion, which could significantly support the transition but may also impose higher financial burdens on Caribbean economies in the short term.

The disparity in revenue distribution highlights the need for proactive engagement by CARICOM to secure a fair share of these funds for investment in sustainable maritime practices.

To fully capitalise on carbon revenues and ensure a just transition, CARICOM countries must prioritise strategic investments in key areas. This includes green port infrastructure, such as alternative fuel bunkering and shore power systems, to reduce emissions at ports; fleet modernisation, through retrofitting vessels to run on alternative fuels like methanol, ammonia, and hydrogen; and capacity building,

ensuring that regional stakeholders have access to the training and technological advancements necessary to support a low-carbon maritime economy.

Given the region's economic and environmental vulnerabilities, equitable revenue distribution is essential. CARICOM must advocate for a funding model that accounts for the disproportionate impact of climate change on SIDS and supports both maritime decarbonisation and broader economic resilience. Strengthening regional collaboration will be key to maximising investments in sustainable shipping while ensuring that revenues also address critical needs such as food security, climate adaptation, and economic diversification.

The IMO's revenue distribution mechanism presents a transformative opportunity for Caribbean SIDS to align maritime decarbonisation with their long-term development goals. By actively engaging in global policy discussions and strategically directing investments, CARICOM can secure a sustainable and resilient future, ensuring that the benefits of the low-carbon transition are equitably shared across the region.

4.1. Introduction

In 2023, the Marine Environmental Protection Committee of the International Maritime Organization (IMO) adopted the revised strategy, aimed at reducing greenhouse gas (GHG) emissions from international shipping. This strategy is the newest milestone on the road to developing a comprehensive IMO strategy for reduction of GHG emissions from ships. The revised strategy envisions net-zero GHG emissions by approximately 2050 and sets interim targets of a 20% reduction by 2030 (striving for 30%) and a 70% reduction by 2040 (potentially reaching 80%), all relative to 2008 levels. To achieve these targets, the strategy mandates the adoption of globally enforceable “mid-term measures,” by 2025. These measures are expected to include a goal-based marine fuel standard regulating the phased reduction of the marine fuel's GHG intensity and an economic mechanism, such as a GHG emissions pricing system, designed to reduce emissions. In addition, these measures should effectively promote the energy transition and provide the world fleet with a needed incentive while also contributing to a level playing field and a just and equitable transition. The potential revenue from these economic measures is significant, with estimates suggesting up to \$3.7 trillion may be generated globally between 2027 and 2050 (Englert, 2022).

All economic elements on the table would raise some revenue, but some of the measures discussed would raise significant amounts (up to \$1.5 trillion between now and 2050) (Englert, 2022). The IMO's commissioned comprehensive impact assessment of the mid-term measures estimated that a levy of \$150-\$300 per ton could yield \$127 billion annually between 2027 and 2030 (DNV, 2024). However, the revenue is expected to decrease to \$103 billion from 2031 to 2040 and \$36 billion from 2041 to 2050, as emissions decline (DNV, 2024). Therefore, effective distribution of this revenue can address key aspects of equitable transition in shipping (Fricaudet et al., 2024; Xu & Miao, 2023) by:

- a) Compensating countries for disproportionately negative impacts of GHG policies.
- b) Promoting technological inclusivity, enabling all countries to participate in the low-carbon transition.
- c) Reducing future shipping emissions to mitigate climate harm.
- d) Addressing climate vulnerability by financing climate adaptation and resilience efforts.

Caribbean countries, like other Small Island Developing States (SIDS), are likely to be particularly impacted by the implementation of the shipping mid-term measures. These countries face potential increases in transport costs due to mid-term measures, (point 1), while also grappling with severe climate impacts partially caused by shipping emissions. (points 3 and 4). Additionally, they would need to invest in low-carbon technologies, such as alternative fuels and energy-efficient infrastructure. However, in

some Caribbean countries, those investments might be hindered by macro-economic, social and governance factors (transition readiness (Fricaudet et al., 2024), such as a higher cost capital, which when combined with the anticipated impacts, might make the transition to low-carbon shipping more costly and difficult (OECD, 2024)(point 2).

Many of these challenges can be addressed through regional collaboration in shared technological investments and pooled resources. By building shared infrastructure, creating joint financial mechanisms, coordinating policies, and fostering cooperation in areas such as climate change and technology development, CARICOM member states can enhance their collective resilience, reduce costs, and promote sustainable development. Ultimately, pooling resources across borders allows for more effective and efficient solutions to common regional challenges, leading to greater economic and political stability in the Caribbean, as discussed further in section 5.

Given these dynamics, this report critically examines the needs of Caribbean SIDS to access IMO-generated revenue. It focuses on CARICOM countries, given their shared regional characteristics and economic interdependencies. The report first characterises the maritime landscape of the region (Section 2), explores the scale and rationale for revenue distribution (Section 3), and assesses specific investment needs for low-carbon transitions in the Caribbean (Section 4). The report concludes with actionable recommendations for equitable revenue allocation (Section 5). The methods, sources and assumptions used to estimate the quantitative results presented throughout the report are detailed in its technical annex.

4.2. Characterisation of ships and maritime energy supply in the Caribbean

The characterisation of ships and maritime energy supply in the Caribbean region is essential for understanding the unique dynamics of the region's shipping industry and its role in the global transition toward decarbonisation. This characterisation accounts for the region's distinct maritime landscape, where small- to medium-sized vessels dominate due to the prevalence of inter-island shipping, tourism-dependent cruise operations, and regional trade flows. Shipping energy consumption and emissions are estimated based on the 2018 data used IMO's 4th Greenhouse Gas Study (Faber, et al., 2020) (see details on the methods in the technical annex). This approach provides critical insights into the energy demand and greenhouse gas emissions associated with vessel activity in a region that relies heavily on maritime transport for economic sustainability.

As a vibrant maritime environment, the Caribbean is home to a diverse maritime sector. The sector represents a mix of commercial shipping, and cruise tourism, as well as small islands that rely heavily on the region's maritime trade for economic survival. The types of ships include:

- a) **Cargo Vessels:** The Caribbean region has significant ports for the transshipment of goods, including bulk carriers, container ships, and tankers (Miller & Clayton, 2023). These are crucial for the flow of goods between regional and international markets.
- b) **Passenger Vessels:** The Caribbean is a popular cruise destination, and it hosts large ships and ferries that operate between islands. Passenger vessels also include yachts and other smaller leisure vessels which together, make up a significant part of the region's maritime traffic.
- c) **Fishing Vessels:** The region's reliance on fishing as a food source requires an extensive fishing fleet. This ranges from small artisanal boats to larger industrial trawlers.
- d) **Tankers and Oil Transport:** Given the Caribbean's strategic location for oil transit, tankers are a significant part of the region's maritime fleet

The Caribbean presents unique challenges and opportunities. The region's heavy dependence on fossil fuel imports and limited infrastructure for alternative fuels contrast with its potential for renewable energy solutions, such as wind and solar power, which could serve as inputs for the production of green hydrogen or ammonia. Additionally, the analysis considers the high frequency of ship movements between CARICOM countries and the vulnerability of SIDS to climate change impacts. Addressing these factors requires tailored solutions that align with the region's economic realities, while fostering innovation and resilience in maritime energy supply.

By integrating vessel-specific and operational data with regional considerations, this characterisation highlights pathways for transitioning the Caribbean's maritime sector toward low-carbon and energy-efficient operations. It underscores the need for investment in retrofitting regional fleets, enhancing port infrastructure for alternative fuels, and leveraging international support to build resilience and competitiveness in the global shipping market.

		import country																				Total		
		Antigua and Barbuda	Bahamas	Barbados	Belize	Dominica	Jamaica	Grenada	Guyana	Haiti	Montserrat	Saint Kitts, Nevis and Anguilla	Saint Lucia	Saint Vincent and the Grenadines	Suriname	Trinidad and Tobago	USA and Puerto Rico	Mexico	Spain	Brazil	China		Others	
e x p o r t c o u n t r y	Antigua and Barbuda	2	23	173	-	21	38	24	3	20	0	133	430	108	44	69	386	-	91	-	-	1 291	2 859	
	Bahamas	139	4 294	33	-	-	548	-	-	123	-	40	53	-	-	148	14 317	1 338	1 654	102	3 379	17 659	43 827	
	Barbados	147	68	-	5	46	144	141	66	-	4	120	393	72	5	320	134	-	291	88	-	1 870	3 915	
	Belize	-	62	-	36	-	65	-	-	6	-	-	-	-	-	-	1 286	1 147	-	8	-	1 048	3 659	
	Dominica	24	2	106	-	4	11	22	4	-	7	24	56	15	3	5	32	-	-	6	-	321	641	
	Jamaica	7	425	13	120	3	1 385	1	24	220	-	12	-	1	-	448	4 561	1 152	66	509	285	12 609	21 842	
	Grenada	22	-	119	-	27	15	-	13	4	-	66	87	152	98	91	32	-	20	23	0	625	1 394	
	Guyana	19	-	31	-	-	22	19	132	9	-	4	27	8	178	687	159	20	135	33	2	1 007	2 491	
	Haiti	14	189	14	18	2	675	-	26	80	-	3	1	-	-	13	1 996	339	-	28	0	1 107	4 505	
	Montserrat	4	-	-	-	1	-	2	-	-	0	10	1	0	-	3	-	17	-	-	-	77	114	
	Saint Kitts, Nevis and Anguilla	258	14	57	-	36	18	30	2	3	23	7	152	13	3	13	1 008	88	44	6	-	1 463	3 237	
	Saint Lucia	121	23	386	-	31	81	130	30	-	2	366	71	76	18	124	335	-	15	100	-	1 386	3 296	
	Saint Vincent and the Grenadines	19	6	218	-	35	3	104	6	-	-	43	90	42	5	152	55	-	0	14	1	405	1 199	
	Suriname	37	-	28	-	1	21	3	239	2	-	1	15	4	27	308	74	2	3	60	1	885	1 710	
	Trinidad and Tobago	41	78	194	1	8	675	206	546	12	2	5	86	113	394	2 134	4 194	674	1 853	2 066	1 394	22 034	36 712	
	USA and Puerto Rico	620	13 661	219	737	9	5 850	34	135	1 469	-	525	270	8	21	3 113								
	Mexico	-	1 110	11	974	2	986	-	41	23	-	-	10	-	-	485								
	Spain	87	758	271	-	-	315	-	29	71	-	9	4	1	23	1 950								
	Brazil	-	384	90	-	-	597	-	36	43	-	26	123	-	29	2 693								
	China	-	223	-	-	-	1 414	1	-	-	-	-	-	1	1	677								
Others	1 196	12 213	1 752	1 256	308	11 682	307	434	2 145	45	2 057	1 127	270	1 197	16 457									
Total	2 757	33 532	3 714	3 148	534	24 545	1 024	1 765	4 230	83	3 452	2 996	886	2 047	29 892									

Figure 4.1. Energy consumed of voyages leaving and arriving in the CARICOM countries, by partner country (EJ/year)
Derived from the 2018 AIS data used for the IMO 4th GHG study (Faber et al, 2020). See technical annex for further details.

4.2.1. Caribbean Energy Demand

Bottom-up Automatic Identification System (AIS)-derived estimates provide a granular and nuanced understanding of vessel activity within the Caribbean, enabling the disaggregation of energy demands and GHG emissions by vessel type, size, and route. This approach offers a more detailed and comprehensive view of the maritime sector's contribution to the region's energy use and emissions, which is crucial for shaping effective decarbonisation strategies. The Caribbean maritime landscape is complex, with diverse activities such as international shipping, regional trade, and cruise tourism, each of which generates distinct energy demands and emissions profiles. By using AIS data, policymakers can gain a clearer picture of where interventions will be most effective and how different regions and sectors contribute to the broader environmental impact.

Figure 4.1 illustrates the energy demands associated with international voyages within CARICOM countries, offering valuable insights into the region's maritime energy dynamics. The data reveal a clear trend, that is, energy demands related to intra-CARICOM activity are highly concentrated in a few economies, namely Trinidad and Tobago, The Bahamas, and Jamaica. This concentration of energy demand reflects the economic geography of the region, where these countries serve as key maritime hubs for both international and regional trade. The dominance of these hubs is further amplified by their strategic geographic locations, acting as central points for transshipment and major gateways for both goods and passengers in the Caribbean. Consequently, addressing energy demands and emissions in these concentrated areas will be critical in reducing the overall environmental footprint of the Caribbean maritime sector.

Trinidad and Tobago's substantial energy demands are tied to its robust petroleum and liquefied natural gas (LNG) export sector, which drives high levels of maritime activity. The country's ports, particularly the Port of Port of Spain, play a pivotal role in handling large volumes of cargo and passenger vessels, including container ships, bulk carriers, and oil tankers. This extensive maritime traffic contributes significantly to GHG emissions, with the Port of Port of Spain being a notable emitter of CO₂, nitrogen oxides (NO_x), sulphur dioxide (SO₂), and particulate matter (PM). Furthermore, the cruise industry, which relies heavily on high-sulfur bunker fuels, exacerbates local air pollution, highlighting the urgent need for cleaner alternatives. The intersection of energy exportation with cruise tourism in Trinidad and Tobago underscores the dual challenge of decarbonising both industrial and tourism-related maritime activities, necessitating a multi-faceted approach to emission reductions in this key regional hub.

Similarly, The Bahamas is a major player in the global cruise industry, hosting one of the world's largest ship registries and experiencing significant energy demands from large passenger and cargo vessels. Freeport, a key transshipment hub in the Caribbean, handles a wide variety of goods, contributing to a substantial amount of

maritime traffic. In addition to this, port operations, which rely on diesel-powered cranes and trucks, add to the region's GHG emissions, primarily in the form of CO₂, NO_x, and particulate matter. The high volume of cruise ships passing through The Bahamas exacerbates the environmental burden, as these ships typically burn heavy fuel oil, which is a major source of air pollution. The dual role of Freeport as both a transshipment hub and a major cruise destination reinforces the complexity of decarbonising the maritime sector in this region, as the heavy vessel traffic further complicates efforts to reduce emissions in one of the most tourism-dependent economies in the Caribbean.

Jamaica, with its Port of Kingston, hosts the Caribbean's largest and busiest transshipment hub, positioning the country as a central player in international trade and regional connectivity. The port handles a diverse range of vessels, including container ships, bulk carriers, and cruise ships, all of which contribute to the region's energy demands and emissions. The emissions from these vessels, particularly SO₂, NO_x, and CO₂, are significant, given the scale of maritime activity at the port. Moreover, the Port of Kingston is central not only to trade but also to regional integration, linking various Caribbean economies. Given Jamaica's strategic importance, the country faces both an opportunity and a challenge in balancing its role as a maritime hub with the need to transition toward cleaner and more sustainable energy solutions in its shipping sector.

Additionally, United States Caribbean territories such as the US Virgin Islands and Puerto Rico also contribute to high energy demands due to their role in transshipment, cruise tourism, and trade with mainland USA (Miller & Clayton, 2023). San Juan, a crucial cruise hub, is particularly notable for its high emissions, especially from cruise ships that rely on heavy fuel oil. These ships produce large amounts of CO₂, NO_x, and sulphur-based pollutants, contributing to local air pollution and posing challenges for the region's environmental health. The additional energy demand from port operations, including the use of diesel-powered cargo handling equipment and trucks, further compounds the environmental impacts of maritime activity in these territories. The U.S. Caribbean territories' integration into regional trade and tourism flows highlights the need for a coordinated approach to energy transition that includes both local and external stakeholders in the push for decarbonisation.

In contrast, smaller CARICOM economies such as St. Vincent and the Grenadines or Grenada exhibit relatively low energy demands, which are indicative of their limited industrial shipping activities. These smaller nations rely more heavily on smaller vessels for inter-island trade, resulting in a comparatively lower energy footprint. However, this disparity in energy demands also underscores the challenges that smaller states face in terms of maritime infrastructure. These countries often depend on the energy systems and maritime infrastructure of larger regional economies for their shipping needs. As such, the lower energy demands in smaller states should not result in their marginalisation in regional decarbonisation plans. Instead, these nations

must be integrated into broader efforts to build sustainable and resilient maritime infrastructure that can serve all CARICOM members, regardless of their individual energy footprints.

The data therefore highlights two key challenges for the Caribbean: first, the need for targeted decarbonisation strategies that address the high energy demands concentrated in a few countries, and second, the necessity of ensuring that smaller economies are not overlooked in regional energy transition plans. While larger economies have the infrastructure and resources to lead the transition, it is critical that the Caribbean collectively develops inclusive strategies that ensure equitable access to the benefits of decarbonisation. This could involve investing in renewable energy infrastructure that serves both large and small economies, creating shared resources for alternative fuels, and ensuring that smaller states have access to the technology and funding needed to modernise their maritime fleets. Regional collaboration will be key to achieving a just and equitable transition for the Caribbean's diverse economies.

In conclusion, the insights derived from bottom-up AIS data highlight the complexity of maritime energy demands and emissions in the Caribbean. These findings call for a strategic, integrated approach to decarbonisation that recognises the varying energy needs across the region. By fostering regional collaboration and ensuring that all CARICOM members, regardless of size, are included in decarbonisation efforts, the Caribbean can transition to a more sustainable maritime sector that meets the challenges of climate change while fostering economic development. The diverse energy profiles of CARICOM countries, from large maritime hubs to smaller island states, must be addressed through tailored solutions that maximise the benefits of renewable energy and minimise the environmental impacts of shipping.

4.2.2. Trends in CO2 Emissions within the CARICOM Region

Trends in CO2 emissions within the CARICOM region reflect patterns observed in energy demand, as illustrated in Figure 4.2. The majority of emissions are concentrated in the maritime corridors of the dominant countries (Trinidad and Tobago, The Bahamas, the United States, and Jamaica). These countries serve as pivotal hubs for regional and international shipping, driven by factors such as their strategic locations, economic significance, and the presence of major ports. In contrast, the remaining CARICOM countries exhibit significantly lower CO2 emissions, indicative of their smaller-scale maritime activity and limited port infrastructure.

		import country																						
		Antigua and Barbuda	Bahamas	Barbados	Belize	Dominica	Jamaica	Grenada	Guyana	Haiti	Montserrat	Saint Kitts, Nevis and Anguilla	Saint Lucia	Saint Vincent and the Grenadines	Suriname	Trinidad and Tobago	USA and Puerto Rico	Mexico	Spain	Brazil	China	Others	Total	
e x p o r t c o u n t r y	Antigua and Barbuda	0	2	13	-	2	3	2	0	2	0	10	33	8	3	5	30	-	7	-	-	99	220	
	Bahamas	11	330	2	-	-	42	-	-	10	-	3	4	-	-	11	1 091	103	128	8	262	1 364	3 369	
	Barbados	11	5	-	0	4	11	11	5	-	0	9	30	6	0	24	10	-	23	7	-	143	300	
	Belize	-	5	-	3	-	5	-	-	0	-	-	-	-	-	-	99	89	-	1	-	81	282	
	Dominica	2	0	8	-	0	1	2	0	-	0	2	4	1	0	0	2	-	-	0	-	25	49	
	Jamaica	1	33	1	9	0	103	0	2	17	-	1	-	0	-	34	350	89	5	39	22	963	1 669	
	Grenada	2	-	9	-	2	1	-	1	0	-	5	7	12	7	7	2	-	2	2	0	48	107	
	Guyana	1	-	2	-	-	2	1	10	1	-	0	2	1	13	52	12	1	10	3	0	77	190	
	Haiti	1	15	1	1	0	52	-	2	6	-	0	0	-	-	1	153	26	-	2	0	85	346	
	Montserrat	0	-	-	-	0	-	0	-	-	0	1	0	0	-	0	-	-	1	-	-	6	9	
	Saint Kitts, Nevis and Anguilla	20	1	4	-	3	1	2	0	0	2	0	12	1	0	1	78	7	3	0	-	113	249	
	Saint Lucia	9	2	30	-	2	6	10	2	-	0	28	5	6	1	10	26	-	1	8	-	107	254	
	Saint Vincent and the Grenadines	1	0	17	-	3	0	8	0	-	-	3	7	3	0	12	4	-	0	1	0	31	92	
	Suriname	3	-	2	-	0	2	0	18	0	-	0	1	0	2	23	6	0	0	5	0	68	131	
	Trinidad and Tobago	3	6	15	0	1	50	16	41	1	0	0	7	9	30	161	305	51	116	155	99	1 530	2 596	
	USA and Puerto Rico	48	1 046	16	57	1	450	3	10	113	-	41	21	1	2	231								
	Mexico	-	86	1	75	0	76	-	3	2	-	-	1	-	-	36								
	Spain	7	59	21	-	-	24	-	2	5	-	1	0	0	2	126								
	Brazil	-	30	7	-	-	46	-	3	3	-	2	10	-	2	206								
	China	-	14	-	-	-	110	0	-	-	-	-	-	0	0	43								
Others	92	942	134	97	24	901	24	33	165	3	158	87	21	91	1 158									
Total	213	2 575	285	243	41	1 887	79	134	325	6	265	231	68	156	2 144									

Figure 4.2. CO2 emissions of voyages leaving and arriving in the CARICOM countries, by partner country (thousand tonnes CO2/year)

**Derived from the 2018 AIS data used for the IMO 4th GHG study (Faber et al, 2020). See technical annex for further details.*

The concentration of CO₂ emissions in these specific country-pairs is tied to the unique economic and geographical characteristics of the Caribbean. Trinidad and Tobago, as a major exporter of LNG and petroleum products, contributing to high levels of outbound shipping activity; Jamaica, as a key transshipment hub, facilitates substantial cargo movement between North and South America; and the Bahamas' active cruise ship industry that adds to its emission footprint.

This uneven distribution of emissions poses a dual challenge for the region. First, high-emission hubs like those mentioned above, must prioritise investments in decarbonisation technologies, such as shore power systems for ports, retrofitting vessels for energy efficiency, and exploring alternative fuels like green ammonia or hydrogen. While, smaller regional maritime economies face the risk of being excluded from the decarbonisation transition due to limited financial and technical capacity, necessitating regional cooperation and external support.

The findings, therefore, underscore the need for tailored policy responses. This requires a regional framework that facilitates shared access to funding mechanisms, promotes standardised emissions reduction practices, and incentivises collaboration among CARICOM members. For example, leveraging Trinidad and Tobago's expertise in energy production or Jamaica's established shipping networks, that could benefit smaller economies seeking to reduce their carbon footprint.

Ultimately, these trends reveal a critical opportunity for CARICOM to position itself as a leader in sustainable maritime practices. By addressing emission disparities through a unified strategy, the region can enhance its competitiveness, reduce environmental vulnerabilities, and contribute meaningfully to global decarbonisation efforts.

4.2.3 Analysis of Energy Demand Concentration in CARICOM Ports

Figure 4.3 highlights the top 20 ports in CARICOM countries ranked by total energy demands associated with arriving voyages. The data reinforces the trend observed in Figure 4.1 and Figure 4.2, which demonstrate that energy demands are heavily concentrated within a small subset of CARICOM countries. This distribution reflects the asymmetric development of maritime infrastructure and shipping activity across the region, with a significant share of energy demand concentrated in the Bahamas, Trinidad and Tobago, and Jamaica.

The top seven ports by arriving energy demand include Freeport (Bahamas), Point Fortin (Trinidad and Tobago), and Kingston (Jamaica), which collectively dominate regional energy demand. Freeport emerges as the largest energy-demanding port in the CARICOM region, with approximately 16 Petajoule of arriving energy demand. This is largely attributable to Freeport's position as a major transshipment hub and its role in handling high volumes of international cargo. Similarly, Point Fortin's energy demand, exceeding 8 PJ, is closely tied to Trinidad and Tobago's position as a key exporter of LNG and petroleum products. Kingston, Jamaica, which also surpasses 8

PJ, highlights the dual importance of containerised trade and its role as a burgeoning cruise tourism destination.

Seven of the top 20 ports are situated outside these three countries, highlighting the uneven distribution of maritime activity and energy demands in the region. Ports in other CARICOM countries, such as Guyana and Suriname, exhibit emerging energy demands associated with expanding oil exploration and export activities, indicating potential shifts in regional energy dynamics. However, many smaller island nations continue to rely on low-volume inter-island trade and tourism, which limits their contribution to overall energy demand but offers unique opportunities for decarbonisation initiatives tailored to small-scale operations.

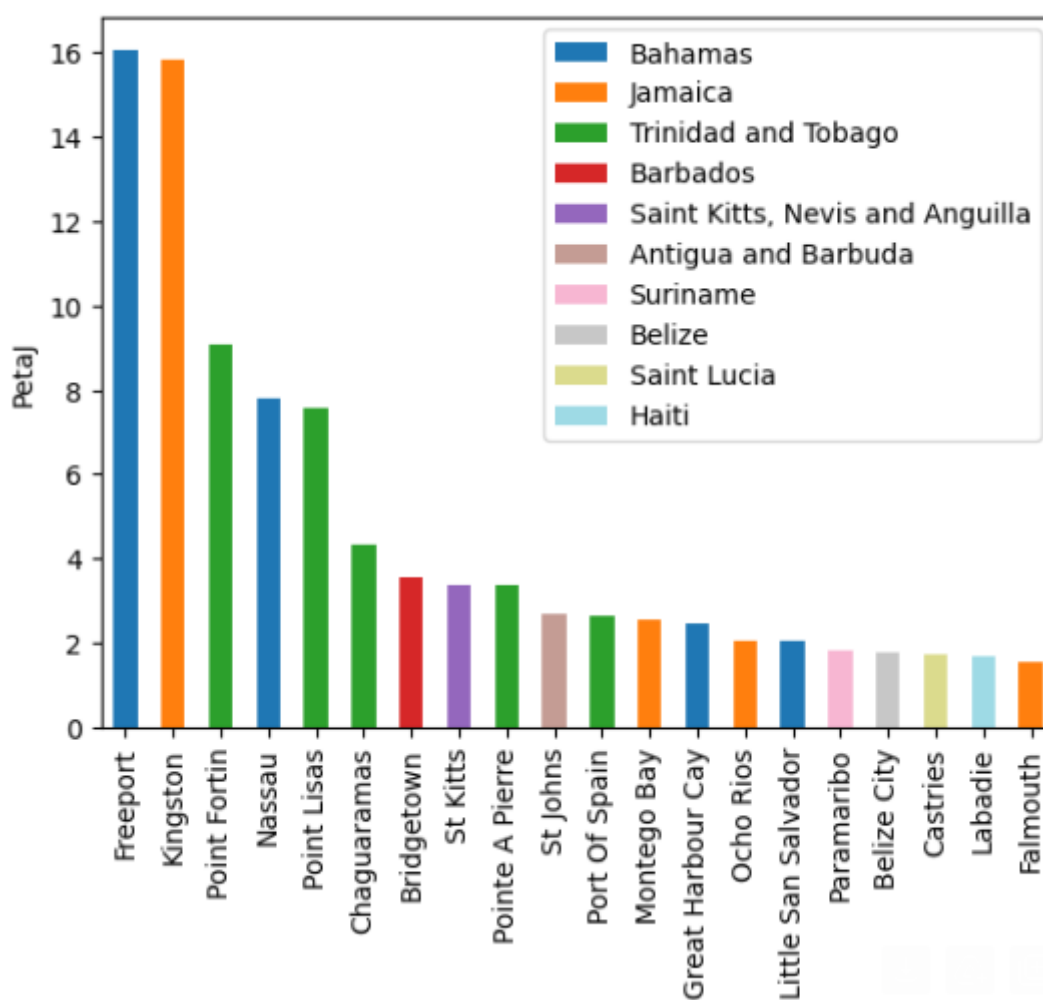


Figure 4.3. Energy demand for trips arriving to the top 20 port in 2018, by energy demand

This concentration of energy demand in a few strategic locations has important implications for policy and investment in the Caribbean. Targeted interventions in high-demand ports, such as implementing alternative fuel infrastructure and improving energy efficiency in operations, could yield significant reductions in GHGs. For smaller

ports and countries, there is potential to leverage regional collaboration to develop sustainable maritime strategies that address disparities in infrastructure and energy use. Furthermore, the geographic and economic realities of the Caribbean demand nuanced approaches that balance the needs of high-demand ports with those of smaller, less industrialised countries to ensure equitable access to the benefits of a decarbonised maritime sector.

This analysis calls therefore for robust regional cooperation, financial mechanisms, and technical support to ensure that the transition to sustainable energy use in CARICOM's maritime sector is inclusive and reflective of the diverse needs and capacities of the region. This includes fostering capacity-building initiatives to support smaller states with limited technical and financial resources, leveraging climate finance and public-private partnerships to fund decarbonisation projects, and developing tailored solutions that consider the region's reliance on shipping for trade and connectivity. By integrating these measures into CARICOM's maritime policies, the region can collectively navigate the challenges of decarbonisation while fostering sustainable development, promoting energy security, and safeguarding the livelihoods that depend on maritime activities.

4.2.4. Energy Demands of Top Ports in the CARICOM Region

Figure 4.4 highlights the energy demands associated with departing voyages from the top 20 ports across CARICOM countries, showcasing patterns that underscore the Caribbean's unique maritime dynamics of the Caribbean. As seen in Figure 4.4, departing voyages consistently demonstrate significantly higher energy demands than arriving voyages. This discrepancy reflects the Caribbean's heavy reliance on export-oriented shipping activities, which involve energy-intensive movements, especially for bulk cargo and fuel exports.

The data reveals that the Bahamas, Trinidad and Tobago, and Jamaica collectively dominate the region's maritime energy profile, hosting 13 of the 20 highest-demand ports. This clustering reflects their strategic geographic positions and roles as regional shipping hubs, key players in energy exports, and major centers for transshipment and tourism. Freeport in the Bahamas emerges as the most energy-intensive port for departing voyages. This dominance can be attributed to Freeport's role as a critical node in global transshipment networks and its capacity to accommodate large vessels due to its deep-water port infrastructure.

Trinidad and Tobago's ports, such as Point Fortin and Point Lisas rank among the highest in energy demands. These ports are pivotal to the export of oil, natural gas, and petrochemical products, highlighting the country's central role in the region's fossil fuel supply chain. This reliance on hydrocarbon-based exports poses a significant challenge to achieving maritime decarbonisation goals, especially as the global shipping industry moves toward adopting alternative fuels.

Jamaica’s ports, particularly Kingston, also feature prominently in the rankings, reinforcing its position as a critical transshipment hub. However, unlike Freeport and Trinidadian ports, Kingston’s energy profile is more diversified, including a mix of containerised cargo, bulk goods, and cruise ship activities.

A nuanced analysis of these trends reveals both opportunities and vulnerabilities for the Caribbean maritime sector. While the dominance of these ports reflects robust shipping activity and economic integration within global trade networks, it also underscores the region’s dependence on energy-intensive export industries. For CARICOM countries, this dependency creates a dual imperative: to decarbonise maritime operations in line with international regulations while maintaining economic competitiveness.

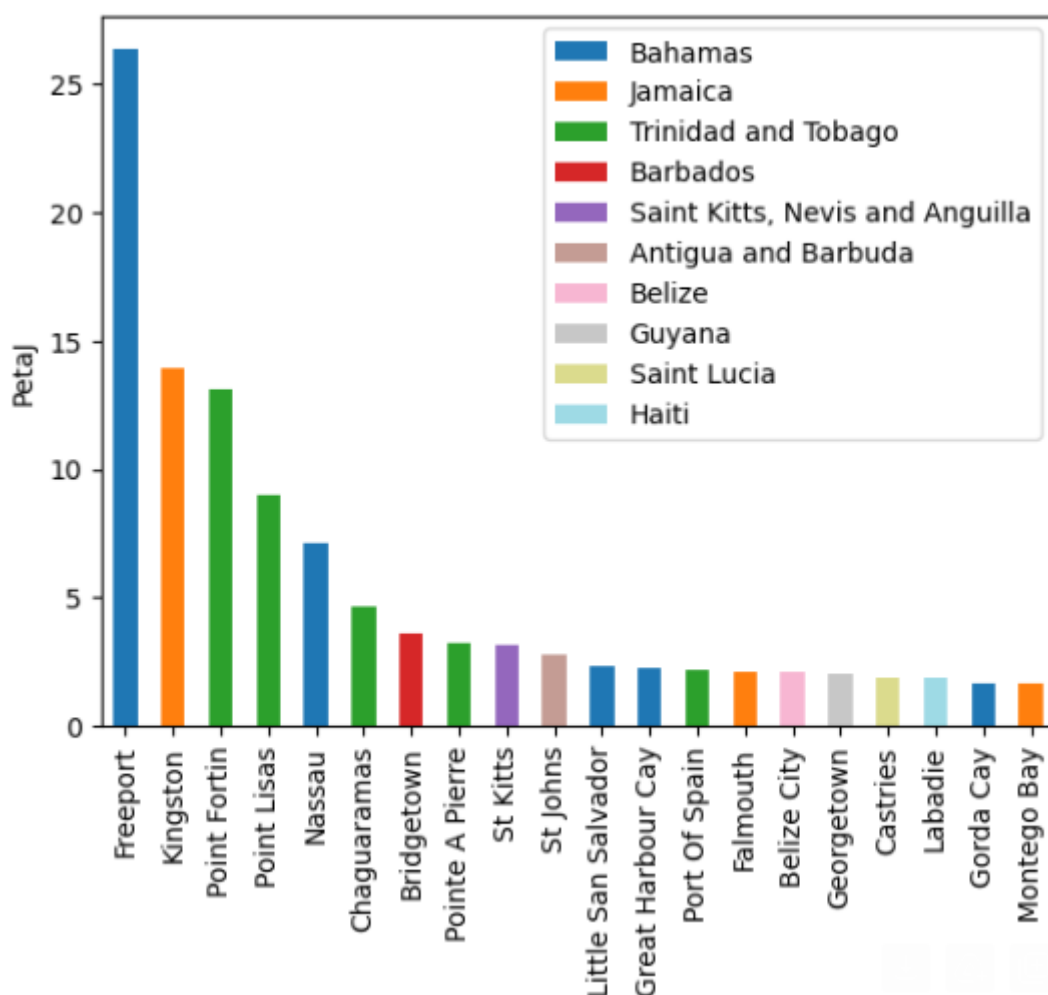


Figure 4.4. Energy demand for trips leaving the top 20 port in 2018, by energy demand

Strategies such as retrofitting vessels, adopting energy-efficient technologies, and transitioning port infrastructure to support alternative fuels will be critical for achieving these objectives. Additionally, leveraging regional cooperation to build capacity for renewable energy and green shipping initiatives could ensure a more sustainable

future for the region's ports. Investments in research and development, alongside partnerships with international agencies, will be essential to address the energy and environmental challenges posed by these high-demand ports.

By contextualising energy demands within broader economic and environmental considerations, this analysis underscores the urgency of aligning the Caribbean's maritime sector with the global transition to low-carbon shipping. It further highlights the need for tailored solutions that balance economic realities with sustainable development goals, ensuring resilience and competitiveness for the region's ports in the decades ahead.

4.2.5. Energy Demands and Vessel Segments in CARICOM Economies

The AIS-derived dataset reveals critical insights into the energy demands and CO2 emissions of various vessel types operating across the Caribbean, reflecting the unique maritime profile of CARICOM economies (Figure 4.5). A detailed analysis of energy demands highlights the outsized role of cruise ships, tankers, and containerships in shaping regional maritime energy demand.

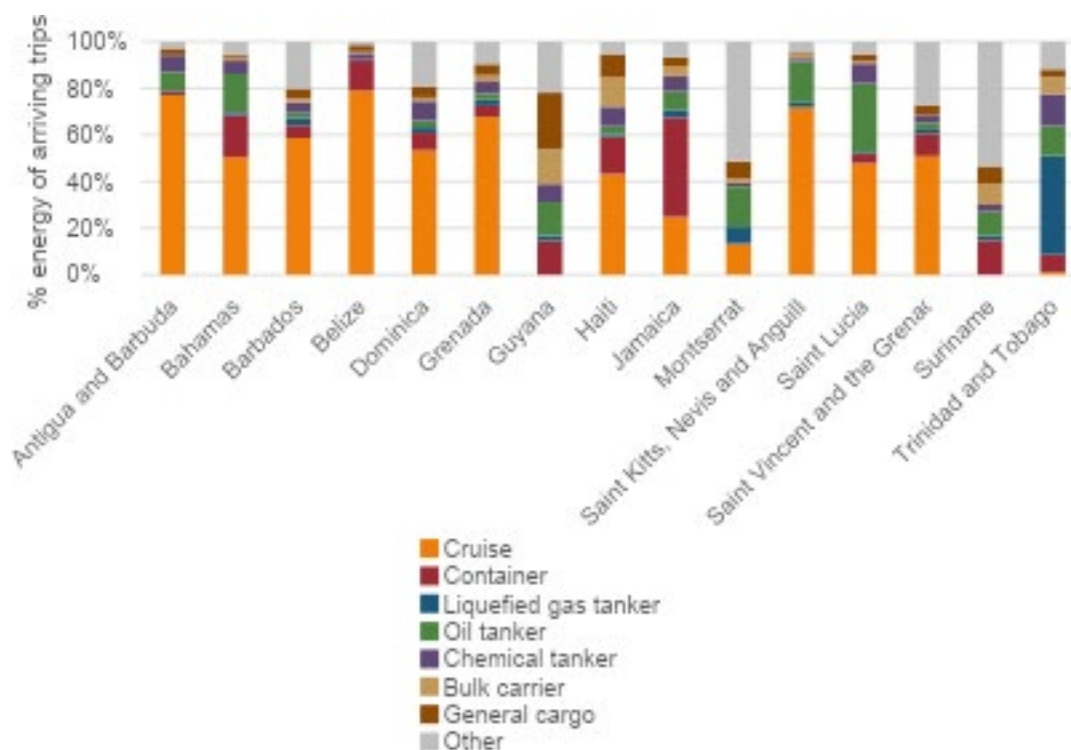


Figure 4.5. Proportion of energy demands by vessel type associated with arriving voyages into the CARICOM countries

Cruise ships emerge as the predominant energy consumers in several CARICOM economies. The heavy reliance on tourism across these countries drives this trend, with cruise activity contributing significantly to the energy demand profiles of destinations like Antigua and Barbuda, Belize, Grenada, and Saint Kitts and Nevis.

The centrality of cruise tourism to these economies underscores the need to align maritime decarbonisation strategies with the sustainability goals of the tourism sector. For example, encouraging shore power adoption and retrofitting cruise ships to accommodate cleaner fuels could reduce emissions without compromising economic benefits.

In addition, countries such as Barbados, Dominica, and Saint Vincent and the Grenadines, where cruise ships contribute to at least half of arriving energy demands should consider policies to attract investments in low-carbon tourism infrastructure. These could include developing green ports and initiatives to partner with cruise operators on energy-efficient itineraries.

Furthermore, the prevalence of tankers, particularly liquefied gas, oil tankers, and chemical tankers, underscores their importance in regional trade and energy supply networks. In Trinidad and Tobago, a hub for energy production in the Caribbean, tankers account for nearly two-thirds of arriving energy demands, reflecting the country's role as a major exporter of petroleum and natural gas products.

Saint Lucia also sees a substantial share of its energy demand attributed to tankers, which is indicative of its reliance on imported fuels for domestic energy needs. Similarly, countries such as the Bahamas, Jamaica, and Guyana, where tankers contribute more than 10% of energy demands, illustrate the interconnected nature of maritime transport and energy security in the region. Investments in cleaner tanker technologies, as well as policies promoting the regional adoption of alternative fuels such as biofuels and green hydrogen, could significantly reduce emissions while supporting energy trade within the Caribbean.

Containerships also play a critical role in sustaining trade and economic growth in the Caribbean. In Jamaica, where containerships account for 40% of arriving energy demands, this reflects the country's position as a key regional transshipment hub. Similar trends are observed in economies like Guyana, Suriname, and the Bahamas, where containerships constitute significant shares of energy demand.

Consequently, efforts to decarbonise this segment should focus on optimising trade routes, introducing energy-efficient vessel designs, and transitioning to alternative fuels such as ammonia or methanol. For example, Jamaica could utilise its strategic position to pilot green shipping corridors, thereby facilitating the movement of low-emission cargo across the Caribbean.

The AIS-derived dataset therefore underscores the diversity of maritime activity in the Caribbean and the need for tailored strategies to address sector-specific challenges. For cruise ships, the focus should be on green port infrastructure and sustainable tourism practices. For tankers, improving energy efficiency and transitioning to alternative fuels can strengthen energy security while aligning with global

decarbonisation goals. For containerships, enhanced trade efficiency and green corridors could ensure the region's competitiveness in international shipping markets. Ultimately, leveraging regional collaboration through CARICOM and global partnerships with the IMO and other entities will be essential for achieving a low-carbon maritime sector in the Caribbean.

4.2.5. Relative Shares of Energy Demand in CARICOM Maritime Activities

Figure 4.6 illustrates the distribution of energy demand for departing voyages from CARICOM countries, revealing a pattern closely aligned with the energy profiles of arriving voyages shown in Figure 4.5. This symmetry reflects the nature of maritime operations in the Caribbean, where key vessel segments, including cruise, container, and tanker ships, dominate energy consumption.

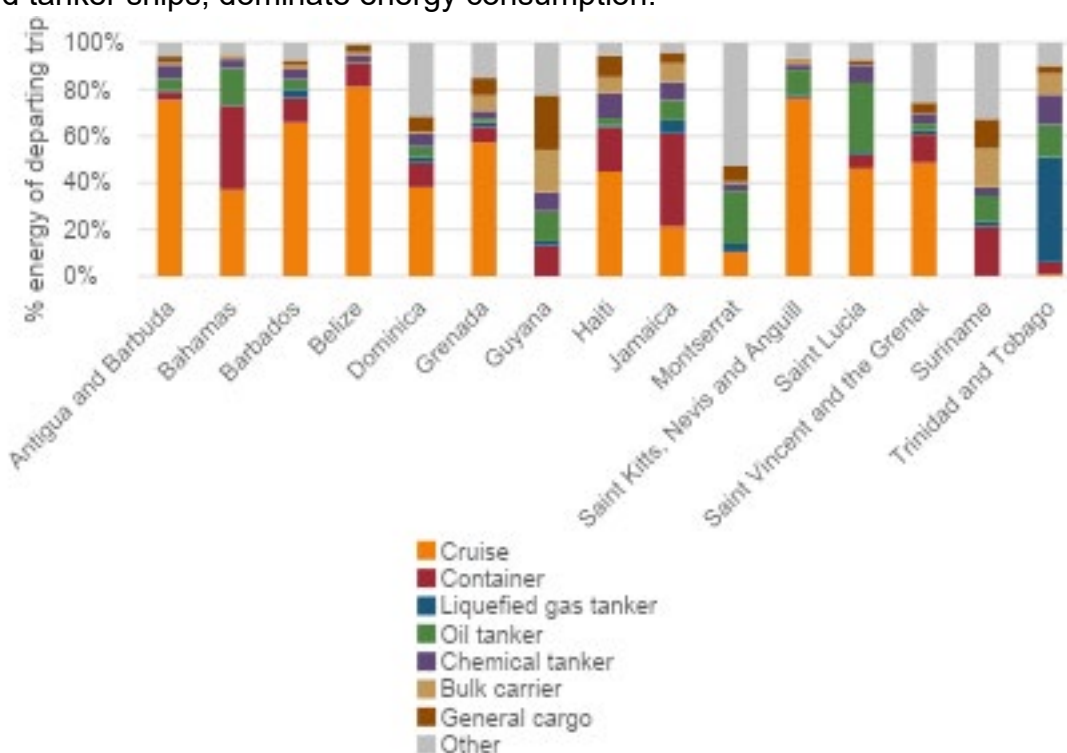


Figure 4.6. Proportion of energy demands by vessel type associated with arriving and departing voyages from the CARICOM countries

[OB]

The significance of cruise ships within this distribution is particularly noteworthy, given the Caribbean's status as a global hub for cruise tourism. Cruise ships' energy intensive nature, driven by their large size, extensive onboard amenities, and short turnaround times, places considerable demand on regional energy resources. This dependence underscores the urgency of exploring alternative fuels and energy efficiency measures specific to the cruise sector to address environmental and economic challenges in the region.

Similarly, container vessels play a vital role in maintaining trade flows within CARICOM and with global partners. The energy demand from these ships highlights the region's reliance on shipping to sustain its economies, which are heavily dependent on imports and exports of goods, including agricultural products, manufactured goods, and fuels. In this context, addressing energy inefficiencies in container shipping could yield significant benefits, such as reducing operational costs and enhancing the region's competitiveness in international trade.

Additionally, tanker vessels, which are integral to transporting fuel and other liquid commodities, further emphasise the Caribbean's current dependence on fossil fuels. The energy demands of these vessels reflect the ongoing challenges of transitioning from traditional fuels to greener alternatives, particularly in a region where infrastructural limitations and financial constraints hinder the widespread adoption of low-carbon technologies.

The alignment between departing and arriving energy demands points to the region's consistent shipping patterns and suggests opportunities for targeted interventions. For example, enhancing port infrastructure to support energy-efficient bunkering or alternative fuel supply could simultaneously address inbound and outbound voyages. Moreover, developing regional maritime policies tailored to CARICOM's shipping profile could accelerate progress toward decarbonisation while fostering economic resilience.

Analysing these patterns, reveals that the Caribbean's maritime energy transition must balance the unique demands of its vessel segments with the region's economic, infrastructural, and environmental realities. Effective solutions must leverage regional strengths, such as geographic proximity for inter-island trade, while addressing gaps in alternative fuel access and energy efficiency to ensure a sustainable and equitable maritime future.

4.2.6. CO₂ Emissions from Vessel Activity in CARICOM Economies

The analysis of AIS data in the IMO's 4th Greenhouse Gas Study reveals critical insights into the distribution of CO₂ emissions generated by maritime vessels arriving in CARICOM countries. Figure 4.7 highlights the significant contributions of cruise vessels, tanker ships, and containerships to overall emissions, reflecting the unique economic and operational characteristics of the Caribbean region.

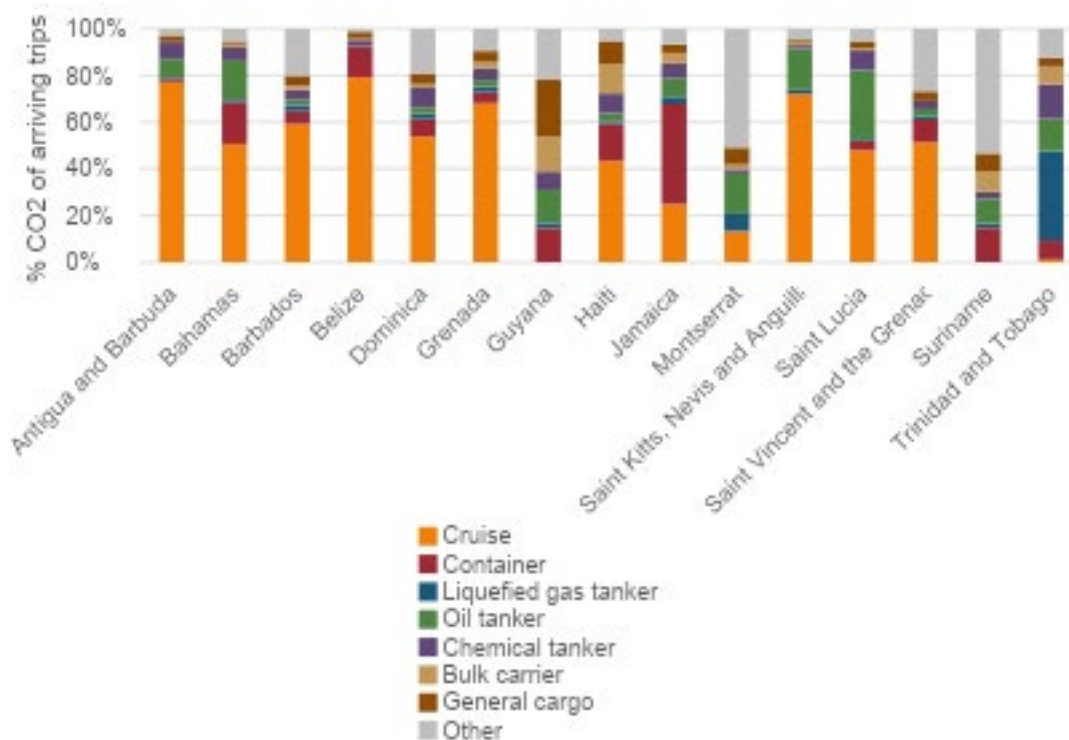


Figure 4.7. Proportion of CO₂ emissions by vessel type associated with arriving and departing voyages into the CARICOM countries

Cruise vessels, responsible for the majority of emissions in countries such as Antigua and Barbuda, Barbados, Belize, Grenada, and Saint Kitts and Nevis, once again underscore the region's economic reliance on tourism. The dominance of cruise emissions is a reflection of the high frequency of calls to ports across these countries, driven by a robust cruise tourism industry. This reliance, while economically vital, exposes these economies to vulnerabilities not only in terms of climate impacts but also in terms of economic sustainability. Addressing emissions from this segment requires integrating decarbonisation strategies into the tourism sector, such as incentivising the adoption of alternative fuels by cruise lines and enhancing the infrastructure for shore-side power to reduce emissions while vessels are docked.

Tanker vessels, including liquefied gas, oil, and chemical tankers, contribute substantially to emissions in energy-exporting and transshipment-focused economies, particularly Trinidad and Tobago and Saint Lucia. These emissions highlight the dual role of the Caribbean as both a consumer and exporter of fossil fuels. Trinidad and Tobago, for instance, operates as a regional energy hub, with its exports heavily tied to the global shipping industry. The high emissions from tanker activity necessitate targeted interventions and a transition toward the export of low-carbon fuels, such as green hydrogen, to align the region with global decarbonisation goals while maintaining its role in energy markets.

Containerships represent a crucial segment of emissions, particularly in economies like Jamaica, where over 40% of CO₂ emissions from incoming voyages are attributed to this vessel type. Jamaica's prominence as a transshipment hub for the wider Caribbean explains this significant share. Similarly, emissions from containerships in Guyana, Suriname, and Belize highlight the importance of containerised trade for agricultural and industrial exports. Mitigating emissions from this segment requires investments in energy-efficient port infrastructure, electrification of terminal equipment, and collaboration with global shipping lines to accelerate the adoption of low-carbon technologies in containership fleets.

The data presented in Figure 4.7 underscores the diversity of emission sources across CARICOM economies, each tied to the specific economic activities and maritime roles of the region's countries. While the dominance of cruise, tanker, and container segments illustrates the region's economic dependence on shipping, it also presents an opportunity to lead in sustainable maritime practices. CARICOM countries can leverage their shared challenges to form a unified strategy for decarbonising the maritime sector. This includes advocating for international financing mechanisms, fostering public-private partnerships, and adopting regional policies that incentivise clean energy transitions across all vessel types.

The findings emphasise the urgent need for tailored mitigation strategies that address the Caribbean's unique maritime dynamics. A regional approach, complemented by investments in innovation and infrastructure, will be critical to balancing economic development with environmental sustainability, ensuring the resilience of CARICOM economies in the face of global climate imperatives.

4.2.7. CO₂ Emissions from Departing Voyages in CARICOM

Figure 4.8 illustrates the relative shares of CO₂ emissions attributed to departing voyages from CARICOM countries. These trends which closely mirror those trends observed for arriving voyages (see Figure 4.7). The prominent contributors to emissions in the region remain cruise, container, and tanker vessel segments, reflecting the unique maritime and economic activities of the Caribbean.

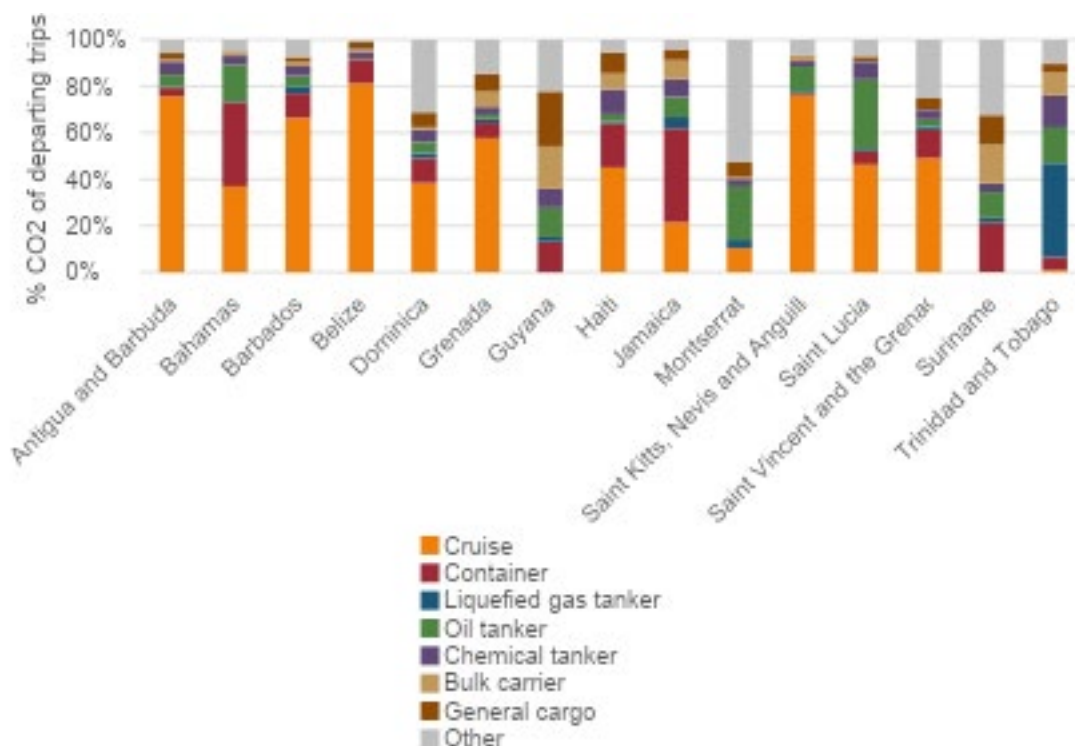


Figure 4.8. Proportion of CO2 emissions by vessel type associated with departing voyages from the CARICOM countries

A deeper analysis reveals that the cruise sector's substantial share of emissions is tied to the region's role as a global hub for cruise tourism. Vessels frequently operate at high energy intensities due to onboard amenities and hoteling functions. This underscores the challenge of balancing tourism-driven economic growth with sustainable environmental practices. In particular, popular Caribbean destinations like the Bahamas, Jamaica, and St. Lucia see significant cruise traffic, contributing heavily to CO2 emissions associated with departing voyages.

The container shipping sector's emissions, on the other hand, reflect the region's dependence on imports for food, manufactured goods, and raw materials. CARICOM's relatively small manufacturing base means that outbound voyages often operate with lower cargo volumes, leading to higher emissions per ton of transported goods. This inefficiency highlights the need for improved cargo consolidation strategies and the development of regional production hubs to optimise shipping patterns and reduce emissions intensity.

Tanker emissions, particularly from voyages departing major oil-producing states like Trinidad and Tobago and Guyana, highlight the ongoing dependence on fossil fuels for export revenues. As these countries expand their energy sectors, there is an urgent need to explore decarbonised alternatives, such as transitioning to clean energy exports (e.g., green hydrogen or ammonia), to mitigate long-term environmental impacts while maintaining economic competitiveness.

The alignment of CO₂ emissions from arriving and departing voyages also suggests that port operations are crucial to the region's overall emissions footprint. CARICOM ports often lack the infrastructure needed for energy-efficient practices, such as shore-to-ship power and bunkering facilities for alternative fuels. Targeted investments in port upgrades could considerably lower emissions, particularly for vessels engaged in short-haul regional trade and tourism.

In summary, while Figure 4.8 provides a quantitative snapshot of CO₂ emissions from departing voyages, it also highlights the interplay between tourism, trade, and energy exports in shaping the Caribbean's maritime emissions profile. Tackling these emissions will necessitate a multi-faceted approach, combining sector-specific strategies with region-wide collaboration to promote energy efficiency, alternative fuels, and sustainable economic development.

4.3. Scale of revenue raised by the various mid-term measures and potential rational for distribution

Let us now discuss the scale of the revenue raised by the mid-term measures, and how this revenue could be distributed across countries (and in particular, to Caribbean countries) and for which uses.

4.3.1. Scale of revenue raised globally

The implementation of mid-term measures within the IMO framework, combining technical requirements, such as a goal-based marine fuel standards, with economic mechanisms—has profound implications for the Caribbean maritime sector. As SIDS that are heavily reliant on shipping for trade, tourism, and connectivity, the Caribbean's response to these measures must account for its economic vulnerabilities, its limited capacity to adopt advanced technologies, and its aspirations for equitable development within the global shipping ecosystem. The design aspects of the economic mechanism, currently under discussion at the IMO, have different impacts on the amount of revenue generated, including:

The flexibility mechanism under discussion, which allows credit trading between ships that either exceed or fail to meet performance standards, could inadvertently marginalise Caribbean operators. This mechanism generates monetary flows from cleaner to carbon-intensive ships. If countries with greater transition readiness (which tend to be richer countries) invest in cleaner vessels, the evidence suggests this is occurring (Fricaudet et al., 2024), then the mechanism is not technologically inclusive. Since regional fleets often comprise older and less efficient vessels, Caribbean countries could become net buyers of credits, creating a financial outflow to wealthier nations with advanced fleets. This mechanism lacks technological inclusivity for developing regions, including SIDS, as it overlooks structural barriers such as limited access to financing for fleet modernisation. For the Caribbean, this would require a parallel system of concessional funding or grants to modernise fleets, ensuring that flexibility mechanisms do not exacerbate existing inequities in maritime transition readiness.

The introduction of a GHG pricing mechanism, whether applied universally or only to emissions exceeding fuel standards, has the potential to reshape the financial landscape of Caribbean shipping. GHG pricing could place a disproportionate burden on Caribbean operators, who often operate on thin profit margins and are heavily reliant on fossil fuels due to the limited availability of alternative energy sources. This is particularly concerning for inter-island trade and the cruise industry, which form the backbone of the region's maritime economy.

However, a well-structured levy could present opportunities. Revenues generated from such a mechanism could be directed toward investments in green port infrastructure, the development of alternative fuel supply chains (e.g., ammonia or hydrogen), and capacity-building initiatives within the Caribbean. Ensuring that a portion of the revenue is earmarked for SIDS would be critical for fostering equitable transition and addressing regional disparities in decarbonisation readiness.

The revenue distribution model associated with mid-term measures is perhaps the most critical factor for the Caribbean. With the potential for a high levy scenario to raise up to \$1.72 trillion globally between 2027 and 2050 (DNV, 2024), a fair and transparent allocation mechanism could transform the decarbonisation landscape for Caribbean countries. Potential uses could include (Dominioni et al., 2023):

- **Fleet Modernisation Grants:** Allocating funds to replace or retrofit older vessels operating in the Caribbean with energy-efficient designs or dual-fuel engines.
- **Port and Bunker Infrastructure Development:** Supporting the establishment of low-carbon fuel infrastructure, which is currently absent in most Caribbean ports, to enable regional adoption of alternative fuels.
- **Technical Assistance and Capacity Building:** Providing resources for training local seafarers, port operators, and policymakers in low-carbon shipping technologies and practices.
- **Climate Adaptation Projects:** Leveraging funds to bolster maritime resilience against climate change impacts, including rising sea levels and intensifying hurricanes that threaten port infrastructure.

The IMO's CIA model two levy scenarios:

- a. A low levy scenario, where the level of the carbon price increases from 2027 to 2050 from \$30 to \$120/tonne CO₂-eq.
- b. A high levy scenario, where the level of the carbon price increases from 2027 to 2050 from \$150 to \$300/tonne CO₂-eq.

In the base trajectory, which corresponds to the lower bound of the emission reduction checkpoints of the IMO trajectory, and when considering all well-to-wake emissions, a low levy scenario would raise around \$500 billion from 2027 to 2050, once rewards to alternative fuels have been distributed (scenario 32, calculated using (DNV, 2024)), while a high levy would raise \$1,720 billion over the same period (scenario 26, calculated using (DNV, 2024)). Please see Figure 4.9. On the other hand, a scenario with no levy but with a flexibility mechanism would raise \$43 billion, after the distribution to surplus units, over the same period.

The distribution of revenue generated from global carbon pricing mechanisms remains a deeply contested issue, particularly regarding equitable allocation among countries.

The debate is further complicated by competing interests and differing national priorities. The Caribbean, primarily comprised of SIDS, provides a unique perspective on this ongoing debate, due to its unique vulnerabilities and significant contributions to global maritime trade. While the IMO advocates for aligning revenue distribution with principles of equity and just transition (Smith et al., 2024), the absence of discussion and consensus on specific allocation mechanisms presents significant challenges for CARICOM countries, as they seek to ensure that the system fairly reflects their specific needs and circumstances.

In response to this complex issue, Dominioni et al. (2023) propose a model that seeks to address these disparities by suggesting that carbon shipping revenue be distributed to all countries, with a designated share reserved specifically for SIDS, Least Developed Countries (LDCs), and potentially some developing countries. The proportion of revenue allocated to these nations would be determined based on specific criteria, such as climate vulnerability. This model acknowledges the disproportionate exposure of these states to the adverse effects of climate change, which include rising sea levels, extreme weather events, and maritime disruptions that directly impact their economies. For the Caribbean, this proposal holds promise, as it could result in a significant influx of financial resources that could be used to fund climate adaptation strategies, decarbonisation efforts, and necessary upgrades to maritime infrastructure. However, the model's success hinges on addressing critical questions related to its implementation. For instance, how should vulnerability be measured? What metrics should be used to define this vulnerability in a way that accurately reflects the multifaceted challenges faced by Caribbean nations, such as their reliance on inter-island shipping, tourism, and their limited fiscal capacity to make investments in climate resilience?

One potential framework for answering these questions lies in the IMO's Comprehensive Impact Assessment (CIA), which offers a useful, though imperfect, estimate of the potential revenue CARICOM countries could access under various distribution scenarios. Notably, scenarios where revenue is allocated solely to SIDS and LDCs, or where higher carbon levies are applied, yield significantly greater financial benefits for the region. For instance, under a high-carbon levy scenario (scenario 26 of the IMO's CIA), CARICOM countries could collectively access an estimated \$17.4 billion between 2027 and 2050—resources that could significantly transform the region's maritime sector. These funds could be used for critical infrastructure projects, such as ports and shipping facilities, as well as initiatives aimed at reducing carbon emissions and improving the region's resilience to climate impacts. In contrast, a low-carbon levy scenario, where revenue is distributed more broadly among developing countries, results in a far more modest sum of \$1.3 billion. This disparity underscores the importance of advocating for distribution models that prioritise the needs of SIDS and LDCs, as their specific vulnerabilities and contributions to global trade warrant special consideration (Smith et al., 2024; Dominioni et al., 2023).

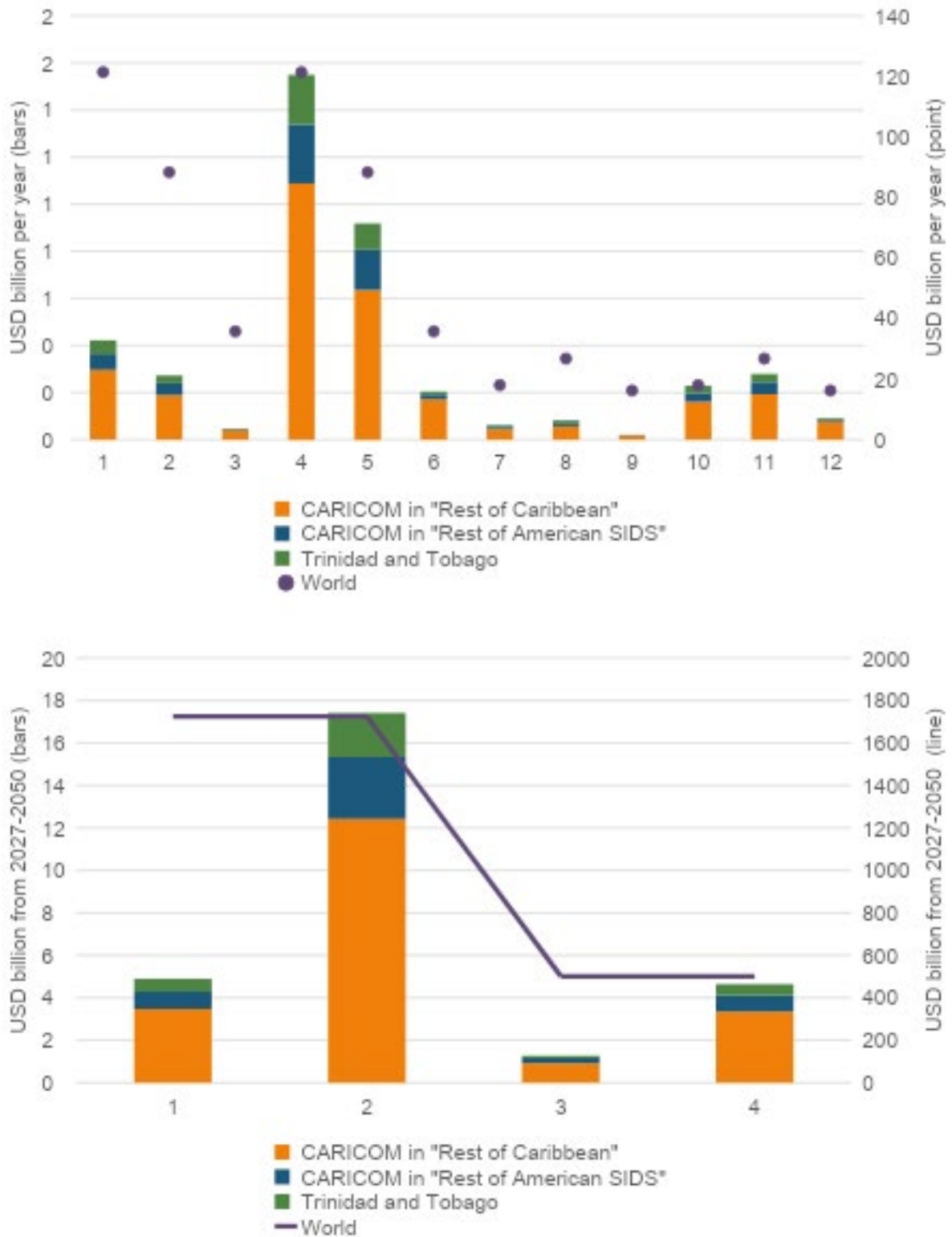


Figure 4.9. Annual and cumulative revenue distributed in the CARICOM countries from 2027 to 2050 (adapted from the IMO's CIA (UNCTAD, 2024))

**The total revenue collected (lines) is distributed proportionally to population and negative impact on GDP*

***Scenario 32 corresponds to a scenario with a low levy (increasing from \$30 to \$120/tonne CO₂-eq from 2027 to 2050), a fuel standard and a flexibility mechanism. Scenario 26 corresponds to a scenario with a fuel standard and a high levy (increasing from \$150 to \$300/tonne CO₂-eq from 2027 to 2050). Both scenarios have the same reduction in emissions. Non-levy scenarios are not represented as they raise very limited amount of revenue.*

4.3.2. Distribution between sectors

The distribution of carbon revenue generated from shipping activities presents a transformative opportunity for Caribbean countries to address both in-sector and out-of-sector priorities. While several countries have outlined potential uses for this revenue, such as rewarding the use of near-zero emission fuels and supporting investment in Research, Development, and Deployment (RD&D) in developing countries, Caribbean states must take advocate for revenue allocation strategies that reflect the region's unique vulnerabilities and opportunities (Figure 4.10). Given the Caribbean's dependence on maritime trade and its heightened exposure to the impacts of climate change, it is critical that the region's specific needs are prioritised in these global discussions. These strategies must be designed not only to address the immediate challenges of decarbonisation but also to provide long-term economic and environmental benefits.

In-sector revenue distribution, which prioritises investments directly related to shipping, is particularly relevant for the Caribbean. Although there is no definition yet, this could encompass retrofitting regional fleets, developing port infrastructure for alternative fuel bunkering, and fostering innovation in renewable energy solutions. For example, the establishment of green hydrogen production facilities in renewable energy-rich countries such as Jamaica or Trinidad and Tobago would not only serve domestic energy needs but could also provide sustainable fuel options for the wider shipping community. Similarly, investment in small-scale, energy-efficient vessels designed for the Caribbean's inter-island trade and tourism industries, would help reduce the region's carbon footprint while simultaneously boosting economic activity. These in-sector investments would directly contribute to the decarbonisation of the region's maritime industry, facilitating a transition to cleaner, more sustainable practices that align with global climate goals.

However, potential out-of-sector uses of shipping carbon revenue are particularly significant for the Caribbean, given its status as a collection of climate-vulnerable SIDS. Given the region's exposure to rising sea levels, extreme weather events, and other climate-related threats, out-of-sector allocations could play a critical role in financing much-needed climate adaptation measures. These measures include strengthening coastal defences, protecting marine ecosystems, and supporting disaster resilience initiatives that are vital for safeguarding both livelihoods and the natural assets on which the Caribbean's economy depends. In addition to these adaptation efforts, the inclusion of compensation mechanisms for Disproportionately Affected Nations (DANs), many of which are Caribbean states, could ensure greater

equity in the transition to low-carbon shipping. Such measures would help address the inequities faced by these countries, whose contributions to global emissions are minimal but who bear a disproportionate share of the impacts of climate change.

The report further emphasises the importance of active revenue distribution, a concept that aligns closely with the Caribbean's advocacy for equitable outcomes. Active distribution mechanisms, designed with equity considerations at their core, would direct revenue to the countries and communities most affected by both the impacts of climate change and the policies designed to mitigate it. For the Caribbean, this could translate into prioritising investments in human capital and technical capacity-building. Strengthening the region's ability to implement and sustain green maritime practices, through training, infrastructure development, and technological support, is essential for ensuring that the benefits of decarbonisation are realised in a manner that is both sustainable and equitable. This active distribution approach is critical in addressing the resource and technology gaps that have historically hindered the Caribbean's ability to transition effectively to greener, more resilient maritime practices.

Moreover, the Caribbean's rich marine biodiversity and its reliance on the ocean economy present a compelling case for directing a portion of carbon revenue toward ocean protection initiatives. By financing projects such as coral reef restoration, marine habitat preservation, and sustainable fisheries management, carbon revenue can help mitigate some of the environmental degradation exacerbated by shipping activities. These efforts not only protect the Caribbean's vital marine ecosystems but also contribute to broader global goals, such as achieving Sustainable Development Goal (SDG) 14—Life Below Water. In this way, the region can leverage its natural resources to both strengthen its resilience to climate change and advance global sustainability objectives.

In conclusion, Caribbean states must assert a dual focus on both in-sector and out-of-sector uses of shipping carbon revenue, advocating for tailored, equity-driven mechanisms that address their unique challenges while capitalising on their regional strengths. By doing so, the Caribbean can position itself as a leader in sustainable maritime practices, ensuring that the benefits of decarbonisation are distributed fairly and inclusively across the region. This approach not only fosters regional growth and resilience but also contributes to global climate goals, reinforcing the importance of equitable and sustainable development in the face of climate change.

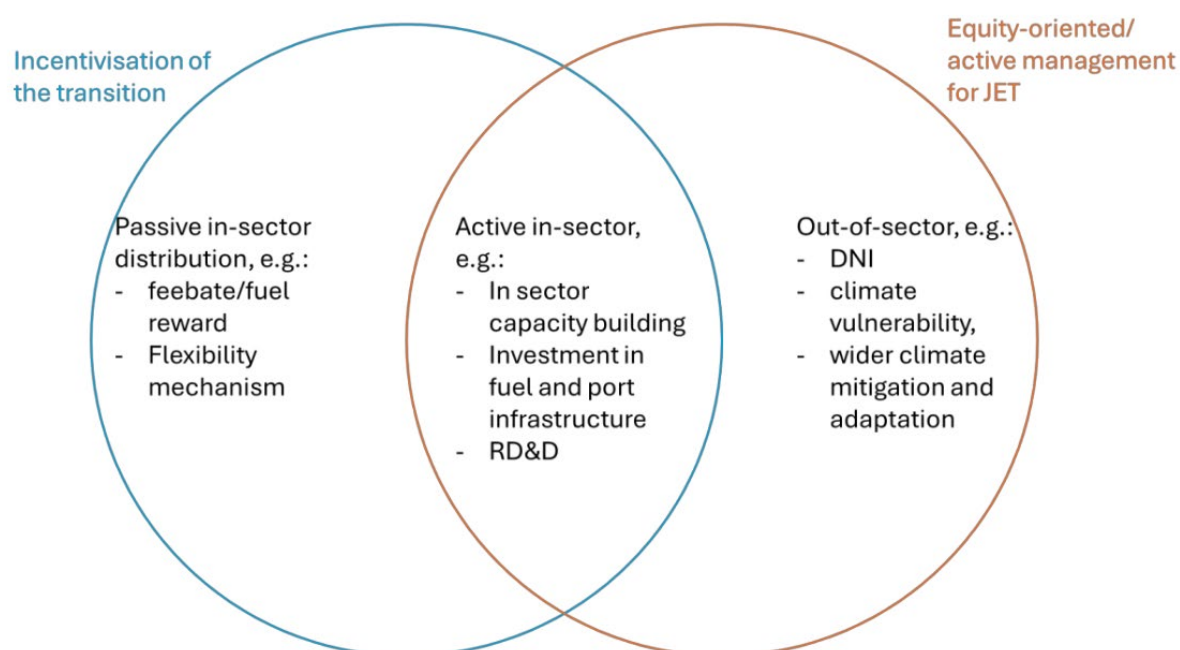


Figure 4.10. Conceptualisation of different types of revenue use. From (Smith et al., 2024)

*JET: Just and Equitable Transition. DNI: Disproportionately Negative Impacts. RD&D: Research, Development and Deployment.

The current preference at the IMO for in-sector revenue distribution (Smith et al., 2024) presents both challenges and opportunities for the Caribbean region. With many countries avoiding explicit reference to out-of-sector revenue distribution and some openly opposing it, this approach, which focuses on using the generated revenue to fund investments within the maritime sector itself, such as retrofitting ships and upgrading port infrastructure, aligns with global decarbonisation goals but may not fully address the broader economic and social challenges faced by SIDS in the Caribbean. While these in-sector investments are undoubtedly important, they risk overlooking key equity issues that are highly relevant to the region. Many countries avoid explicit reference to out-of-sector revenue distribution, and some even oppose it, potentially missing an opportunity to address the full spectrum of vulnerabilities and needs that SIDS face in the transition to a low-carbon economy.

For the Caribbean, the reliance on in-sector revenue distribution limits the ability to address critical out-of-sector challenges, particularly those that affect the broader economy and the well-being of its population. This is particularly evident when considering the increase in consumer costs arising from higher shipping expenses due to decarbonisation measures. Many Caribbean economies are heavily reliant on imports, and any increase in shipping costs will disproportionately impact consumer welfare, particularly for vulnerable populations. Moreover, these increased costs risk exacerbating regional inequalities and undermining development goals in the countries that are already facing fiscal constraints and climate vulnerabilities. In such

a scenario, the focus on in-sector investments alone fails to account for the socio-economic ripple effects that would reverberate throughout the entire Caribbean region.

This is where out-of-sector revenue distribution becomes critical. Directing funds toward social safety nets, economic diversification, or climate adaptation measures would help ensure a truly equitable transition for the Caribbean. For example, carbon revenue could be used to subsidise the adoption of renewable energy across various sectors, including agriculture, tourism, and industry. Additionally, it could strengthen disaster resilience by funding projects that enhance infrastructure to withstand extreme weather events and rising sea levels, which are increasingly common in the region. Compensating for climate-related damages disproportionately impacting SIDS could also be an important use of these funds. Without these broader, out-of-sector investments, the region's ability to maintain socio-economic stability and build climate resilience will be severely undermined, leaving many Caribbean nations vulnerable to the accelerating effects of climate change.

Furthermore, the Caribbean is already experiencing significant climate change impacts, including rising sea levels and more frequent extreme weather events, and disruptions to its maritime infrastructure, all of which are partly driven by global shipping emissions. A revenue distribution framework that excludes these broader climate impacts risks marginalising the very regions most in need of financial support for mitigation and adaptation. In this context, the limited absorptive capacity of many Caribbean states for in-sector investments further underscores the necessity of a balanced approach that includes out-of-sector allocations. Such an approach would ensure that the region can address both the immediate requirements of decarbonising the maritime sector and the long-term need for climate adaptation across various sectors.

To promote equity and resilience, the Caribbean should advocate for a hybrid revenue distribution model at the IMO. Such a model would prioritise in-sector investments to modernise maritime infrastructure and fleets while allocating a substantial portion of revenues to out-of-sector needs, such as building adaptive capacity and offsetting socio-economic disruptions. This dual approach would strike a balance between supporting the region's transition to low-carbon shipping and ensuring that Caribbean nations are not left behind in terms of broader climate resilience and social equity. By advocating for this hybrid model, the Caribbean could align itself with global decarbonisation goals while addressing the unique challenges faced by SIDS and other vulnerable economies, ensuring that the transition to low-carbon shipping is both inclusive and just.

By advocating for clearer recognition of out-of-sector needs in global policy discussions, the Caribbean can establish itself as a leader in equitable climate policy. Doing so would not only help secure the resources required to navigate this critical transition but would also demonstrate the region's commitment to fostering a just,

inclusive, and resilient future for its people and economies (Figure 4.11) (Smith et al., 2024; Dominioni et al., 2023).

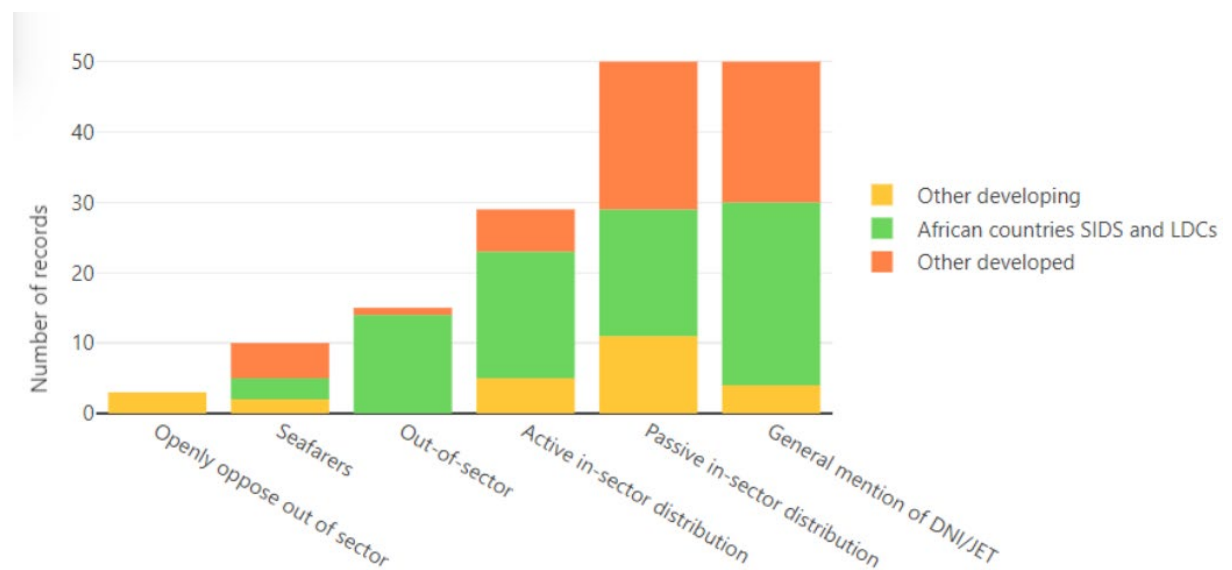


Figure 4.11. Support for various uses of revenue expressed at the IMO's 17th Intersessional Working Group on GHGs. From (Smith et al., 2024)

**As one country might have supported more than one type of revenue distribution, the total counts is larger than the number of countries who voiced an opinion*

4.4. Specific needs for the Caribbean

After evaluating the revenue raised by the mid-term measures and the potential rationale for distribution, this section assesses the specific investment needs in the CARICOM countries. The first subsection assesses the level of investment needed onboard ships to decarbonise trips in the CARICOM countries. The following two subsections discuss the level of investments needed in ports, bunkering infrastructure, and shore power. Subsection 3.3 discusses the question of investment in alternative fuel production. The last subsection discusses uses out-of-sector.

4.4.1. Investments needed on-board ships to decarbonise shipping in the Caribbean

This section focuses on the unique considerations for decarbonising shipping in the Caribbean by analysing the investments required on board ships operating in the region. Investments in energy efficiency (EE) technologies are critical to reducing emissions across the region's diverse fleet, which includes smaller vessels engaged in inter-island trade and larger ships serving international routes. These fleets play an integral role in the Caribbean's economy, facilitating trade, tourism, and connectivity. However, many of these vessels are owned and operated by small-scale businesses, making them highly sensitive to cost increases. Consequently, any push for EE technologies must account for this cost sensitivity and provide targeted financial support to ensure widespread adoption. Collaboration between local governments and international organisations is vital to establish mechanisms such as green shipping funds or carbon credit systems. These mechanisms could offset the high upfront costs and promote investments in cleaner technologies across the region.

Retrofitting ships for alternative fuels represents both a challenge and an opportunity for the Caribbean. Limited access to renewable energy infrastructure and high initial costs make retrofitting a complex process. However, the transition also offers a chance to align the region's shipping sector with global decarbonisation regulations and future-proof its fleet. For example:

- **Dual-fuel Internal Combustion Engines (ICE) using Methanol and Low-Sulphur Heavy Fuel Oil (LSHFO):** Methanol, potentially produced using biomass from the region's agriculture and forestry industries, offers a viable option for the Caribbean. Given the region's potential to leverage agricultural and forestry by-products to produce green methanol locally, investments in retrofitting ships for methanol use could significantly reduce reliance on imported fuels.
- **Dual-fuel ICE using Ammonia and LSHFO:** Ammonia retrofitting is less immediately viable due to safety concerns and limited infrastructure in the Caribbean. Nevertheless, strategic investments in ammonia bunkering facilities at major ports such as Kingston (Jamaica) and Freeport (Bahamas) could position

the Caribbean as a future transshipment hub for green ammonia, creating new economic opportunities.

- **Dual-fuel ICE Hydrogen and LSHFO:** Hydrogen retrofitting presents significant technological and financial challenges for the region, particularly for long-haul shipping. However, hydrogen holds potential for regional ferries and short-sea shipping, especially if produced locally from renewable energy sources such as solar or wind. This warrants further exploration and pilot projects to evaluate feasibility.

A shift to alternative fuels will require strong collaboration between CARICOM governments, port authorities, and international partners. Policy incentives, including tax breaks, grants for retrofitting, and subsidies for renewable energy infrastructure, will be critical to ensure that these transitions are economically viable for local operators. Without such policies, small-scale operators may struggle to compete in a decarbonised shipping industry, potentially exacerbating economic disparities within the region.

Additionally, the financial and operational challenges of decarbonising shipping are particularly pronounced for the Caribbean due to its small-scale economies and limited resources. Regional cooperation and international support will be crucial to overcoming these barriers. Access to global climate financing and partnerships with key shipping stakeholders could help bridge the funding gap. Moreover, it is essential to develop equitable policies that distribute investment burdens fairly between local operators and foreign ship-owners, ensuring that the cost of decarbonisation does not disproportionately impact small Caribbean businesses.

This assessment highlights the urgent need for tailored investment strategies that reflect the Caribbean's unique maritime, economic, and environmental conditions. Integrating EE technologies, alternative fuel retrofits, and investments in shore power infrastructure will allow CARICOM countries to take meaningful steps toward decarbonising their maritime sector. These measures will not only contribute to global emissions reductions but also enhance the region's resilience and competitiveness in a low-carbon economy.

The decarbonisation of shipping within the Caribbean region presents unique financial and operational challenges, particularly when considering the diverse nature of ship operations across CARICOM countries. While some ships primarily operate within CARICOM countries, others occasionally dock at ports in these nations. This means that decarbonising all trips within CARICOM requires retrofitting ships which possibly only make one port call in the region per year, introducing disproportionate costs per trip, particularly when compared to retrofitting vessels that predominantly operate throughout the region². This disparity is illustrated in Figure 4.12, which shows that the

² We refer here to ships which make at least half of their trips to or from a CARICOM country.

investments required to decarbonise the fleet rise sharply as the share of trips decarbonised increases. The required onboard investment to retrofit the fleet operating in CARICOM is shown on the y-axis, depending on the proportion of trips made to and from CARICOM that are decarbonised (x-axis). The cost curve is convex with respect to the share of trips decarbonised, indicating rapidly escalating expenses as decarbonisation targets approach 100%. For instance, decarbonising 50% of the trips would require investment of approximately \$4.4 billion, whereas decarbonising all trips to and from CARICOM countries would require a staggering \$56 billion in onboard investments. Energy efficiency and retrofitting for alternative fuels, such as ammonia, represent the bulk of these costs, whereas shore power accounts for only a small fraction. This cost structure highlights the importance of prioritising high-frequency vessels in the region for retrofitting to maximise the impact of investments. By targeting vessels that operate predominantly within the region, CARICOM countries can achieve significant emissions reductions at a lower overall cost. Such prioritisation also aligns with the region's strategic goals of improving energy efficiency and building a sustainable maritime sector.

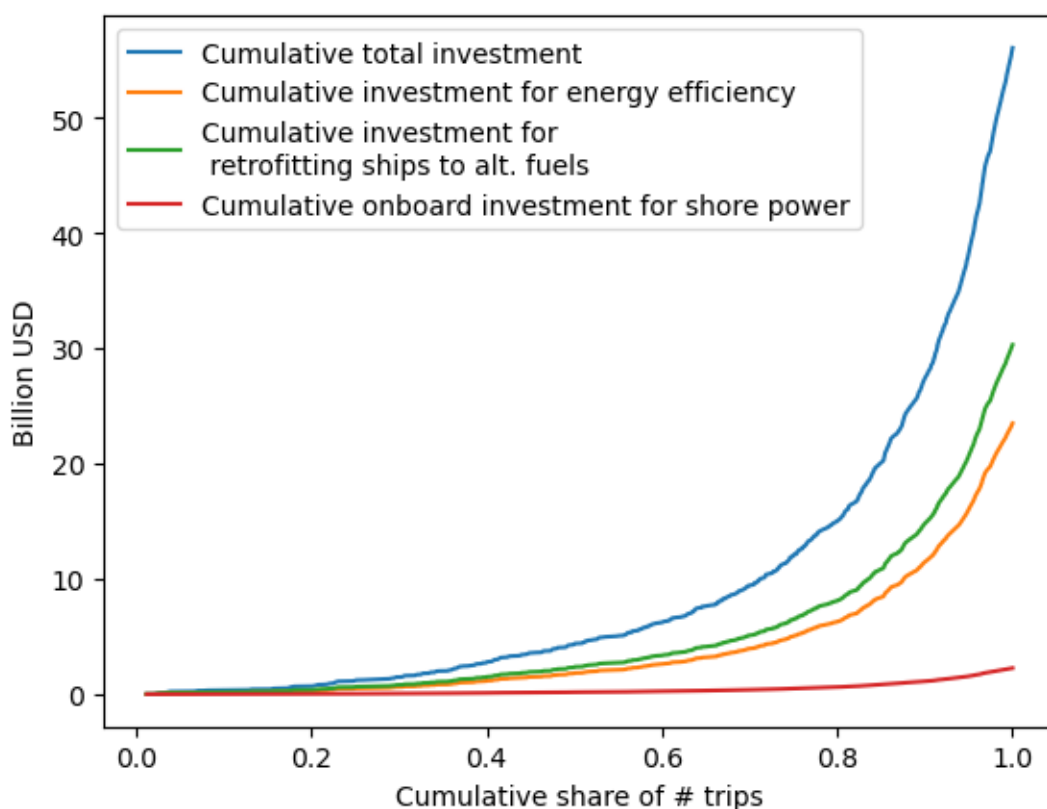


Figure 4.12. Onboard investments needed to decarbonise 2018 shipping in CARICOM countries, if the fleet is retrofitted to advanced energy technologies and to dual-fuel ICE ammonia

**Methods and assumptions used to derive the estimates plotted are described in the technical annex of the document.*

Not all technology options are equally expensive on-board ships. Figure 4.13 underscores the relative cost differences across various technological options for decarbonisation. Among the options, retrofitting ships for liquid hydrogen stands out as the most expensive due to its complex handling and storage requirements, which involve cryogenic systems and significant design modifications. In contrast, ammonia and methanol emerge as more cost-effective alternatives, with projected investments ranging between \$4 billion and \$7 billion to decarbonise 75% of trips to and from CARICOM countries. Additional investments in energy efficiency measures, such as hull optimisation, propulsion systems, and digital technologies, are estimated to range from \$2 billion to \$15 billion, depending on the region's level of ambition and adoption speed. Excluding liquid hydrogen due to its limited cost competitiveness, the total investment required for onboard retrofits could range from \$7 billion to \$23 billion. This underscores the critical importance of strategic decision-making in the adoption of decarbonisation technologies, balancing cost-effectiveness with long-term sustainability and regulatory compliance.

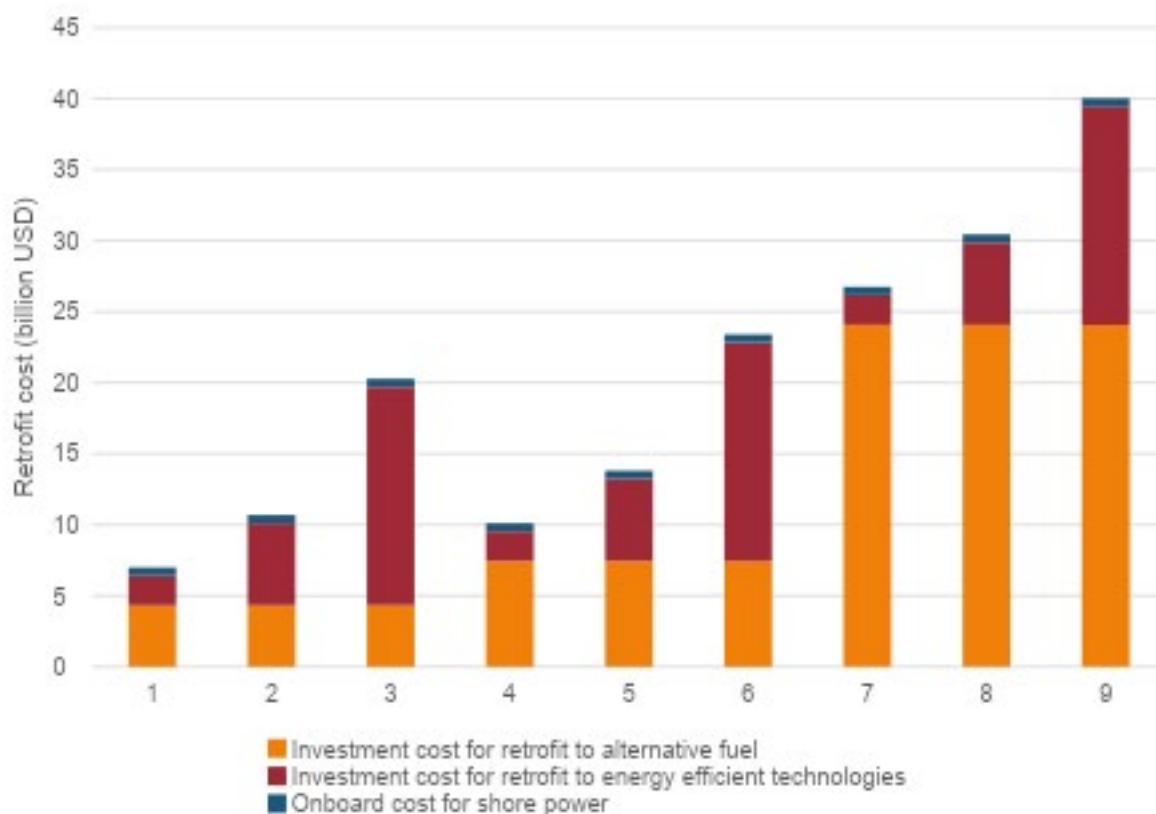


Figure 4.13. Investments needed to decarbonise ships covering 75% of the trips in the CARICOM countries in 2018, depending on the technology chose

**DF: dual-fuel; EE: energy efficiency; ICE: international combustion engine; LH2: liquefied hydrogen*

*** Methods and assumptions used to derive the estimates plotted are described in the technical annex of the document.*

However, a critical aspect of the Caribbean context is ownership. Ownership dynamics within the region significantly shape the distribution of decarbonisation costs. Despite the Caribbean's reliance on maritime trade, only 3% of the ships operating in the region are owned by CARICOM-based companies, as highlighted in Figure 4.14. However, these domestically owned vessels account for 9% of all voyages to and from CARICOM ports, according to Figure 4.15, reflecting their outsized role in regional connectivity and trade. This imbalance in ownership means that the majority of the \$56 billion investment required for full decarbonisation would fall on non-CARICOM ship owners, primarily from nations such as the United States, which dominate shipping activity in the region. While CARICOM-based ship owners would face an investment range of \$0.5 billion to \$1.4 billion to retrofit their fleets, the substantial financial burden for decarbonising the region's maritime activities would predominantly rest with external stakeholders, creating opportunities and challenges for equitable collaboration.

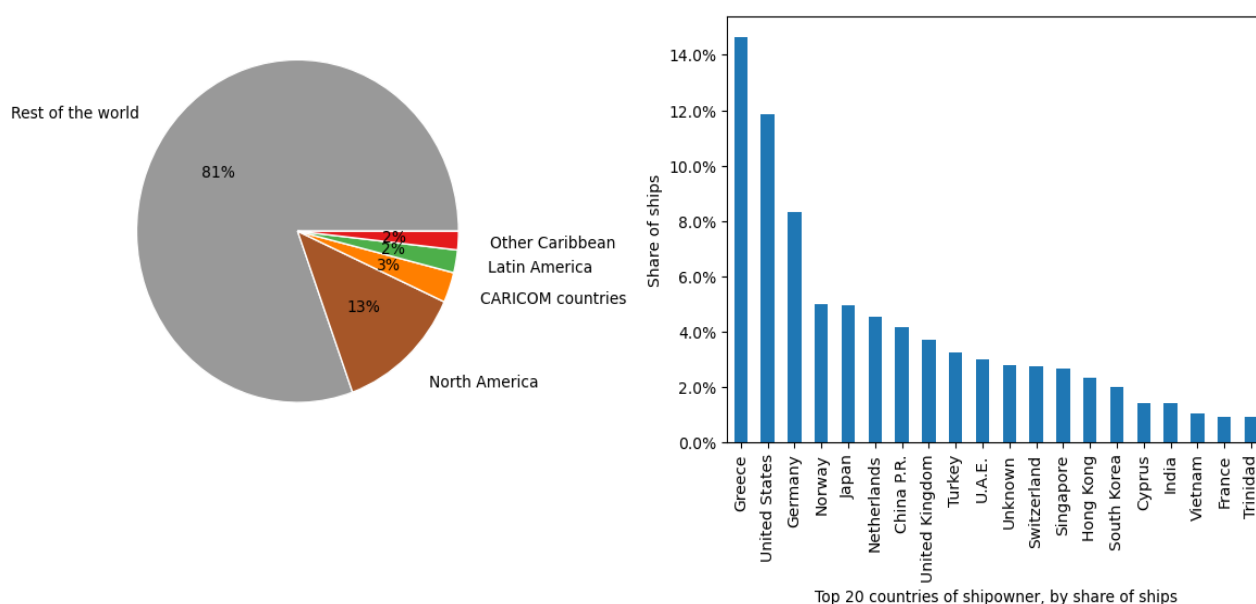


Figure 4.14. Share of the fleet operating in the Caribbean region in 2018, by country of ownership

**Methods and assumptions used to derive the estimates plotted are described in the technical annex of the document.*

*** Plotting numbers correspond to the 47% of the ships operating in the CARICOM countries, which could be matched to the Clarksons database.*

**** A ship is considered "operating in the Caribbean region" if it has made at least one voyage to or from on one of the CARICOM countries in 2018*

This ownership dynamic raises complex questions about the equitable distribution of decarbonisation-related revenues within the Caribbean. Should revenues generated from mechanisms such as carbon pricing or emissions trading be allocated to external ship owners, who bear the bulk of retrofitting costs? Or should these revenues remain

within the region to support broader initiatives such as climate adaptation, economic diversification, and capacity building? The situation is further complicated by the prominence of flags of convenience in the region, particularly in countries like the Bahamas, Saint Vincent and the Grenadines, and Trinidad and Tobago. Although these nations rank among the top ship-owning countries in the region, the ships they register often represent only a small fraction of total voyages. This raises further questions about how these countries benefit, or fail to benefit, from decarbonisation investments and policies.

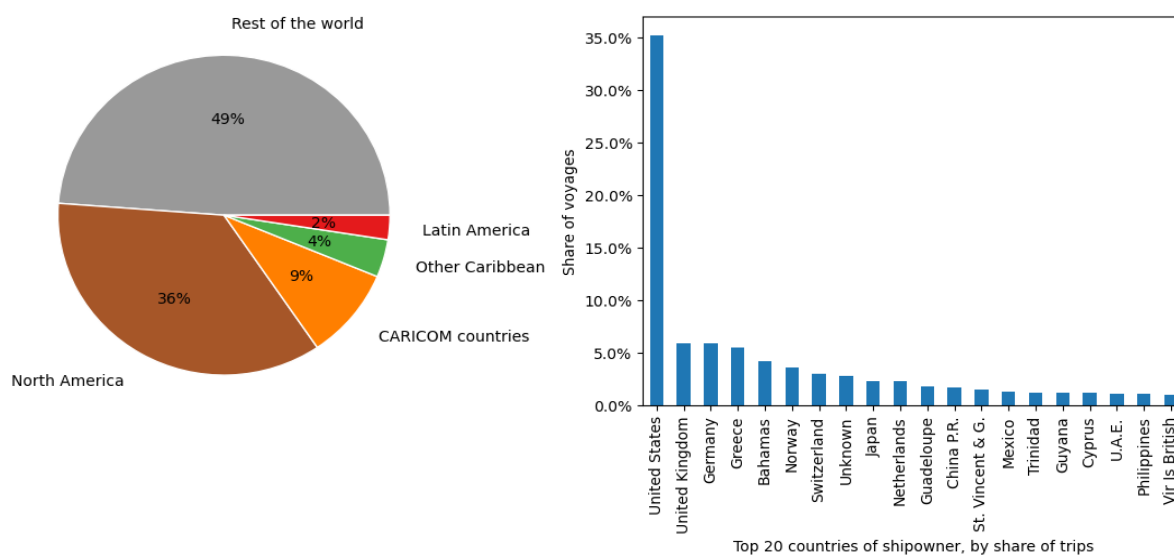


Figure 4.15. Share of voyages from and to the CARICOM countries in 2018, by region of ownership of the ship

- Methods and assumptions used to derive the estimates plotted are described in the technical annex of the document.*
- Plotting numbers correspond to the voyages to and from the CARICOM countries, made by ships which could be matched to the Clarksons database (47% of ships operating in CARICOM countries)*

We, therefore, estimate the investment needed to retrofit all ships owned by shipowners headquartered in CARICOM countries in 2024 in Clarksons World Fleet Register (WFR) database (no matter the operation of their ships). This corresponds to the investment that would directly be on the balance sheet of shipowners based in CARICOM countries. We find that CARICOM-based shipowners would need to invest between \$0.5 billion and \$1.4 billion to retrofit their fleets for zero- or low-carbon operations. This relatively modest figure compared to the overall decarbonisation investment underscores the limited financial burden directly borne by the region, but it also highlights the critical need for CARICOM to leverage external financing mechanisms and partnerships to address the broader decarbonisation challenges faced by the region.

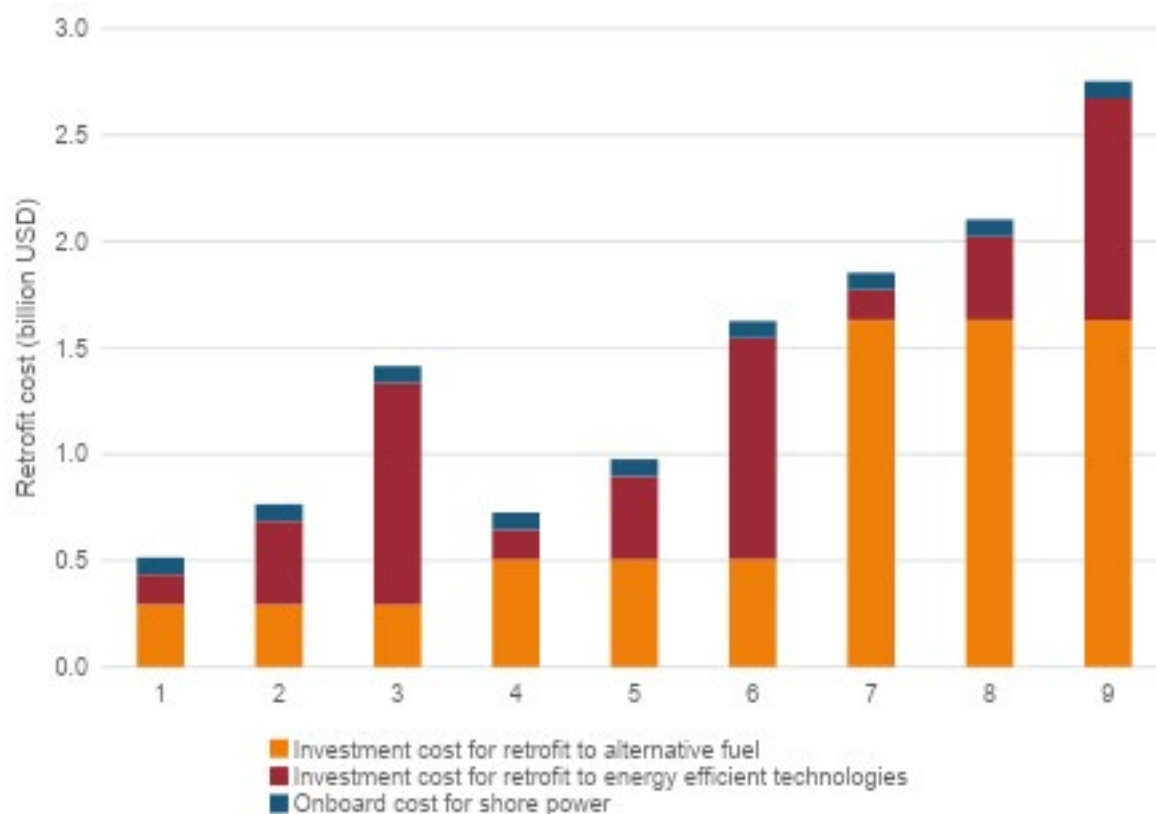


Figure 4.16. Investments needed to decarbonise ships owned by shipowners headquartered in CARICOM countries in 2018 (according to the Clarksons WFR), depending on the technology chosen

- Methods and assumptions used to derive the estimates plotted are described in the technical annex of the document.*
- DF: dual-fuel; EE: energy efficiency; ICE: international combustion engine; LH2: liquefied hydrogen*

To address these challenges, Caribbean policymakers must advocate for international frameworks that ensure fair revenue distribution while aligning with the region's development priorities. Collaborative engagement with global shipping stakeholders is essential to secure the investments needed to retrofit fleets, expand port infrastructure for alternative fuels, and enhance energy efficiency. Such advocacy should emphasise the Caribbean's unique vulnerabilities to climate change as a moral and strategic imperative for international support. Additionally, aligning revenue distribution mechanisms with the Sustainable Development Goals (SDGs) could bolster the case for increased funding, enabling the region to bridge the gap between its ambitious decarbonisation targets and the financial realities of transforming its maritime sector. By integrating equitable revenue-sharing models, capacity-building initiatives, and targeted investments, the Caribbean can position itself as a leader in sustainable maritime practices while ensuring the benefits of decarbonisation are shared fairly and inclusively.

4.4.2. Bunkering infrastructure in ports

The Caribbean region is a significant hub for maritime trade and tourism, making bunker fuel infrastructure critical. This infrastructure supports the steady flow of goods and passengers across the region while also serving as a key driver of economic activity. The region's strategic location at the crossroads of major shipping routes, combined with its reliance on maritime connectivity, underscores the importance of ensuring that bunkering facilities remain competitive, sustainable, and aligned with global decarbonisation trends. The five Caribbean countries in this study, stand out for their notable contributions to bunkering operations, playing vital roles in supporting both regional and international maritime traffic.

The Bahamas is a leading player in the region's bunkering landscape, leveraging its proximity to major shipping routes. Nassau and Freeport are the primary hubs, offering extensive bunkering services to vessels transiting between North, Central, and South America. These ports serve as critical refueling points, ensuring that ships navigating these high-traffic corridors can maintain efficient operations. The Bahamas' position near the Atlantic gateway to the Panama Canal enhances its strategic importance, while its infrastructure caters to a diverse mix of vessels, including cargo ships, tankers, and cruise liners. This makes The Bahamas not only a key economic player but also a critical node in regional maritime connectivity.

Barbados, though smaller in scale, contributes significantly to the region's bunkering capacity. The Port of Bridgetown, its primary hub, provides essential refueling services for cruise ships and cargo vessels operating in the southern Caribbean. While its operations are not as extensive as those in larger hubs like The Bahamas or Trinidad and Tobago, Barbados has carved out a niche by catering to smaller vessels and tourism-focused operations. Its bunkering activities play an integral role in supporting the island's economy, particularly by serving the vibrant cruise tourism sector, which relies heavily on well-maintained and readily accessible refueling facilities.

Jamaica has emerged as a key bunkering hub, driven by its strategic location and growing investments in alternative fuels. With major operations centered in Kingston and Montego Bay, Jamaica provides critical support to vessels transiting the Panama Canal. The country's geographic position, acting as a gateway between the Caribbean Sea and the Atlantic Ocean, makes it an indispensable player in global shipping. Additionally, Jamaica is making strides in diversifying its bunkering offerings, with growing investments in liquefied natural gas (LNG) infrastructure. These efforts not only enhance its competitiveness but also position Jamaica as a forward-thinking leader in sustainable maritime practices.

Saint Lucia adds value to the regional bunkering network through its focus on the cruise and tourism industries. Castries serves as the primary hub for bunkering operations, offering refueling services to the steady stream of cruise ships that visit the island. While its bunkering infrastructure is more limited compared to regional

heavyweights like Trinidad and Tobago, Saint Lucia's operations are crucial for maintaining the smooth functioning of its tourism-driven economy. These services ensure that the island remains a desirable destination for cruise operators, highlighting the interconnectedness of tourism and maritime logistics.

Trinidad and Tobago stands out as a regional leader in bunkering due to its extensive oil and gas resources. With major facilities located in the Port of Spain and Point Lisas, the country supplies both residual and distillate fuels to vessels operating in the region. As one of the leading oil and gas producers in the Caribbean, Trinidad and Tobago has a distinct advantage in meeting the diverse fuel needs of ships, from tankers to cargo carriers. Its bunkering operations not only drive significant revenue for the country but also strengthen its position as a key player in regional energy and maritime logistics. The country's capacity to provide marine fuels at scale is unmatched in the Caribbean, further cementing its role as a vital component of the region's shipping ecosystem.

The transition to sustainable marine fuel infrastructure represents a significant investment opportunity for the region. Using the methodology outlined in the technical annex, it is estimated that replacing fossil marine fuel bunkering barges currently operating in CARICOM countries would require an investment of approximately USD 0.6 billion. This investment reflects the financial commitment needed to modernise the region's maritime fuel infrastructure in line with global decarbonisation efforts. By addressing these challenges, the Caribbean can strengthen its position as a competitive and sustainable maritime hub, ensuring its long-term economic and environmental resilience.

4.4.3. Shore power infrastructure in ports

Shore power investments present an immediate and impactful opportunity for decarbonisation in the Caribbean, particularly given the region's high reliance on tourism and cruise ships. Ports in the Caribbean, such as those in The Bahamas, Jamaica, and the Dominican Republic, stand to benefit significantly from adopting shore power technologies, which allow vessels to switch off their engines while docked, thereby reducing emissions. This shift is especially important for cruise ships, which are among the most energy-intensive vessels. However, the effectiveness of this initiative depends on ensuring that shore power is generated from renewable energy sources rather than imported fossil fuels. By coupling electrification with renewable energy development, the region could achieve meaningful emissions reductions while also advancing energy independence.

The application of shore power in smaller regional ports is complicated by limited grid capacity and the high cost of infrastructure upgrades. Smaller ports often lack the robust energy infrastructure required to support the electrification of quays, making large-scale implementation a significant financial and logistical challenge. A phased approach to shore power investment, starting with major ports and gradually

expanding to secondary facilities, could address these barriers incrementally. Standardising shore power systems across CARICOM states could further reduce costs and promote interoperability, ensuring that ships can seamlessly access electrified quays throughout the region. Collaboration between port authorities, governments, and international partners will be critical to achieving this standardisation.

In the Caribbean context, electrifying quays also provides opportunities to enhance regional energy security by leveraging renewable energy sources. Solar, wind, and even geothermal energy can play a pivotal role in powering shore-side infrastructure while reducing reliance on imported fossil fuels. Such a strategy not only aligns with global decarbonisation trends but also supports regional goals under the CARICOM Energy Policy, which prioritises clean energy transitions. By integrating renewable energy into shore power systems, Caribbean ports can significantly lower greenhouse gas emissions from maritime activity while simultaneously addressing energy vulnerabilities and improving sustainability.

To assess the investment required for implementing shore power infrastructure across CARICOM ports, it is essential to identify ports with the highest potential to reduce emissions. This involves analysing which ports host the greatest number of ship-days, as these are the areas where shore power could have the most significant impact. Figure 4.17 provides a detailed breakdown of ship-days in the top 20 CARICOM ports in 2018, highlighting Chaguaramas (Trinidad and Tobago) and Freeport (The Bahamas) as leading candidates for shore power investments due to their high levels of port occupation. As these ports serve as critical hubs for transshipment and tourism, their electrification would deliver significant emissions reductions. The relatively equitable distribution of ship-days across other ports, however, suggests that a regionally coordinated strategy is essential to maximise the benefits of shore power infrastructure.

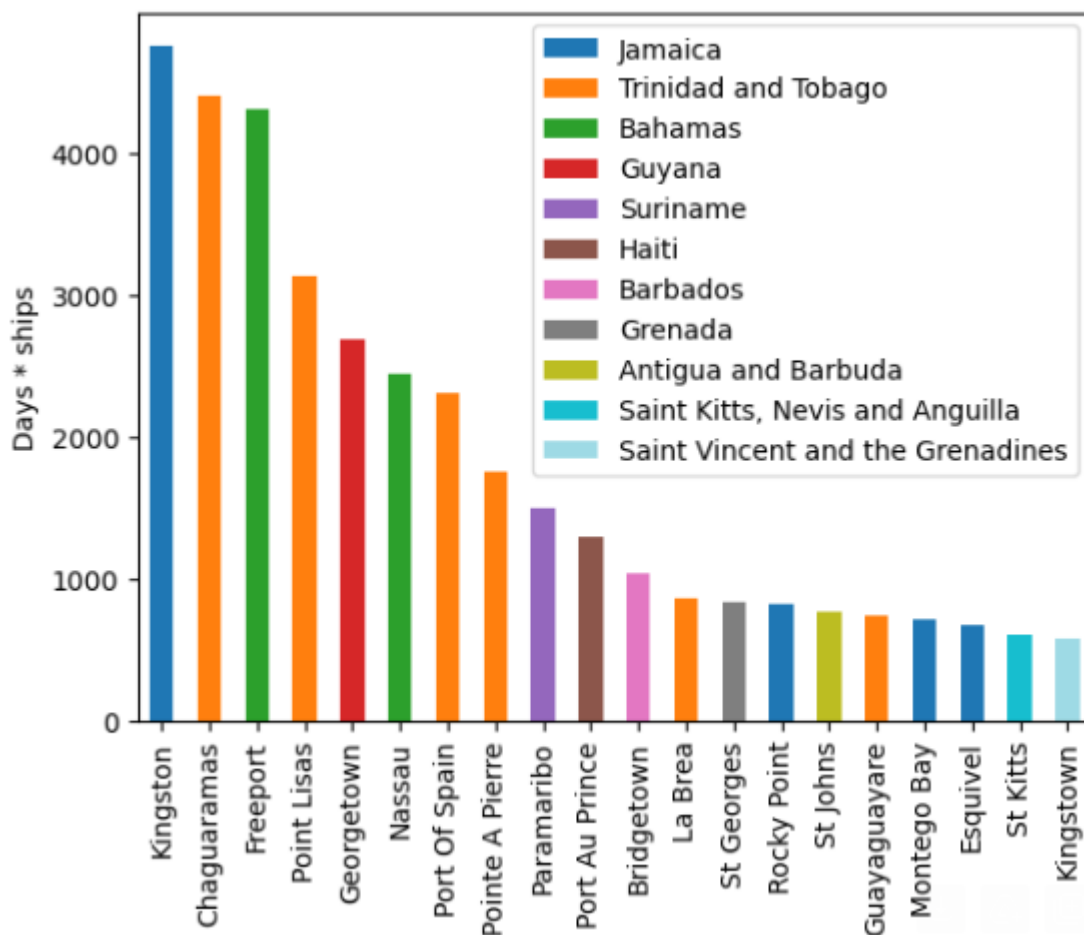


Figure 4.17. Number of days × ships spent in the top 20 ports of the CARICOM countries in 2018 (measured by days × ships)

Furthermore, CARICOM's maritime landscape features a unique blend of small- to medium-sized ports that serve diverse purposes, including energy exports, inter-island cargo trade, and cruise tourism (Caribbean Community (CARICOM), 2023). Unlike major global shipping hubs, CARICOM ports typically accommodate smaller vessels with shorter port stays. Unlike global shipping hubs that cater to large vessels and extended port stays, CARICOM ports primarily accommodate smaller ships engaged in energy exports, inter-island cargo trade, and cruise tourism. Despite shorter port stays, the aggregate emissions from idling ships are significant, particularly for vessels associated with the cruise and energy sectors. High-traffic ports like Chaguaramas and Freeport, which are central to regional transshipment and tourism, present prime opportunities for shore power implementation (IMO, 2021)). Electrifying these quays would not only reduce emissions but also reinforce the economic competitiveness of these vital ports.

A tiered investment approach highlights the flexibility of deploying shore power infrastructure development with regional priorities and available resources. Fully electrifying all CARICOM ports to accommodate every ship at any time would require

an estimated \$0.3 billion in investment for ports charging points (but excluding renewable energy) (see details in the technical annex). Alternatively, optimising shore power usage to achieve an 80% utilisation rate would lower the required investment to \$0.1 billion. This cost differential highlights the importance of strategically aligning infrastructure development with port traffic patterns and anticipated energy demands. By focusing on high-impact areas first, CARICOM states can achieve meaningful progress while minimising financial burdens.

Despite these opportunities, CARICOM countries face unique barriers to implementing shore power compared to larger economies. Many of these states have limited access to affordable financing for large-scale infrastructure projects and rely heavily on fossil fuel imports for electricity generation, making the operational cost of shore power potentially high. Without substantial investment in renewable energy, the operational costs of shore power infrastructure could remain prohibitively high. However, the region's abundant renewable energy resources, such as solar, wind, and geothermal energy, present opportunities to couple shore power investments with renewable energy development, thereby reducing long-term costs and emissions (International Renewable Energy Agency (IRENA), 2022).

Investing in shore power infrastructure also aligns with CARICOM's broader climate goals and international commitments. As signatories to the Paris Agreement, CARICOM countries are committed to reducing greenhouse gas emissions and promoting sustainable development. By electrifying quays and reducing air pollution in densely populated port cities, shore power investments would deliver significant health and environmental benefits. These initiatives position the region as a leader among SIDS in pioneering sustainable maritime practices and achieving climate resilience. (United Nations Framework Convention on Climate Change (UNFCCC), 2021).

Finally, the equitable distribution of ship-days across multiple ports underscores the need for regional collaboration to maximise the benefits of shore power. CARICOM's collective approach to shore power development should include pooling resources, harmonising technical standards, and leveraging international climate financing mechanisms. Multilateral organisations such as the Caribbean Development Bank and the Green Climate Fund could play pivotal roles in bridging funding gaps, while partnerships with the IMO and the International Renewable Energy Agency (IRENA) could provide technical and policy support (IRENA, 2022; IMO, 2021). By working together, CARICOM countries can overcome financial and technical barriers, ensuring a successful transition to low-carbon port operations that benefit the entire region.

4.4.4. Infrastructure for fuel production

The methods used to estimate the amount of investment needed to produce the equivalent quantity of ammonia required to power ships leaving the CARICOM countries are detailed in the technical annex. The results indicate that meeting the

energy demand for voyages departing CARICOM would require the construction of approximately seven ammonia production plants, requiring a total investment of \$57 billion (see methods in the technical annex). While this estimate underscores the financial commitment required, the feasibility of locating such facilities within CARICOM countries introduces additional complexities. These considerations include evaluating the region's renewable energy potential, assessing its industrial capacity, and determining whether such an investment aligns with the region's broader economic strategy. Addressing these questions is pivotal to ensuring that ammonia production contributes effectively to decarbonising shipping while also supporting CARICOM's sustainable development goals.

CARICOM countries face significant challenges in establishing the large-scale ammonia production facilities needed for decarbonisation. One of the primary barriers is achieving the economies of scale required to ensure cost-efficient production. Large-scale ammonia plants rely heavily on access to concentrated renewable energy production and robust industrial infrastructure, both of which are underdeveloped across much of the Caribbean. While the region has abundant renewable energy resources, such as solar, wind, and geothermal energy, unlocking their full potential to power ammonia production would require substantial upfront investment. Additionally, the geographic dispersion of CARICOM member states presents logistical and political challenges, necessitating regional cooperation to consolidate energy production and optimise infrastructure development. Without such collaboration, efforts to establish ammonia plants could exacerbate existing disparities among CARICOM states, leaving smaller or less-developed countries at a disadvantage.

Investing in smaller-scale production plants within CARICOM countries could foster technological inclusivity and regional participation in the energy transition. However, this approach has inherent risks. For example, smaller-scale plants lack the cost-efficiency of larger facilities, leading to higher production costs that could cascade down to consumers. These increased costs might result in higher shipping rates or require sustained government subsidies, diverting limited financial resources from other critical areas such as healthcare, education, or climate resilience initiatives (Atlantic Council, 2023). Furthermore, smaller plants are more susceptible to disruptions in the supply chain and fluctuations in global ammonia prices, adding an element of economic vulnerability to this strategy.

The profitability and long-term sustainability of ammonia production in the Caribbean are heavily dependent on external factors, particularly carbon pricing mechanisms. A global shipping levy or similar carbon pricing scheme could provide the necessary revenue streams to support ammonia production plants, making them economically viable. However, this approach carries inherent uncertainties. If mid-term decarbonisation measures successfully reduce shipping emissions, the demand for carbon credits or levies could decline, reducing the financial incentives for ammonia

production (Smith et al., 2022). This dependency on volatile global markets underscores the need for CARICOM countries to carefully assess the economic viability of ammonia production investments. Developing complementary policies and diversifying energy strategies may help mitigate the risks associated with relying solely on carbon pricing mechanisms.

Overall, the establishment of ammonia production facilities in the Caribbean represents both a significant opportunity and a formidable challenge. On one hand, it could position the region as a leader in sustainable maritime practices while creating economic opportunities linked to renewable energy development. On the other hand, the financial, logistical, and operational hurdles associated with ammonia production highlight the need for a balanced and strategic approach. Regional collaboration, international partnerships, and innovative financing mechanisms will be essential to overcoming these challenges and ensuring that ammonia production contributes meaningfully to CARICOM's energy transition and sustainable development objectives.

4.5. Strategic Considerations for CARICOM

Locating ammonia production plants outside CARICOM countries, in regions with greater industrial capacity and renewable energy availability, could substantially reduce production costs while ensuring the scalability of operations. This approach would leverage the efficiencies offered by industrial hubs that are already equipped with the necessary infrastructure and energy resources to support large-scale ammonia production. However, such a strategy would significantly limit CARICOM's direct economic participation in the green shipping transition. By outsourcing production, the region risks losing opportunities for technological capacity building, workforce development, and the economic returns associated with operating a critical piece of the green shipping value chain. To strike a balance, CARICOM could explore hybrid solutions, such as establishing smaller regional hubs for ammonia production that are supported by international financing mechanisms. These hubs could operate in synergy with larger facilities located outside the region, allowing CARICOM countries to capture some of the economic and social benefits while leveraging economies of scale offered by external production. This approach would create pathways for job creation, local expertise development, and energy independence, enhancing the region's role in the global decarbonisation effort.

Additionally, CARICOM countries must actively advocate for equitable access to international climate finance to support investments in renewable energy infrastructure critical to ammonia production. The costs of building the renewable energy capacity required for ammonia plants are prohibitively high for many CARICOM nations, making external funding essential. Partnerships with multilateral organisations such as the Green Climate Fund, the IMO, and IRENA can help unlock the financial and technical

support needed to bridge this gap. Moreover, CARICOM countries can strengthen their position by leveraging regional integration frameworks, such as the Caribbean Community Climate Change Centre (CCCCC), to coordinate and amplify their advocacy for climate financing. These collaborative efforts can position CARICOM as a unified bloc that is ready to address the decarbonisation of shipping while ensuring that its unique challenges as SIDS are recognised and addressed by the global community. Such advocacy is crucial to secure concessional financing and grants that reduce the financial burden on individual member states.

By aligning investments strategically with regional strengths and priorities, CARICOM countries can address the challenges of developing ammonia production infrastructure while maximising socio-economic and environmental benefits. Identifying opportunities where CARICOM's renewable energy potential, geographical position, and policy frameworks intersect can ensure that the region remains competitive in the evolving global shipping landscape. For example, investments in hybrid production hubs could enhance CARICOM's energy security, reduce dependency on imported fuels, and foster regional cooperation. Furthermore, prioritising policies that integrate ammonia production with broader development goals, such as renewable energy expansion, job creation, and climate resilience, can ensure that these investments deliver long-term benefits for the population. Through innovative financing, collaboration with international stakeholders, and a commitment to sustainability, CARICOM can transform the challenges of ammonia production into a significant opportunity for regional growth and environmental stewardship.

4.6. Further out-of-sector uses

The ongoing transition to decarbonise the shipping sector in the Caribbean offers opportunities that extend far beyond the maritime domain, influencing several key areas of development and environmental stewardship. As CARICOM countries embrace this transition, they stand to gain not only from a cleaner maritime industry but also from the broader economic and ecological benefits it generates. Investments made in green shipping technologies, such as ammonia and hydrogen production, can serve as catalysts for advancing regional climate mitigation and adaptation strategies. Additionally, the revenues generated from carbon levies and green fuel initiatives can be reinvested into initiatives that promote ocean protection, food security, and capacity building across the Caribbean. This multifaceted approach positions the shipping sector's decarbonisation as a vehicle for tackling long-standing structural challenges while helping to meet the region's sustainable development goals.

4.6.1. Climate Mitigation and Adaptation

One of the most significant benefits of shipping decarbonisation lies in its potential to catalyse regional climate mitigation efforts. By creating synergies with the renewable energy sector, investments in green fuels such as ammonia and hydrogen can bolster

CARICOM's capacity to reduce its reliance on fossil fuels. For instance, renewable energy infrastructure developed to support ammonia production could provide broader benefits by supplying clean energy for other sectors such as tourism, agriculture, and manufacturing. The expansion of solar and wind energy projects could not only lower the carbon footprint of ammonia production but also reduce energy costs for CARICOM countries, helping to decarbonise energy-intensive industries that are traditionally reliant on imported fossil fuels (Atlantic Council, 2023).

From an adaptation perspective, the Caribbean's vulnerability to climate change demands significant investment in resilient infrastructure. Revenues generated through global shipping levies, such as carbon taxes, could be funneled into adaptation projects such as coastal defense systems, resilient port facilities, and disaster risk reduction measures. For example, countries like Antigua and Barbuda, which depend heavily on port infrastructure for trade and tourism, could use these funds to protect critical coastal infrastructure from the devastating effects of climate change (UNTAD, 2024). This adaptive capacity would help safeguard the region's economic interests and strengthen its resilience to future climate-related shocks.

4.6.2. Ocean Protection

The decarbonisation of shipping could also play a crucial role in ocean protection, an area of growing concern for the Caribbean. The Caribbean Sea is an invaluable economic and ecological resource, supporting fisheries, tourism, and marine biodiversity. However, it faces significant environmental pressures, including overfishing, pollution, and habitat degradation. Decarbonisation efforts, particularly in shipping, can contribute to the protection of this vital ecosystem. Investments in green port technologies could reduce harmful emissions such as nitrogen oxides, sulfur oxides, and particulate matter, which degrade coastal water quality and harm coral reefs and marine life (McLean et al., 2022). Furthermore, promoting zero-emission shipping routes and incentivising cleaner practices among regional fishing fleets and cruise ships could extend the environmental benefits across maritime industries, fostering a more sustainable relationship with the region's ocean resources.

Additionally, revenues generated through carbon levies and climate financing mechanisms could support the expansion of marine protected areas (MPAs) in the Caribbean. Currently, MPAs cover only about 20% of the region's territorial waters, leaving many critical ecosystems unprotected. By allocating funds from international shipping levies or climate finance mechanisms, CARICOM countries could increase their MPA coverage and enhance the preservation of vital marine ecosystems such as seagrass beds and mangroves, which serve essential carbon sequestration functions (Bustamante, et al., 2014). These areas are not only critical for biodiversity but also for the long-term health of the region's fisheries and tourism industries, creating a sustainable and protective framework for the Caribbean's ocean environment.

4.6.3. Development Finance

Shipping decarbonisation represents a new and innovative pathway for generating development finance within CARICOM countries, many of which face limited fiscal capacity due to small economies and high debt burdens. By aligning decarbonisation efforts with the region's Sustainable Development Goals (SDGs), particularly SDG 7 (affordable and clean energy) and SDG 13 (climate action), CARICOM countries can unlock international climate finance through mechanisms like the Green Climate Fund (GCF) and the Global Environment Facility (GEF). These funding sources can help bridge the gap between the high upfront costs of green technologies and the region's financial constraints, enabling countries to invest in projects that promote both environmental sustainability and economic development.

Moreover, partnerships with global shipping companies and other stakeholders can bring direct investments into local economies. Multinational shipping firms, driven by the need for carbon offsets, may fund community-led projects such as mangrove restoration or sustainable aquaculture, which not only provide environmental benefits but also create economic opportunities for local populations. Barbados, for example, has already piloted projects linking coastal ecosystem restoration with carbon markets, offering a model for other Caribbean states to replicate (Wakefield Adhya, 2022). These collaborations can drive innovation, create jobs, and strengthen the region's capacity to address climate change while also enhancing local resilience.

4.6.4. Food Security

The Caribbean faces significant challenges in achieving food security, with most nations importing over 70% of their food requirements (FAO, 2021). Investments in renewable energy infrastructure related to decarbonisation could indirectly enhance food security by supporting energy-intensive agricultural processes, including irrigation and cold storage. By leveraging renewable energy for these essential agricultural functions, CARICOM countries could reduce their dependence on imported fossil fuels and bolster their local food systems, creating greater resilience in the face of global supply chain disruptions.

An emerging opportunity lies in the integration of renewable energy technologies with water desalination and wastewater treatment. Ammonia production plants, which require substantial water input, often include desalination systems as part of their infrastructure. These systems could be repurposed to supply freshwater for agricultural purposes, addressing water scarcity in countries like Barbados and Antigua and Barbuda, where water resources are limited. Successful renewable-powered desalination projects have already supported small-scale farming (Taha Sayed, et al., 2023), and similar initiatives could be expanded to enhance agricultural productivity and water access across CARICOM.

Moreover, the nitrogen by-products of ammonia production could be repurposed as fertilizers, reducing the region's reliance on costly imported fertilizers and promoting sustainable agricultural practices. Countries with significant agricultural potential, such as Guyana, could benefit from integrating decarbonisation infrastructure into food systems, creating synergies between the shipping, energy, and agriculture sectors to foster more sustainable and resilient food production systems.

4.6.5. Education and Training

The transition to green shipping technologies presents an important opportunity for capacity building and workforce development in the Caribbean. As the shipping sector moves toward decarbonisation, new industries and technologies including hydrogen fuel cells and advanced renewable energy systems will require a highly skilled workforce. Educational institutions, particularly those in CARICOM countries, can play a pivotal role by establishing specialised programs to train students in these emerging fields, ensuring that the region is equipped with the necessary expertise to drive and sustain the green transition.

Investing in education and training for green technologies can have ripple effects across multiple sectors, creating a broader skills base for industries such as public transportation, manufacturing, and energy management. For example, training programs focused on fuel cell technology and renewable energy systems could benefit not only the maritime sector but also energy grid management and logistics operations. Institutions like the University of the West Indies (UWI) and the Caribbean Maritime University (CMU) are already well-positioned to take on this role by preparing the next generation of professionals in green technologies and maritime decarbonisation, addressing regional skill gaps while strengthening the workforce (UWI, 2024; JIS, 2025).

Furthermore, the push for decarbonisation in the maritime sector can attract global partnerships and funding for research and development in green technologies. This presents an opportunity for the Caribbean to become a hub for innovation in green shipping and other sustainable industries. Institutions such as the Caribbean Centre for Renewable Energy and Energy Efficiency (CCREEE) could expand their focus to include maritime decarbonisation, fostering regional expertise and positioning CARICOM as a leader in sustainable development and clean technology innovation.

4.6.6. Technology Transfer

Technology transfer is a critical mechanism for enabling the adoption of green technologies in the Caribbean, where local innovation capacity remains limited. The transition of the maritime sector to zero-emission fuels and digital optimisation tools offers significant opportunities for technology diffusion into other sectors. One such area is the application of hydrogen and ammonia fuel technologies, initially developed for zero-emission shipping, to land-based transportation systems. Hydrogen fuel cells

could be adapted to power buses, trucks, and other vehicles, reducing the Caribbean's dependence on imported fossil fuels and helping to diversify the region's energy sources. Countries such as Jamaica and Trinidad and Tobago, which boast well-established transport networks, could benefit significantly from this cross-sector application (McLean et al., 2022).

Advancements in digital technologies, such as autonomous shipping and predictive maintenance systems, could also improve operational efficiency in sectors beyond maritime transport. For example, real-time data analytics used in smart ports could be applied to logistics and supply chain operations in agriculture and manufacturing, helping to optimise processes and reduce inefficiencies. This could enhance the competitiveness of Caribbean products in global markets and support broader economic diversification efforts.

Finally, technology transfer could also contribute to strengthening disaster risk management strategies in the region. For instance, weather-monitoring technologies developed for maritime navigation could be integrated into regional early warning systems for hurricanes and floods, improving resilience against climate-related disasters. By adopting and adapting cutting-edge technologies, CARICOM countries can not only drive the decarbonisation of their maritime industries but also enhance their capacity to manage environmental risks and build long-term climate resilience.

4.7. Challenges to Out-of-Sector Integration

Despite the promising opportunities, integrating out-of-sector uses into the decarbonisation of the shipping industry presents a number of challenges that need to be addressed in order to unlock the full potential of these initiatives. One key obstacle is the limited institutional capacity within CARICOM countries to manage large-scale projects that span multiple sectors. Many regional institutions face resource constraints, making it difficult to implement ambitious cross-sector solutions that require coordination, financing, and expertise across various fields. Additionally, fragmented regional cooperation further complicates efforts to address these challenges. While CARICOM countries share common goals, their efforts are often disconnected due to differing national priorities, administrative structures, and lack of consensus on the best path forward. To effectively implement these out-of-sector opportunities, a coordinated regional approach is crucial. This will require strengthening existing institutions, improving inter-governmental coordination, and fostering greater collaboration among stakeholders. By overcoming these institutional challenges, CARICOM can ensure that the benefits of decarbonisation reach all sectors of society, thus maximising its impact.

Another significant challenge lies in balancing investments between maritime decarbonisation and other key sectors, ensuring that the finite resources available are optimally distributed. The need for substantial financial and human resources to support green shipping technologies and infrastructure must be weighed against the demands of other critical sectors, such as agriculture, energy, and tourism. If these resources are not carefully prioritised, there is a risk of overstretching capacity, which could undermine the effectiveness of both maritime and non-maritime initiatives. Additionally, the benefits of decarbonisation-related investments must be distributed equitably across sectors and populations, with particular attention given to marginalised communities that often bear the brunt of environmental and economic challenges. Ensuring that the transition to green shipping does not inadvertently exacerbate existing inequalities will be key to achieving the broader objectives of sustainable and inclusive development. A thoughtful, inclusive approach to decision-making and investment distribution will be essential in addressing these concerns.

Moreover, the Caribbean's dependence on external financing to support decarbonisation and other regional development initiatives brings another layer of complexity to the process. While international climate finance mechanisms offer essential funding, they often come with specific conditions that can limit the flexibility of how these resources can be allocated and used. For example, donor organisations and financial institutions may impose restrictions on the types of projects that qualify for funding or require that funds be used in a way that does not align with local priorities. This can create a disconnect between the financial support available and the real needs on the ground in CARICOM countries. In light of these challenges, it is crucial that CARICOM countries prioritise regional integration and strengthen institutional frameworks to ensure that the benefits of international financing are maximised. Additionally, CARICOM must advocate for more equitable financing mechanisms in global climate negotiations to ensure that the region has the autonomy to address its unique needs and circumstances while contributing to global climate goals.

Notwithstanding these challenges, shipping decarbonisation presents a transformative opportunity for CARICOM countries to tackle the urgent issues of climate change, ocean protection, and development finance. By strategically aligning decarbonisation efforts with regional priorities, CARICOM countries can leverage the economic and environmental benefits of the transition to a green shipping sector. These efforts can contribute to a more sustainable future by addressing pressing challenges such as reducing greenhouse gas emissions, safeguarding marine ecosystems, and enhancing resilience to climate-related disasters. The success of these efforts, however, will depend on robust governance, regional cooperation, and proactive engagement in international climate negotiations. To ensure equitable access to resources, CARICOM must advocate for fair and flexible financing solutions that allow

the region to address its unique developmental and environmental challenges. With strong leadership, regional unity, and international collaboration, the Caribbean can make meaningful strides toward a sustainable and inclusive future.

4.8. Conclusion

The IMO's CIA revenue distribution presents a crucial opportunity for CARICOM countries to advance equitable development while mitigating the socio-economic and environmental impacts of shipping. The estimated potential revenue of \$1.3 billion to \$17.4 billion between 2027 and 2050 offers a considerable promise of resources, but it also presents a challenge in terms of how these funds are strategically allocated. In the context of the Caribbean's unique vulnerabilities, resource limitations, and development priorities, the need for careful planning and targeted investment is clear. The Caribbean region, often facing economic fragility due to its small size and dependence on external markets, must ensure that these revenues are harnessed to directly benefit its people, creating long-term, sustainable outcomes. By developing strategic pathways to maximise the value of this funding, CARICOM can position itself to not only address immediate needs but also build resilient systems that support future development.

Firstly, the Caribbean's dependence on imported goods and the region's position as a transshipment hub amplify the adverse impacts of increased shipping costs on welfare. The revenue from the IMO's CIA can play a vital role in mitigating these impacts, provided it is directed toward projects that address pressing regional priorities such as food security, climate resilience, and the development of sustainable infrastructure. Rather than merely providing grants or loans, these funds should be used to build and enhance the infrastructure needed to support the transition to green shipping, such as alternative fuel facilities, improved port efficiency, and onboard retrofitting for vessels (DNV, 2024). By strategically allocating these resources, CARICOM countries can not only support the global decarbonisation of shipping but also cushion their populations from potential economic disruptions and enhance their resilience to future challenges.

Table 4.1. DNV Estimation and Rationale

(DNV, 2024)Use	Estimate	Rationale
Onboard ships:	\$7-23	Incentives to reduce shipping GHG emissions
Retrofit to alternative fuels	billion ³ , but	Technological equity (but most ships are not owned by
Retrofit to energy efficient technologies	\$0.5-1.6	shipowners based in the CARICOM countries)
Retrofit to shore power	restricted to	Reduction in the increase in transport cost and
	shipowners	therefore welfare impacts
	based in the	
	CARICOM	
	countries	

³ Investment to retrofits to methanol or ammonia dual-fuel ships responsible for 75% of the trips to and from CARICOM countries

(DNV, 2024)Use	Estimate	Rationale
In ports: Alternative bunkering infrastructure Shore power Port efficiency (cost not estimated)	\$0.7 billion ⁴	Incentives reducing shipping GHG emissions Technological equity Reduction in the increase in transport cost and therefore welfare impacts
Alternative fuel production	\$57 billion	Incentives to reduce shipping GHG emissions Technological equity (but fuel production infrastructure might not stay competitive, once subsidies fade out) Reduction in the increase in transport cost and therefore welfare impacts

Secondly, while the table outlines significant investments required for onboard retrofits, port upgrades, and alternative fuel production, foreign ship owners will bear a considerable portion of these costs. However, CARICOM countries must ensure that they strategically position themselves to benefit from these investments by implementing policies that prioritise local participation and development. For example, the establishment of alternative bunkering infrastructure at regional ports can serve multiple purposes: reducing greenhouse gas emissions, enhancing the region's attractiveness as a hub for sustainable shipping (McLean et al., 2022), and ensuring that Caribbean economies capture a share of the global green shipping market. This approach not only aligns with the global decarbonisation agenda but also strengthens the Caribbean's competitive edge in the maritime sector. By fostering local involvement in these initiatives, CARICOM countries can ensure that the economic benefits of the green transition are felt regionally, boosting employment and fostering technological development.

The broader impacts of maritime decarbonisation also hold significant potential for out-of-sector uses such as food security, climate adaptation, and development finance. Investments in renewable energy for alternative fuel production, for example, can create synergies with the agricultural sector by providing a reliable energy source for irrigation, cold storage, and other essential functions. This would reduce the region's dependence on imported food and enhance food security by supporting local agriculture. Similarly, the revenue generated from shipping decarbonisation can be used to fund climate adaptation projects that address the region's vulnerability to rising sea levels, extreme weather events, and other climate-related threats. By integrating these initiatives with the broader goals of decarbonisation, CARICOM can create a multiplier effect, driving both environmental and socio-economic benefits (Beckles & Alleyne, 2022). The convergence of maritime decarbonisation with regional development priorities offers an opportunity for the Caribbean to advance

⁴ For an average 80% utilisation of the quays and assuming replacing all bunkering barges operating in CARICOM countries by ammonia bunkering barges

sustainability while addressing the immediate needs of its communities, particularly those in coastal areas who are most vulnerable to climate impacts.

However, these opportunities must be navigated carefully to address the challenges that accompany the transition, particularly around issues of technological equity. While the decarbonisation of the shipping sector holds promise for advancing regional development, there is a risk that external stakeholders could disproportionately benefit from these advancements, leaving local communities and economies behind. The high costs of constructing alternative fuel production facilities, estimated at \$57 billion, highlight the need for regional collaboration to pool resources, attract foreign investment, and ensure that the benefits of these investments are felt locally. The creation of regional hubs for ammonia production, powered by renewable energy, represents a potential solution to this challenge. These hubs could help ensure that CARICOM countries are active participants in the green transition, promoting regional integration and economic diversification while addressing the need for local capacity building and sustainable infrastructure.

Ultimately, the transition to low-carbon shipping should not be viewed solely as an environmental obligation but also as an opportunity to redefine the Caribbean's developmental trajectory. By aligning decarbonisation strategies with the region's socio-economic realities and development aspirations, CARICOM countries can leverage these efforts to advance broader goals such as sustainable economic growth, job creation, and technological innovation. The success of this transition will hinge on the region's ability to mobilise resources effectively, engage in strategic international partnerships, and advocate for equitable access to funding and resources. By actively participating in global negotiations and ensuring that the needs of SIDS are prioritised, the Caribbean can help shape a global decarbonisation framework that is fair and supportive of the region's unique challenges and opportunities.

In conclusion, the IMO's CIA revenue distribution represents a critical opportunity for CARICOM countries to tackle significant regional challenges while supporting global decarbonisation of the shipping industry. To realise the full potential of these revenues, CARICOM must adopt a strategic, integrated, and equitable approach to resource allocation. This means focusing on initiatives that not only advance maritime decarbonisation but also support the region's broader development goals, including food security, climate adaptation, and economic diversification. By investing in transformative projects, fostering regional collaboration, and ensuring that the benefits of decarbonisation extend beyond the maritime sector, the Caribbean can forge a pathway towards a more sustainable and resilient future for its people.

Policy Scenarios and Caribbean Outcomes

The choice between a low or high levy scenario has direct and far-reaching implications for the Caribbean, and these scenarios must be carefully considered in

the context of regional priorities. While the low levy scenario, projecting global revenues of \$500 billion by 2050, may seem like a reasonable target, it is unlikely to generate the resources needed to address the full scale of the maritime decarbonisation challenges faced by SIDS. On the other hand, the high levy scenario, which offers a potentially transformative financial opportunity, presents higher short-term costs for operators, which could place additional burdens on Caribbean economies in the immediate term. In light of these considerations, it is crucial for CARICOM countries to advocate for mechanisms that ensure a significant portion of these revenues is reinvested in the region. This reinvestment would help alleviate the financial strain of decarbonisation while supporting the equitable transition to a low-carbon maritime sector.

In this context, a low levy scenario could provide limited financial support but would also risk reinforcing existing vulnerabilities within the Caribbean maritime sector, such as reliance on outdated fleets and infrastructure. The region would continue to face challenges in upgrading its ports and fleets to meet the demands of green shipping, and this could hinder long-term sustainability. As such, CARICOM stakeholders must lobby for a robust and comprehensive levy system that includes targeted revenue redistribution mechanisms. These mechanisms would direct much-needed funding to the Caribbean, enabling the region to address its unique challenges and priorities. Through strategic advocacy and engagement, CARICOM countries can secure the resources necessary to support the decarbonisation of their maritime sectors and bolster their overall resilience.

The Caribbean's ability to implement mid-term measures within the IMO framework represents both a challenge and a significant opportunity for the region's development. To capitalise on this opportunity, the Caribbean must advocate for policies that prioritise equity and ensure access to the financing necessary for decarbonisation. This includes promoting technological inclusivity, ensuring that small economies can participate in the transition, and facilitating the flow of resources to areas where they will have the greatest impact. With strategic investments in infrastructure and regional collaboration, CARICOM can position itself as a leader among SIDS in the global transition to low-carbon shipping, while safeguarding the region's economic resilience and advancing its sustainable development goals.

This need for equitable revenue distribution underscores the importance of regional alignment on priorities and a collective advocacy approach within the IMO and other international forums. CARICOM countries must engage with global stakeholders to ensure that the revenues generated from the levy are allocated in a way that maximises benefits for the region. These funds should be directed toward projects that address shared vulnerabilities and support the region's transition to a low-carbon economy. From upgrading port infrastructure to investing in renewable energy solutions, the allocation of these revenues must reflect the specific needs of the

Caribbean. Through collaboration and unified action, CARICOM can advocate for a system that recognises the unique challenges and opportunities facing the region.

However, challenges to equitable revenue distribution persist, particularly given the disparity in institutional capacity between Caribbean countries and larger developing nations. Many Caribbean states struggle with limited administrative capacity to compete for climate financing, which often places them at a disadvantage in securing resources for decarbonisation efforts. Furthermore, the broad categorisation of “developing countries” in international climate negotiations can dilute the focus on the specific needs of SIDS and LDCs. To overcome these challenges, CARICOM must advocate for a revenue allocation model that explicitly takes into account the region’s climate vulnerability, its economic dependence on maritime trade, and its capacity constraints. By pushing for a more tailored approach to funding allocation, CARICOM can ensure that the Caribbean receives the support it needs to navigate the complex challenges of maritime decarbonisation.

To effectively absorb and deploy the revenues generated through the IMO’s CIA, the region’s maritime stakeholders—including port authorities, shipping operators, and governments—must enhance their capacity for efficient fund management. This requires the establishment of transparent governance structures, as well as regional coordination to ensure that funds are deployed in an efficient and effective manner. The funds must be directly linked to long-term decarbonisation and climate adaptation goals to ensure that they contribute to a sustainable, resilient maritime sector. With these systems in place, CARICOM can make the most of global carbon revenues to support a just and equitable transition to low-carbon shipping, strengthening its maritime sector and improving its long-term economic outlook.

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4.AI. Introduction to Annex

Structure

This technical annex to the report “Distributing shipping carbon revenue in the Caribbean SIDS” details the methods underlying the results provided in the main report. It is organised as follows:

- Section 1 explains how the movements, energy, carbon emissions of ships operating in the CARICOM countries were estimated

Where the next sections describe the assumptions and modelling method of the investments needed to decarbonise shipping voyages in CARICOM countries:

- Section 2 for investments onboard ships
- Section 3 for investments in bunkering infrastructure in ports
- Section 4 for shore power investments in ports
- Section 5 for infrastructure for fuel production

4.AI.1. Characterisation of ships and maritime energy supply

This analysis is informed by data from the IMO’s 4th Greenhouse Gas Study (Faber et al., 2020), which incorporates AIS data for the year 2018. Individual AIS records are aggregated to provide hourly positional and speed data, enabling a granular understanding of vessel movements across Caribbean waters. Vessel specifications, including size, engine type, and operational profiles, are matched with hourly AIS data to model fuel consumption. Individual ships are identified in this database using their IMO number, and matched to the equivalent HIS database which contains further design information (e.g. engine power, deadweight).

4.AI.2. Investments needed onboard ships to decarbonise shipping in the Caribbean

To estimate the amount of investment needed onboard ships to decarbonise shipping in CARICOM countries, we provide an estimate for:

- The level of investment needed per ship (expressed \$/kW of engine power). In this report, we estimate 3 types of investment onboard ships needed to decarbonise shipping:
 - Energy efficiency (EE) (details in subsection 2.1)
 - Alternative marine fuels (subsection 2.2)
 - Shore power (subsection 2.3)
- The pool of ships which need to be decarbonised and their engine power (subsection 2.4)

4.AI.2.1. Energy efficiency onboard ships

We use three possible levels of energy efficiency investments, used in the IMO’s comprehensive impact assessment (DNV, 2024). While the IMO’s CIA’s

categorisation of EE provides a useful starting point, the Caribbean's context demands an assessment tailored to regional priorities.

- **Enhanced EE Technologies:** optimised bow shapes, variable engine speed, steel plant operation improvement, air lubrication and battery hybridisation.
- **Advanced EE Technologies:** wind-assisted propulsion, solar panels, waste heat recovery systems, wind turbines, heat pump, aerodynamic optimisation.
- **Cutting-edge EE Technologies:** hull and machinery performance, autonomisation, reduced ballast design.

4.AI.2.2. Alternative fuel investments onboard ships

To estimate the level of investment needed onboard ships so that they can use zero/new-zero carbon fuel, we assume that ships are retrofitted to those alternative fuels, rather than scrapped and replaced by new ones. The latter option would end up being more costly, but it is still a possible scenario if retrofitting was not economically, practically or technologically possible. Based on the IMO's CIA (DNV, 2024), we consider 3 possible retrofit possible, namely:

- Dual-fuel Internal Combustion Engine (ICE) methanol/low-sulphur heavy fuel oil (LSHFO)
- Dual-fuel ICE ammonia/LSHFO
- Dual-fuel ICE hydrogen/LSHFO

The investment costs for energy efficiency and retrofit to alternative fuels are adapted from the IMO's CIA (DNV, 2024), which however only reports some ship size and types. The reported investment costs are converted to \$/kW engine power for each ship size and type and the average investment per kW engine power is used⁵. This assessment is likely an approximation of the investment estimates by the IMO's CIA (DNV, 2024), but in the absence of more detailed results, this assessment is considered to give a broad scale of investment needed in the CARICOM countries.

4.AI.2.3. Shore power investments onboard ships

Assumptions underlying the investments onboard ships to be able to use shore power when in ports is taken from the Global Maritime Energy Efficiency Partnerships⁶ and following the approach by Merkel et al (2023), which again reports ranges of value for a selection of ship types and sizes. We use a similar approach as the one used for alternative marine fuels and energy efficiency: the absolute estimates were converted to \$/kW and averaged. We use the upper end of the range for each ship type and size reported, as in (Merkel et al., 2023).

⁵ The resulting investment estimates are \$250/kW for retrofitting the ship to methanol, \$430/kw for ammonia and \$1390/kW for hydrogen dual fuel ships; \$180/kw for the enhanced EE package, \$500/kW for the advanced EE, and 1330 for the cutting-edge EE package.

⁶ <https://glomeep.imo.org/technology/shore-power/>

4.AI.2.4. Identifying the pool of ships to be decarbonised

We multiply those investment estimates per kW of engine power (EE, alternative fuel and shore power) by the engine power of each ship operating in the CARICOM countries and sum it across all ships. Ships operating in the CARICOM countries are identified using the AIS database used for the IMO's 4th GHG study, which contains all voyages made by ships in 2018 from and to individual ports, including the ports located in the CARICOM countries.

Using 2018 data might lead to an underestimate of investments level, if the fleet operating in the CARICOM countries has grown since then. While we do not have evidence of this for all CARICOM countries, the port calls data collected in Section 1 of this compilation for Jamaica do not suggest a significant increase in shipping between 2018 and 2023. However, given this limitation, the estimates should be considered as a first approximation rather than precise estimates. Furthermore, not all this investment cost would be borne by ship owners headquartered in CARICOM countries, as many of the ships operating in the CARICOM countries are owned by ship owners headquartered outside of the CARICOM countries.

To address the latter limitation, we estimate the investment would be borne by ship owners based in the CARICOM countries. To do so, we map the Clarksons World Fleet Register (WFR), which has detailed information on the ship owner of each ship in 2024 and its country of headquarter, and the ships recorded in the 4th GHG study AIS data. Clarksons does not allow users to download the full database with all IMO numbers, so while some ships were mapped using the IMO numbers (27%), most ships were mapped using information on their deadweight, year of building, gross tonnage and shipping segment. When the combination of those 4 pieces of information was not unique to a ship, or when the combination could not be found in the other database (for example, when the reported deadweight in both databases was not exactly the same), the ships could not be matched. 47% of the ships operating to and from CARICOM countries were matched using either of those methods.

4.AI.3. Bunkering infrastructure in ports

To estimate the investments needed in bunkering infrastructure, we estimate the investment needed to replace existing barges bunkering fossil marine fuel operating in the CARICOM countries by ammonia bunkering barge. This relies on two estimates:

- The new build price of an ammonia bunkering barge
- The number existing barges bunkering fossil marine fuel.

Regarding the former estimate, Clarksons WFR reports new build prices for several bunkering barges (Figure 4.AI. 1) but not for ammonia barges; however, as the new

build prices ammonia tankers are on average 0.73 times per deadweight those of LNG tankers (see Figure 4.AI. 2), and given that we have some data points on the new build price of LNG bunkering barges (see equation on Figure 4.AI. 1), we estimate the price (in million USD) of a newbuild ammonia bunkering barge as $(0.0042 \times dwt + 37.801) \times 0.73$.

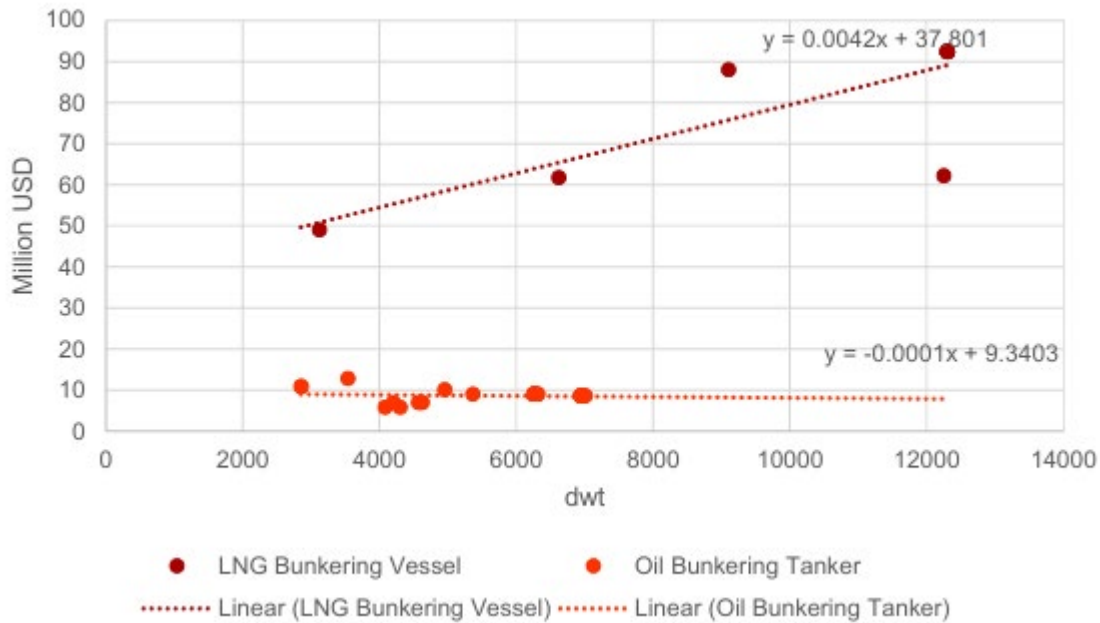


Figure 4.AI. 1. Newbuild prices of bunkering vessels reported in Clarksons WFR

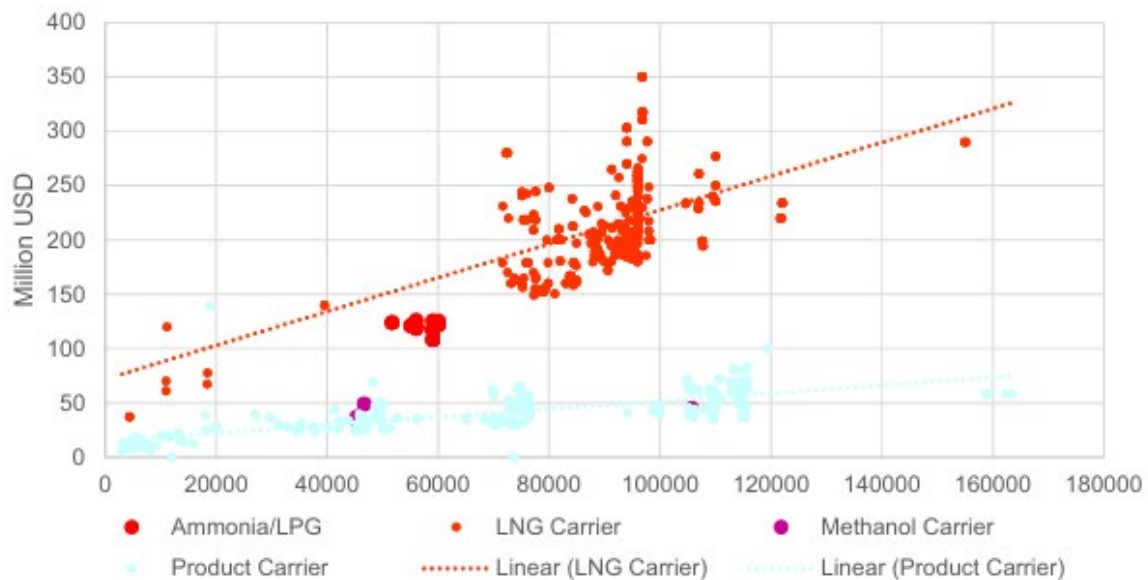


Figure 4.AI. 2. Newbuild price of tanker, reported in Clarksons WFR

To estimate the number of fossil bunkering barges currently operating in the CARICOM countries, we conduct a desktop research using Marine Traffic website (all

oil tankers stationed in the CARICOM countries were investigated)⁷, Clarksons WFR and news articles available online. Although this approach might have missed a few ships, there is some confidence the order of magnitude of the investments needed is correct. We find that 6 bunkering ships are operating regularly in CARICOM countries (listed in Table 4.AI.1): 4 oil bunkering barges of average deadweight of about 6 000 tonnes and 2 LNG bunkering barges of average deadweight of about 12 500 tonnes.

Table 4.AI.1. List of bunkering ships operating in the CARICOM countries

IMO number	Ship name	Ship's deadweight	Bunkering type	Main bunkering location
9382126	Kalymnos	6 257	Oil	Jamaica
9886768	Avenir Achievement	13 136	LNG	Jamaica
9596545	JC Trader	4 300	Oil	Jamaica
9438212	Lorena B	6 963	Oil	Trinidad & Tobago
9381653	Kerkyra	6 290	Oil	Trinidad & Tobago
9936288	New Frontier 2	11 962	LNG	Bahamas

4.AI.4. Shore power infrastructure in ports

Estimating the amount of investment needed to install shore power in ports requires the estimation of:

- The number of quays to be installed in the CARICOM region.
- The amount of investment needed to install on quay (excluding onboard ship investments, which are already covered in section 2)

Regarding the latter estimate, we first compute for each day of the year the number of ships stopping at the same time in each port of the CARICOM countries, using the 2018 AIS data from the 4th GHG study. The results are plotted on Figure 4.AI. 3., which illustrates the distribution of simultaneous ship stops at the top 20 CARICOM ports, showing significant variability in port activity. A notable 27% of CARICOM ports experienced no more than one ship stopping at the same time in 2018, indicating that these smaller ports require minimal shore power infrastructure, with only a single quay needing electrification. This is particularly relevant for ports in smaller islands like Dominica or St. Kitts and Nevis, which serve primarily as regional hubs for limited cargo and passenger movements. On the other hand, major ports such as Chaguaramas (Trinidad and Tobago), Kingston (Jamaica) and Freeport (Bahamas) exhibit considerably higher traffic, with up to 23 vessels calling simultaneously. These high-traffic ports would necessitate

⁷ Ship's positions were observed on the 3rd January 2025.

substantial investment in shore power infrastructure to ensure availability for all vessels.

We use the assumptions of Merkel et al (2023) by assuming an investment cost per quay of \$ 673 000 (Merkel et al., 2023). The investment needed so that each ship stopping in CARICOM ports finds a free electrified quay is calculated for each port as $673\,000 \times \text{maximum number of ships in port in 2018}$, and then summed for all ports in CARICOM countries. However, this calculation may overstate the need, as some ports lack the physical capacity to accommodate the maximum number of vessels recorded in the AIS data (which stopped at the same time in 2018), and some ships likely waited in or near the port but not at quay.

To refine the estimates and better align investments with operational realities, we applied an average utilisation rate of 80%. The investment needed so that quays are utilised on average 80% of the time is calculated for each port as:

$$673\,000 \times \frac{\text{average number ships in port in 2018}}{80\%},$$

rounded to the nearest unit, and then aggregated for all ports in CARICOM countries. This approach adjusts the number of required electrified quays based on average vessel activity in each port, ensuring more efficient use of resources. For the 5 busiest ports, the adjusted calculations were sense-checked against satellite imagery and port layouts, by checking that the number of existing quays was at least equal to the number of quays to be equipped with shore power (using google maps, and assuming an average 180m length per quay).

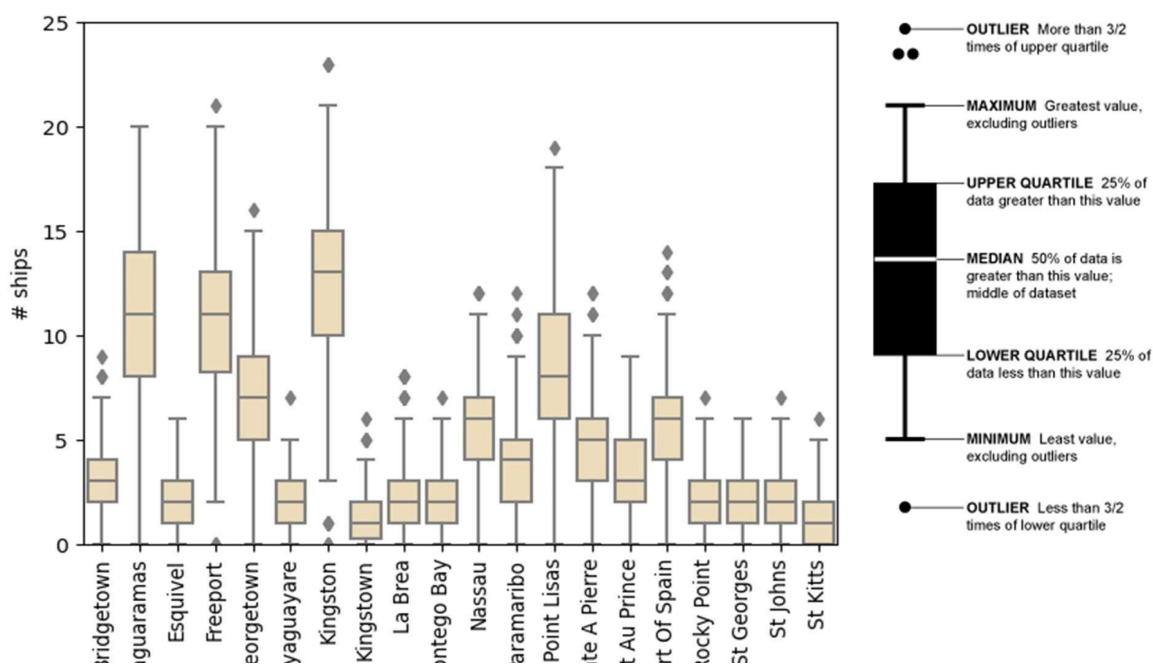


Figure 4.AI. 3. Number of ships at the same time in ports

**The variation plotted represents the variability throughout the year, for each day*

*** Read: in Chaguaramas, 50% of the time, at least 11 ships are stopping in the port (median); 25% of the time, at least 14 ships are stopping in the port (75% inter-quartile); and 25% of the time, less than 8 ships are sitting in the port (25% inter-quartile).*

While these estimates provide a starting point, they should be interpreted as indicative rather than definitive. A more detailed assessment, including in-port surveys and engagement with stakeholders, would refine these projections further.

4.AI.5. Infrastructure for fuel production

To estimate the investments required to establish fuel production infrastructure in the Caribbean region, we first estimate two quantities:

- The capital investment required to build a green ammonia production plant;
- The quantity of ammonia needed to power voyages departing from CARICOM countries

Regarding the former, the investment cost for a large ammonia plant producing 1 million tonnes of ammonia per year (18.8 PJ/year) is set at \$8.1 billion, following UMAS estimates⁸. This cost includes infrastructure for renewables, water desalination or wastewater treatment, electrolyser, hydrogen compression and storage, air separation unit and ammonia synthesis. It is worth noting that this study takes the case of a large ammonia production plant to benefit from the economies of scale and would require a certain level of concentration of the production.

The energy demand data for voyages leaving CARICOM countries is estimated in 2018 using the AIS-derived database used in Faber et al., 2020. The results are plotted onto Figure 4.AI. 4. Energy demand for voyages leaving the CARICOM countries in 2018, which shows the energy demand used to power trips leaving CARICOM countries in 2018. Producing the energy demand used to power those trips would require the construction of ~7 of the ammonia producing plants described above, hence a total investment of \$57 billion.

⁸ UMAS, upcoming

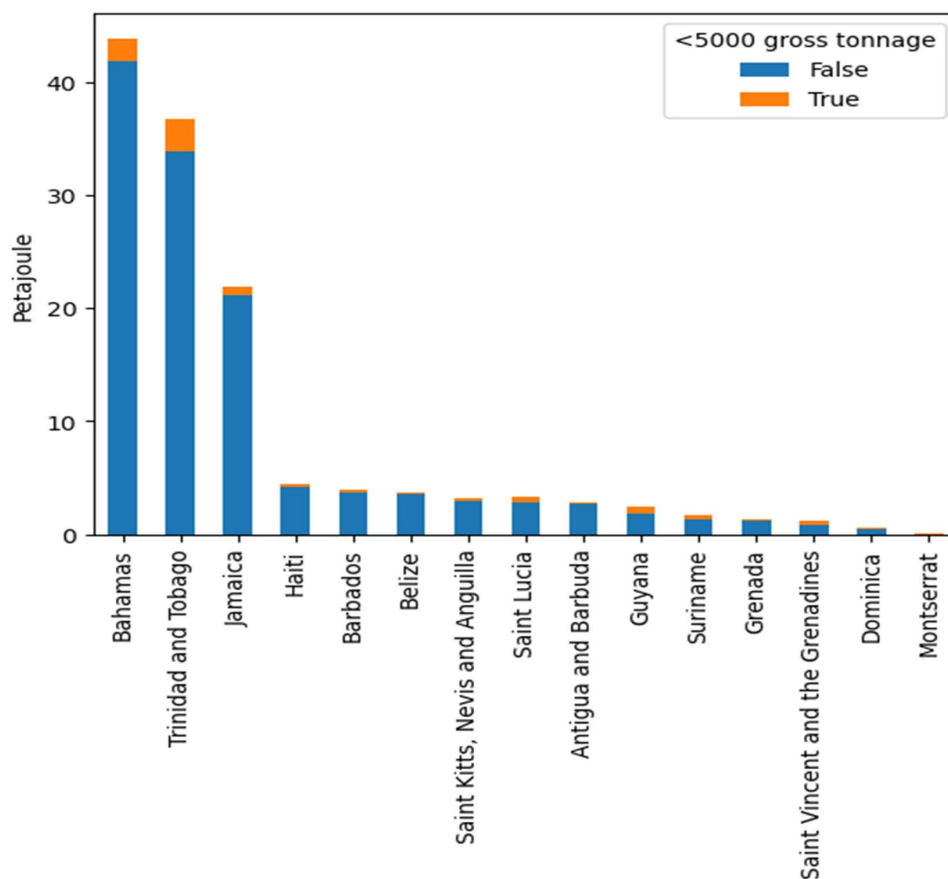


Figure 4.AI. 4. Energy demand for voyages leaving the CARICOM countries in 2018

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SECTION 5

ASSESSING THE POTENTIAL IMPACT OF THE IMO MID-TERM GHG MITIGATION MEASURES ON FOOD SECURITY IN CARIBBEAN NATIONS



ASSESSING THE POTENTIAL IMPACT OF IMO MID-TERM GHG MITIGATION MEASURES ON FOOD SECURITY IN CARIBBEAN NATIONS

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EXECUTIVE SUMMARY

This study investigates the potential impacts of the International Maritime Organization (IMO) mid-term greenhouse gas (GHG) mitigation measures on food security in the Caribbean. With a heavy reliance on food imports and vulnerabilities to external shocks, the region faces significant challenges in achieving food security. The study's primary objectives are to assess the critical commodities influencing food security in the Caribbean, evaluate the welfare impact of policy scenarios, and examine the revenue distribution from carbon levies in mitigating food security risks. Using a Global Dynamic Model (GDL), the study forecasts food import volumes and expenditure from 2024 to 2050. The Linear Approximate Almost Ideal Demand System (LA-AIDS) model is employed to derive expenditure and price elasticities, while Compensating Variation (CV) is applied to assess the welfare impacts of the IMO's mid-term measures. Three key policy scenarios—no carbon levy, high carbon levy, and low carbon levy—are modeled with varying revenue distribution mechanisms to gauge their effect on food security. The results highlight that, in the short term, carbon levies may lead to food price increases, which could exacerbate food insecurity in vulnerable populations. Over the long term, the Caribbean faces challenges in maintaining affordable and stable food supplies. Scenario 26 (high carbon levy) emerges as the most effective in generating revenue to compensate for welfare losses, particularly in Small Island Developing States (SIDS) and Least Developed Countries (LDCs), thereby mitigating the impact on food security. The results suggest that a well-structured carbon levy, designed with targeted revenue distribution mechanisms, can play a critical role in mitigating the adverse impacts of the IMO's mid-term measures on food security. To enhance food security resilience, policy efforts should focus on diversified agricultural strategies, improved food affordability mechanisms, and regional cooperation.

5.1. Introduction

The International Maritime Organization's (IMO) 2023 strategy for reducing greenhouse gas (GHG) emissions marks a significant step in the global shipping sector's path toward decarbonization. The strategy targets net-zero GHG emissions by around 2050, with key milestones: a 20% reduction by 2030, aiming for up to 30%, compared to 2008 levels; and a 70% reduction by 2040, with an aspirational goal of 80%. Ongoing IMO negotiations seek to establish a new set of legally binding, globally enforceable mid-term measures to support these targets. These measures are expected to include both a technical component, such as a fuel standard, and an economic mechanism (levy, or a trading mechanism linked to the fuel standard, called a "flexibility mechanism"). A common element across proposals is a fuel standard that progressively tightens limits on the GHG intensity of marine fuels, driving sector-wide decarbonization toward the 2050 net-zero goal. However, some policy aspects remain under discussion, particularly regarding the economic measure's design:

- Whether to introduce a "flexibility mechanism" allowing credit trading between ships that over- and under-perform on emissions.
- Whether a GHG price should apply solely to emissions exceeding the fuel standard's limits (targeting underperforming ships) or to all emissions, effectively creating a universal GHG price or carbon levy for all ships.

Caribbean economies are deeply integrated into the global market, with international trade in goods and services playing a vital role in their economic growth and development (Nguyen and Jolly 2013). The Caribbean faces significant challenges in achieving food security⁹, including climate change and extreme weather events, limited arable land, high dependence on food imports, environmental degradation, and insufficient agricultural technology and infrastructure (Stanberry and Fletcher-Paul 2024a). Most Caribbean nations are classified as net-food importers (Forgenie et al. 2024; Forgenie, Hutchinson, and Muhammad 2024; Walters and Jones 2016), importing approximately 80-90% of their food needs (Forgenie, Hutchinson, and Muhammad 2024; Daley et al. 2023). The region's imports to be susceptible to global market volatility, trade disruptions, and shifts in international policies, which can significantly affect food prices and availability. In particular, the shipping industry, which plays a crucial role in the Caribbean's food imports, is facing mounting pressure to reduce greenhouse gas (GHG) emissions in line with international climate commitments. The International Maritime Organization (IMO) has introduced mid-term GHG mitigation measures aimed at reducing the carbon footprint of the global shipping industry. These measures, including carbon levies and flexibility

⁹ According to FAO (2012), food security is defined as "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life

mechanisms, are expected to have far-reaching implications on trade costs and, by extension, food security in the Caribbean region.

The IMO's mid-term GHG mitigation measures are designed to create financial incentives for the shipping sector to adopt greener technologies and practices, but they also risk increasing the cost of food imports due to higher shipping cost. The economic impact of the mid-term measures is likely to be overall negative on the world economy but unevenly distributed, with gross domestic product (GDP) of import-dependent small island developing states (SIDS) like those in the Caribbean particularly impacted. Most of the literature on this issue mostly looks at the total impact on the economy, while there has been a recent call at the IMO to consider the impact on food imports and food security more specifically. Given the Caribbean's heavy reliance on imported food, even a modest rise in transportation costs could have serious repercussions for food security, particularly for vulnerable populations. This study seeks to assess the potential impacts of the IMO's mid-term GHG mitigation measures on food security in the Caribbean by examining three key policy scenarios: a no carbon levy with a flexibility mechanism (Scenario 24), a high carbon levy with a flexibility mechanism (Scenario 26), and a low carbon levy with a flexibility mechanism (Scenario 32). These scenarios will be modelled with variations in revenue distribution to assess their effects on welfare, especially in relation to rising food prices.

The main objectives of this study are to: (1) Understand the critical commodities and drivers of food security in relation to trade and shipping in Caribbean countries; (2) Assess the negative impact of various policy scenarios on Caribbean countries' welfare, particularly in the context of transport cost increases related to food security; and (3) Evaluate the magnitude of revenues generated from a carbon tax relative to the estimated food security impacts, should the mid-term measures include revenue distribution. By focusing on these objectives, the study will provide a comprehensive assessment of how IMO mid-term measures intersect with local food systems and the potential consequences for food security in the Caribbean.

This study is important for informing policy decisions and providing actionable recommendations for Caribbean governments and stakeholders to enhance food security resilience in light of international environmental agreements. Given the region's vulnerability to external shocks, it is crucial to examine how global climate policies intersect with local food systems and identify strategies for ensuring that Caribbean nations can continue to meet their food needs while contributing to global sustainability efforts.

5.2. The State of Food Security in the Region

Food security in the Caribbean remains a pressing issue, with the region's

vulnerability exacerbated by both external and internal challenges. Despite ongoing regional efforts to improve food security through initiatives such as the Caribbean Community's (CARICOM) food security program, many countries still face persistent food insecurity (Karpyn et al. 2021). A significant proportion of the population relies heavily on food imports, making the region particularly sensitive to price fluctuations and trade disruptions. Caribbean small island developing states (SIDS) are especially affected by the complex interplay of factors such as limited arable land, climate change-induced weather events, rising food prices, and inadequate infrastructure. These issues are compounded by the growing demand for imported food, which has made many countries in the region net-food importers, with estimates indicating that up to 90% of food is imported (Daley et al. 2023; Forgenie et al. 2024). In addition, according to Beckford et al. (2013), the regions' high dependence on imports for food constitutes a major threat to food security.

Recent statistics highlight the severity of food insecurity in the region, with countries like Trinidad and Tobago and Jamaica experiencing high levels of food insecurity (Stanberry and Fletcher-Paul 2024b). The growing number of people at risk of hunger has prompted governments and international organizations to explore more sustainable food production and distribution systems. To address these challenges, Caribbean nations must not only improve agricultural productivity and reduce dependency on food imports but also invest in building resilience against climate-related shocks. This would involve adopting more diversified and sustainable agricultural practices, enhancing food storage and distribution networks, and ensuring equitable access to food for vulnerable populations across the region.

5.3. Food Import Dynamics in the Caribbean Region

Food import volumes in the Caribbean region from 1961 to 2023 exhibit a clear upward trend (Figure 5.1), reflecting the growing dependence on imported food to meet domestic demand. In the early decades, food imports were relatively low, typically below 1 million tonnes annually. However, as populations grew, tourism expanded, and agricultural production faced constraints, food imports began to rise steadily. By the early 2000s, import volumes consistently exceeded 3.5 million tonnes per year, and this growth accelerated in subsequent decades, reaching around 4.3 and 4.5 million tonnes in 2010 and 2015, respectively (FAO 2025). In more recent times, 2023, food import volumes were estimated at around 5.9 million tonnes (FAO 2025). This surge in imports reflects rising demand for diverse food products, including cereals, dairy, meat, and processed foods, driven by changing dietary preferences and economic development in the region. The increasing reliance on imports highlights critical food security concerns, as Caribbean countries remain vulnerable to global supply chain disruptions, price volatility, and climate-related

challenges affecting both local and global food production. Understanding these trends highlights the urgent need for policies that strengthen agricultural resilience, promote local food production, and reduce dependency on imports.

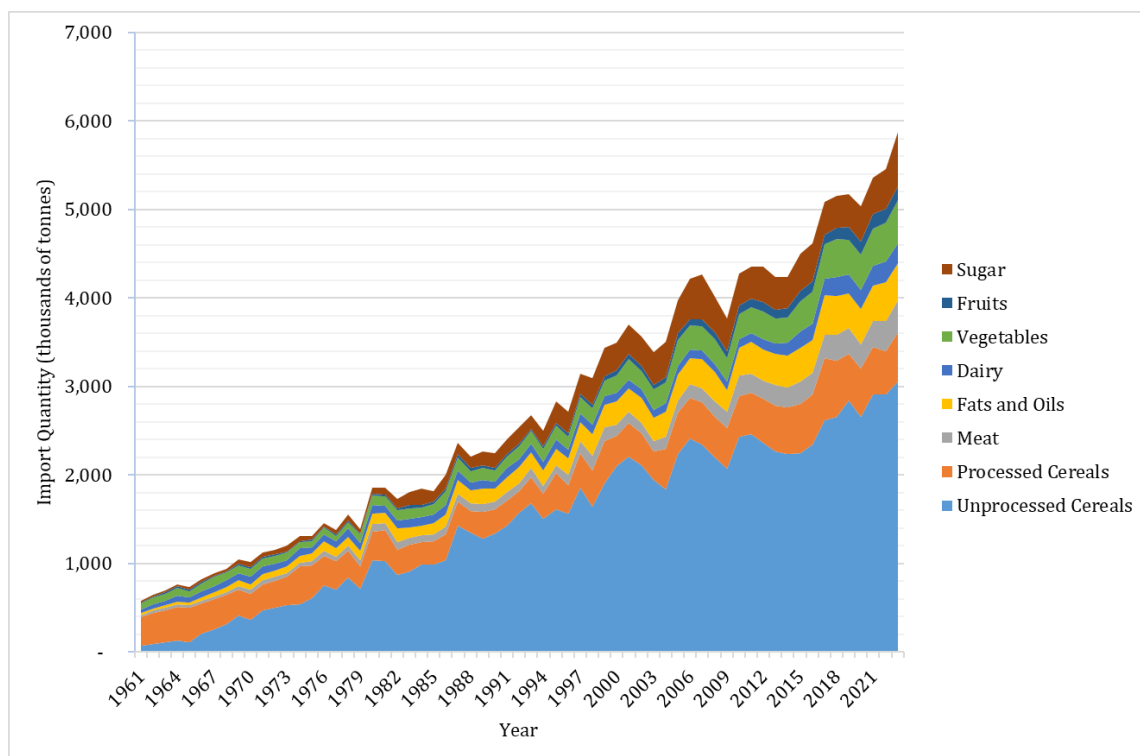


Figure 5.1. Caribbean food import volume (1961-2023) based on data from FAOSTAT (FAO 2025).

Since 2000, food import expenditure in the Caribbean region has demonstrated a marked and sustained upward trend (Figure 5.2), reflecting increased reliance on imported food driven by growing demand, changing consumption patterns, and possibly rising global food prices. In 2000, the region's expenditure stood at approximately US\$1.29 billion, rising steadily to US\$2.96 billion by 2008. Although there was a slight dip during the 2009 financial crisis, expenditure rebounded, surpassing US\$3.32 billion by 2011 (FAO 2025). From 2015 onwards, the trend continued upward, reaching US\$3.78 billion in 2018 and surpassing US\$4.79 billion in 2021. By 2022, expenditure climbed to a record US\$5.86 billion, further increasing to US\$6.01 billion in 2023. These figures highlight the region's growing dependency on food imports and the vulnerability of Caribbean nations to global price shocks and supply chain disruptions. Understanding these trends emphasizes the critical need for regional strategies to promote local agricultural development, enhance food production, and strengthen food security amidst changing environmental and economic conditions.

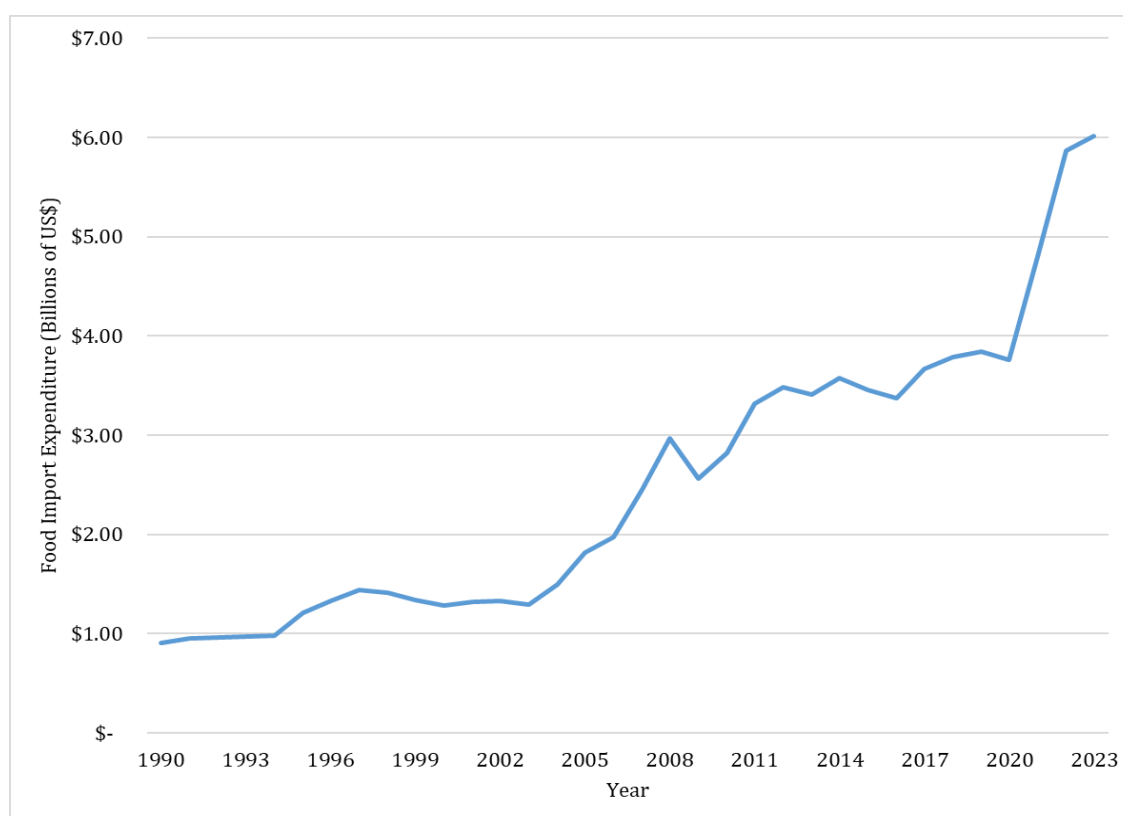


Figure 5.2. Caribbean food import expenditure (1961-2023) based on data from FAOSTAT (FAO 2025).

In 2023, the Caribbean region's total food import expenditure amounted to approximately US\$6.01 billion, with significant variation in spending across major food commodity categories. Unprocessed cereals¹⁰ accounted for 16.87% of the total, translating to approximately US\$1.01 billion. Processed cereals¹¹ had a slightly larger share at 18.70%, equating to about US\$1.12 billion, making it the highest expenditure category. Meat imports followed closely with a 17.20% share, amounting to approximately US\$1.03 billion. Fats and oils¹² represented 10.66% of the expenditure, totaling around US\$640 million, while dairy products accounted for 13.65%, roughly US\$820 million. Vegetables made up 10.20%, or about US\$613 million, while fruits had a smaller share at 5.23%, equaling US\$314 million. Sugar imports contributed 7.48% to total expenditure, amounting to around US\$450 million. Processed cereals and meat dominated the import landscape, highlighting their critical role in regional diets. Meanwhile, fruits and sugar represented the smallest shares, indicating relatively lower import dependency. The significant expenditure on cereals and meat highlights the need to explore strategies for boosting local production and reducing the region's vulnerability to international food market

¹⁰ Raw wheat, maize and other cereals.

¹¹ Cereal flours baked cereal items and other processed cereal items.

¹² Animal fats (excluding butter) and vegetable oils & margarine.

fluctuations.

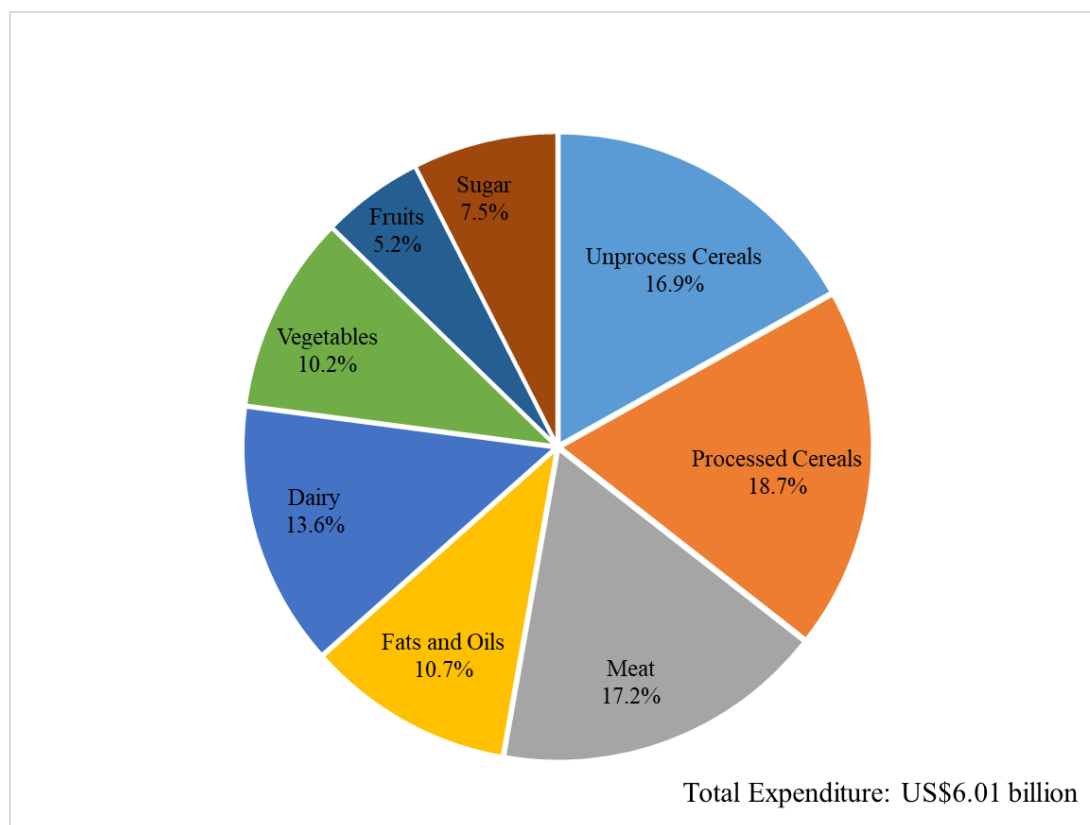


Figure 5.3. Caribbean food import expenditure share (2023) based on data from FAOSTAT (FAO 2025).

5.4. Method and Data Source

To answer the research question, we model the impact of various baskets of mid-term measures on the food prices and related welfare in the Caribbean. This is done in several steps:

1. We first model the evolution of food imports and food expenditures in the absence of mid-term measures (baseline scenario) until 2050 (section 5.4.1)
2. We then model the impact of three mid-term measures onto the import prices of selected food commodities (section 5.4.4)
3. Finally, we model the impact of the import price increase modelled in step 2 onto imported quantities and welfare, proxied by the measure of “compensating variation” (sections 5.4.2 and 5.4.3).

5.4.1. Forecasting Food Expenditure: The GDL Model

To forecast total food import expenditure from 2024 to 2050, a Geometric Distributed Lags (GDL) model was utilized. This model allows for the incorporation of lagged effects, reflecting the delayed influence of past values of key variables on future

expenditures. In the GDL model, the impact of past values decays at a constant rate, often assumed to be a geometric progression. The model is useful when the influence of past observations on the current outcome weakens with time but does not disappear entirely. The general form of the model can be written as:

$$Y_t = \alpha + \sum_{i=0}^{\infty} \beta_i X_{t-i} + \varepsilon_t \quad (1)$$

In the model, Y_t represents the dependent variable at time t , which is influenced by past values of the independent variables. The terms X_{t-i} refer to the lagged values of the independent variables, capturing their influence from previous periods on the current dependent variable. The coefficients β_i are the parameters to be estimated, indicating the strength of the relationship between the lagged variables and the dependent variable. The constant term, α , represents the intercept term, while ε_t is the error term, accounting for any unobserved factors or random variations not captured by the model.

In the context of forecasting total food expenditure for the Caribbean region between 2024 and 2050, the GDL model is specified where the dependent variable in the model is total food import expenditure, while the independent variables included a one period lagged values of total expenditure, population, and year.

$$\begin{aligned} Expenditure_t = \alpha + \beta_1 Expenditure_{t-1} + \beta_2 Population_{t-1} + \beta_3 Year_{t-1} \\ + \varepsilon_t \end{aligned} \quad (2)$$

In the GDL model, the dependent variable, $Expenditure_t$, represents the total food import expenditure at time t . This value is the focal point of the forecast and is influenced by a range of lagged factors. The first independent variable, $Expenditure_{t-1}$, is the total food import expenditure from the previous period (lagged by one year). This term captures the effect of past food import expenditure on the current period's expenditure, reflecting the inertia in food import trends. The second independent variable, $Population_{t-1}$, represents the population of the country lagged by one period. It accounts for how changes in population size influence food import expenditure, as a larger population typically leads to higher food demand and, consequently, higher expenditure. The third variable, $Year_{t-1}$, captures the temporal trends by representing the lagged year. This variable accounts for broader time-related effects, such as changes in economic conditions and other structural shifts that may influence food imports over time. Lastly, ε_t is the error term, which represents any unobserved factors or random fluctuations that are not captured by the model.

In this model, we assume that import prices and income remain constant throughout the forecast period. As a result, only the lagged values of total expenditure, population, and year are included in the model. This assumption simplifies the model and allows us to focus on the key dynamics of past expenditure, population, and time,

while holding other potentially influencing factors constant. By using this GDL model, we are able to forecast future food import expenditure in the Caribbean while incorporating both the historical relationship between expenditure, population, and time, as well as the diminishing influence of these factors over time. The results provide valuable insights into how future trends in population and past expenditure may shape food import patterns in the coming decades, specifically from 2024 to 2050.

5.4.2. Changes in import prices due to the mid-term measures

As low-carbon shipping technologies are more expensive than conventional ones, any policy leading to a reduction in shipping emissions through technological changes will increase the cost of transportation. This will in turn increase the price of imports, especially in the short-term, if part or all of this shock is passed onto the consumer. To model this effect, we model the percentage change in import prices for each food group:

$$\Delta \text{import price}_{\text{food group},sc} = \frac{\sum_{c \in \text{Caribbean}} \sum_{HS \in \Omega_{\text{food group}}} TES_{HS,c} \times (1 + \Delta MLC_{c,UNCTAD \text{ group},sc}) + TEO_{HS,c}}{\sum_{c \in \text{Caribbean}} \sum_{HS \in \Omega_{\text{food group}}} TES_{HS,c} + TEO_{HS,c} + FOB_{HS,c}} \quad (3)$$

× *ShareShockImporte*

where

- *TES* the transport expenditures by sea in the BAU scenario for all trade flows going to a Caribbean importer *c*, for each commodity *HS* contained in the food category $\Omega_{\text{food group}}$ (e.g. all HS codes corresponding to fruits)
- *TEO* the transport expenditures by other modes
- *FOB* the FOB value of the imports
- $\Delta MLC_{c,UNCTAD \text{ group},sc}$ the percentage change in maritime logistic cost provided by UNCTAD (2024) for the corresponding commodity group (for fruits, this is agricultural products) in scenario *sc*.
- *ShareCostImporter* the share of the cost increase which is borne by the consumer.

5.4.3. Welfare Measure: Compensating Variation

The welfare literature presents numerous indices for evaluating changes in welfare resulting from various policy regimes. One key factor influencing welfare changes is price increases, which negatively affect consumer welfare by reducing their purchasing power and diminishing their utility. When prices vary, consumers may experience changes in utility levels, which can be assessed using measures such as consumer surplus (CS), compensating variation (CV), and equivalent variation (EV). As noted by Azzam and Rettab (2012), Aghabeygi and Arfini (2020), and Forgenie, Hutchinson, and Muhammad (2024), in the context of rising food prices, CV

represents the minimum compensation consumers require to endure higher prices. Conversely, EV reflects the maximum amount consumers are willing to pay to avoid such price increases. CV quantifies the compensation needed to maintain consumers' initial utility level despite rising prices, while EV measures the amount consumers would pay to preserve their original utility level amid price hikes.

Price increases driven by policy measures aimed at reducing greenhouse gas (GHG) emissions in maritime transport can significantly affect consumer welfare, especially in net-food importing developing countries such as the Caribbean. In the context of Caribbean nations, Scenarios 24, 26, and 32—representing varying combinations of carbon levies and flexibility mechanisms—are expected to raise shipping costs, leading to higher prices for imported food. Compensation variation serves as a valuable tool for assessing the welfare impact of these price increases, as it estimates the compensation required to maintain consumers' original utility levels. This approach provides critical insights into the adverse effects of these policy scenarios on food security and consumer well-being. Detailed theoretical explanations and derivations of CV can be found in Azzam and Rettab (2012). However, the general formula for calculating CV as utilized by Azzam and Rettab (2012); Aghabeygi and Arfini (2020) and Forgenie, Hutchinson, and Muhammad (2024) is:

$$CV = \sum_{i=1}^n p_i^0 q_i^0 \left(\frac{dp_i}{p_i^0} + \frac{dq_i^H}{q_i^0} + \frac{dp_i}{p_i^0} \frac{dq_i^H}{q_i^0} \right) \quad (4)$$

In equation (4), CV is the total compensating variation or welfare loss incurred by consumers due to price increase from policy 24, 26, and 32. In the context of food imports, p_i^0 and q_i^0 represent the initial price and quantity of the i^{th} food group before any price change. The percentage change in price is given by $\frac{dp_i}{p_i^0}$, where $dp_i = p_i^1 - p_i^0$, and p_i^1 and p_i^0 are the prices in the subsequent and initial periods, respectively. Similarly, the percentage change in Hicksian quantities is $\frac{dq_i^H}{q_i^0}$, where $dq_i^H = q_i^1 - q_i^0$, and q_i^1 and q_i^0 denote the Hicksian quantities in the subsequent and initial periods, respectively. However, as noted by Azzam and Rettab (2012), Hicksian quantities are not directly observable but can be derived by taking the total differential of the Hicksian demand function as follows:

$$\frac{dq_i^H}{q_i^0} = \sum_{j=1}^n \epsilon_{ij}^H \frac{dp_j}{p_j^0} \quad (5)$$

In equation (5), ϵ_{ij}^H represents the Hicksian or compensated price elasticities for $i=1,2,\dots,n$ and $j=1,2,\dots,n$. Equations (4) and (5) are applied to assess the welfare impacts of rising food import prices under different GHG mitigation policy scenarios on Caribbean consumers.

5.4.4. Expenditure and Price Elasticities: The LA- AIDS Model

The Almost Ideal Demand System (AIDS) model, developed by Deaton and Muellbauer (1980), is widely regarded and is one of the most popular demand systems in empirical research. Its popularity, as highlighted by Barnett and Seck (2008), stems from several appealing features, such as perfect aggregation across consumers, adherence to the axiom of choice, a flexible functional form that aligns well with observed data, ease of estimation, and the capacity to impose and test theoretical constraints like homogeneity and symmetry. Alston and Chalfant (1993) and Eales and Unnevehr (1994) further note that these properties have contributed to the widespread use of the AIDS model in the empirical literature. The AIDS model for each imported food group in terms of budget shares is expressed as follows:

$$w_{it} = \alpha_0 + \sum_j \gamma_{ij} \log p_{jt} + \beta_i \log \log \left(\frac{E_t}{P_t} \right) + \varepsilon_{it} \quad (6)$$

In Equation (6), w_{it} represents the budget share of the i^{th} imported food commodity group, calculated by dividing the expenditure on the i^{th} group by the total expenditure (E_t) on all groups. p_{jt} denotes the price of the j^{th} imported food commodity. ε_{it} is a white noise error term and α , γ , and β are parameters to be estimated. P_t is the stone price index which gives the linear approximate AIDS (LA-AIDS) model. The stone price index is specified as:

$$\ln P = \sum_{i=1} w_i \ln p_i \quad (7)$$

Equation (6) is estimated using the stone price index in equation (7) using iterated seemingly unrelated regression estimation (ISURE) technique with the three theoretical restrictions¹³ imposed: adding-up, homogeneity, and symmetry.

The estimated parameters in equation (6) are used to derive expenditure (income) and price elasticities. Expenditure or income elasticity measures the responsiveness of the demand for a good or service to changes in total expenditure or income. It is calculated as the percentage change in the quantity demanded divided by the percentage change in total expenditure or income. Price elasticity, on the other hand, quantifies the responsiveness of the demand for a good or service to changes in its price. It is defined as the percentage change in the quantity demanded divided by the percentage change in the price of the good. The formula to derive expenditure using the LA-AIDS model (Equation (6)) is:

¹³ See Deaton and Muellbauer (1980) for more detailed explanation regarding the theoretical restrictions.

$$\eta_i = \frac{\beta_i}{w_i} + 1, \quad (8)$$

Marshallian and Hicksian price elasticities are derived using equations (9) and (10) respectively:

$$\epsilon_{ij}^M = -\delta_{ij} + \frac{\gamma_i}{w_i} - \frac{\beta_i w_j}{w_i} \quad (9)$$

$$\epsilon_{ij}^H = \epsilon_{ij}^M + \eta_i w_i \quad (10)$$

In the given context, η_i represents the expenditure elasticity of import demand, while ϵ_{ij}^M and ϵ_{ij}^H represent the Marshallian and Hicksian price elasticities of import demand, respectively. The variable w_i denotes the mean budget share of the i^{th} imported food group, and δ_{ij} is the Kronecker delta, taking a value of 1 for own-price elasticity and 0 otherwise. Equation (10) is of particular importance for this analysis as it is utilized in equation (5) to derive the changes in Hicksian quantities which is essential to calculate CV as outlined in equation (4).

5.4.5. Data and Source

Data for this study was obtained from the Food and Agriculture Organization (FAO) online database. Annual import volumes (in tonnes) and expenditure (in US\$) for eight major food categories — unprocessed cereals, processed cereals, meat, fats and oils, dairy, vegetables, fruits, and sugar — were analyzed for the period 1961 to 2023. The exact composition of those categories are presented in Appendix 4. The study covered thirteen Caribbean nations, namely Antigua and Barbuda, The Bahamas, Barbados, Belize, the Dominican Republic, Grenada, Guyana, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago. These nations were included based on data availability – in particular, Haiti and Dominica were excluded because they were not covered by the FAOSTAT dataset. Due to the unavailability of direct import prices for each commodity, import unit values were calculated by dividing expenditure on each food category by its corresponding import volume. Population data for the same period was sourced from the World Bank online database, while forecasted population figures for the period 2024 to 2050 were obtained from the Our World in Data database. Empirical estimations were conducted using EViews and Stata 18, while welfare analysis was completed using Microsoft Excel.

5.5. Results and Discussion

5.5.1. Food Import Expenditure Forecast: 2024-2050

Figure 5.4 presents the projected food import expenditure for the Caribbean region from 2024 to 2050, derived using the GDL¹⁴ model. The forecasted food import expenditures indicate a steady upward trend, beginning at US\$6.19 billion in 2024 and rising to US\$22.52 billion by 2050, with food import expenditure potentially ranging as low as US\$5.74 billion to as high as US\$26.51 billion over the forecast horizon. By 2030, food import expenditure is projected to reach approximately US\$7.83 billion, with values ranging as low as US\$6.67 billion and as high as US\$8.99 billion. In 2040, this figure is expected to rise to US\$14.02 billion, with potential expenditures spanning from US\$11.93 billion to US\$16.12 billion. Additionally, in 2050, the forecasted expenditure reaches US\$22.52 billion, with values ranging from a lower bound of US\$18.53 billion to an upper bound of US\$26.51 billion.

The forecasted composition of food import demand in the Caribbean for 2030, 2040, and 2050 highlights significant shifts across various food categories. Unprocessed cereals are projected to maintain their dominance, accounting for 19.45% of total food imports in 2030 and slightly increasing to 20.03% by 2050. Meat imports are expected to rise steadily, from 17.37% in 2030 to 18.43% by 2050, reflecting a growing demand for animal-based protein. Meanwhile, processed cereals are forecasted to decline from 15.29% in 2030 to 12.54% by 2050, suggesting a shift toward less processed food options. The share of fats and oils is expected to increase from 13.04% in 2030 to 14.10% by 2050, reflecting changing dietary habits. Dairy imports, however, will decrease, dropping from 12.38% in 2030 to 10.16% in 2050. Vegetables and fruits are forecasted to see a modest increase, with vegetable imports rising from 9.52% in 2030 to 10.08% by 2050, and fruit imports growing from 6.11% in 2030 to 7.34% in 2050. Sugar imports remain relatively stable, rising slightly from 6.83% in 2030 to 7.31% by 2050, despite health concerns. These trends suggest evolving dietary preferences and shifts in the regional food import landscape.

¹⁴ The results of the GDL model are presented in Appendix 1.

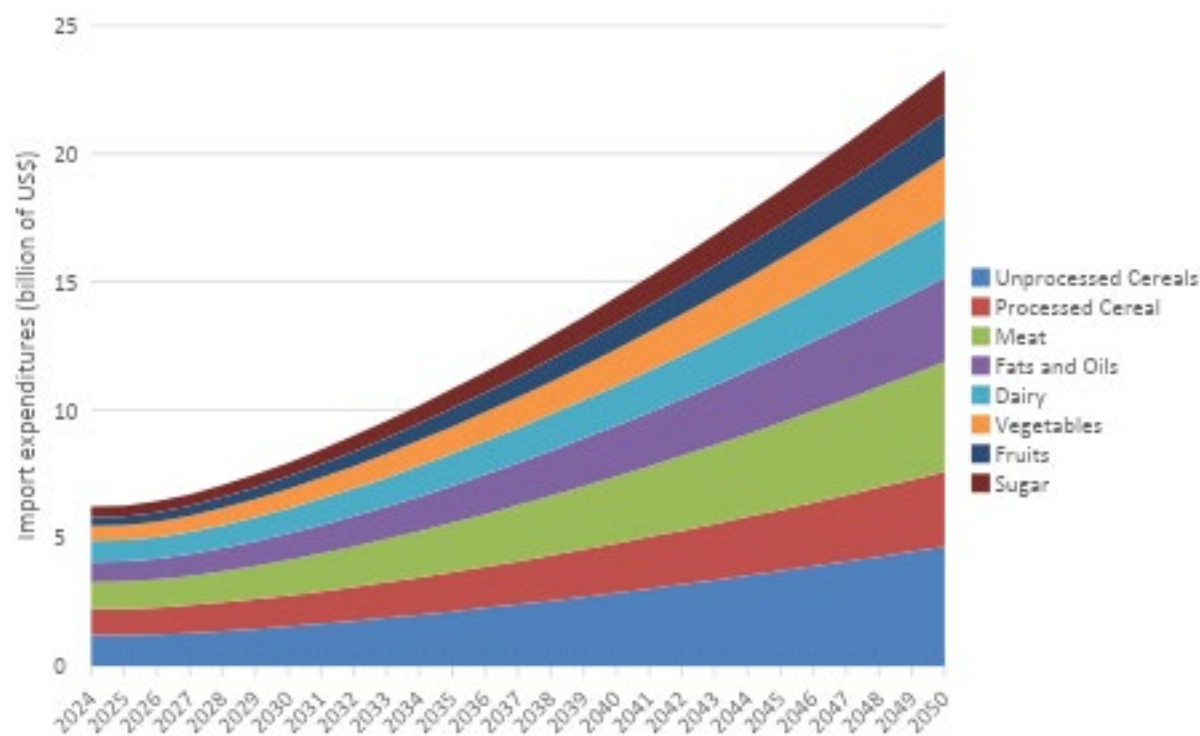


Figure 5.4. Forecasted food import for the Caribbean region for the period 2024-2050.

5.5.2. Import Demand Response to Changes in income and prices

The estimated elasticities derived from the LA-AIDS model using data from 1961 to 2023 provide crucial insights into the import demand response for key food commodities in the Caribbean.

5.5.2.1. Expenditure elasticities

The Expenditure or income elasticities in Figure 5.5 indicate the responsiveness of import demand to changes in income. All commodities exhibit positive expenditure elasticities, implying that an increase in income leads to higher import demand within the Caribbean region. Fruits (1.567), fats and oils (1.239), and sugar (1.210) display the highest elasticities, suggesting these commodities are highly income-sensitive. This means that if income within the Caribbean region increases by 1% on average, import demand for fruits, fats and oils, and sugar is expected to increase by 1.57%, 1.24%, and 1.21%, respectively, all things being equal. Meat (1.189) and vegetables (1.183) also exhibit significant income responsiveness. Conversely, processed cereals (0.680) and dairy (0.682) have the lowest expenditure elasticities, indicating their demand is less influenced by income changes.

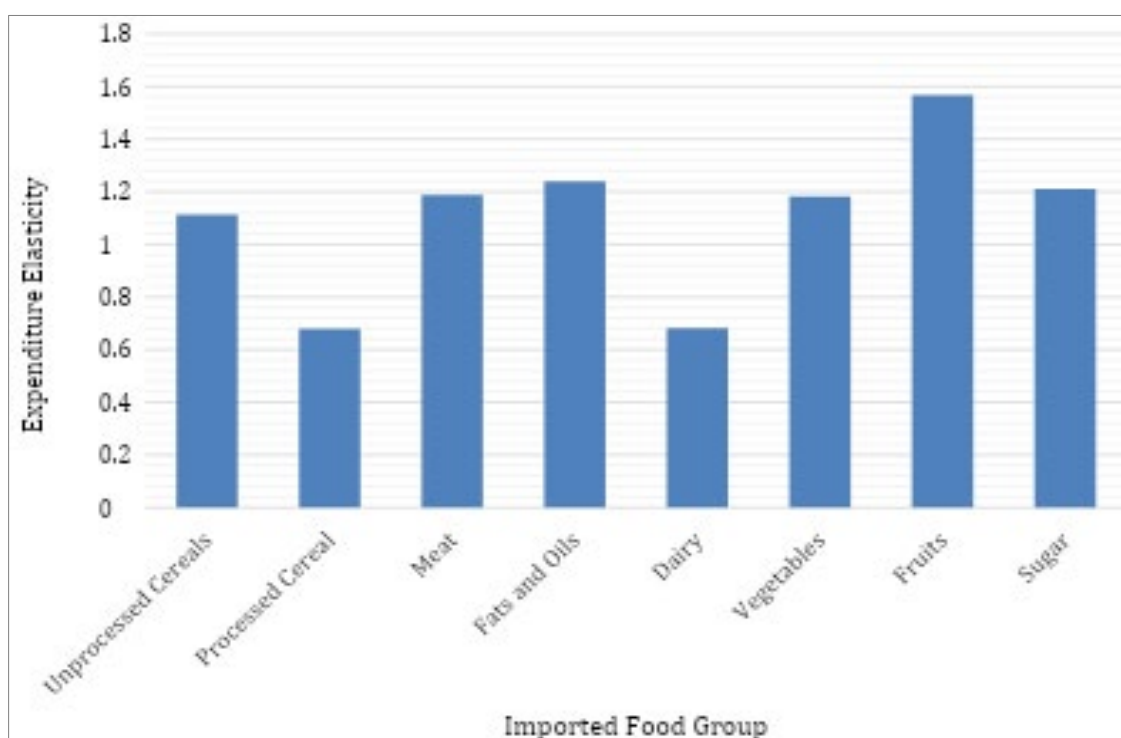


Figure 5.5. Expenditure (income) on imported food groups.

5.5.2.2. Own-Price Elasticities

Figure 5.6 highlights the Marshallian and Hicksian own-price elasticities of demand for the eight (8) major imported food categories for the Caribbean region. All estimated own-price elasticities are negative¹⁵ as expected. Based on the Marshallian own-price elasticities, it was found that imported sugar (-1.016) and processed cereals (-0.862) are the most price-sensitive commodities. The results suggest that if import prices increase by 1% on average, import quantity will fall by 1.02% and 0.86% for sugar and processed cereals, respectively, all things being equal. Imported fats and oils (-0.363) and vegetables (-0.419) are the least responsive to price changes, reflecting potential consumer dependence on these essentials. In contrast, Hicksian own-price elasticities, which account for pure substitution effects which generally makes them smaller in magnitude than Marshallian elasticities, are also negative across all commodities but generally less elastic than the Marshallian estimates. Sugar (-0.936) and processed cereals (-0.713) remain the most price-sensitive. Fats and oils (-0.230) exhibit the lowest elasticity, reinforcing their importance as a staple product with minimal substitution possibilities.

¹⁵ Own-price elasticities are usually negative as there is an inverse relationship between quantity demanded and prices. When prices increase the quantity demanded falls, and vice versa.

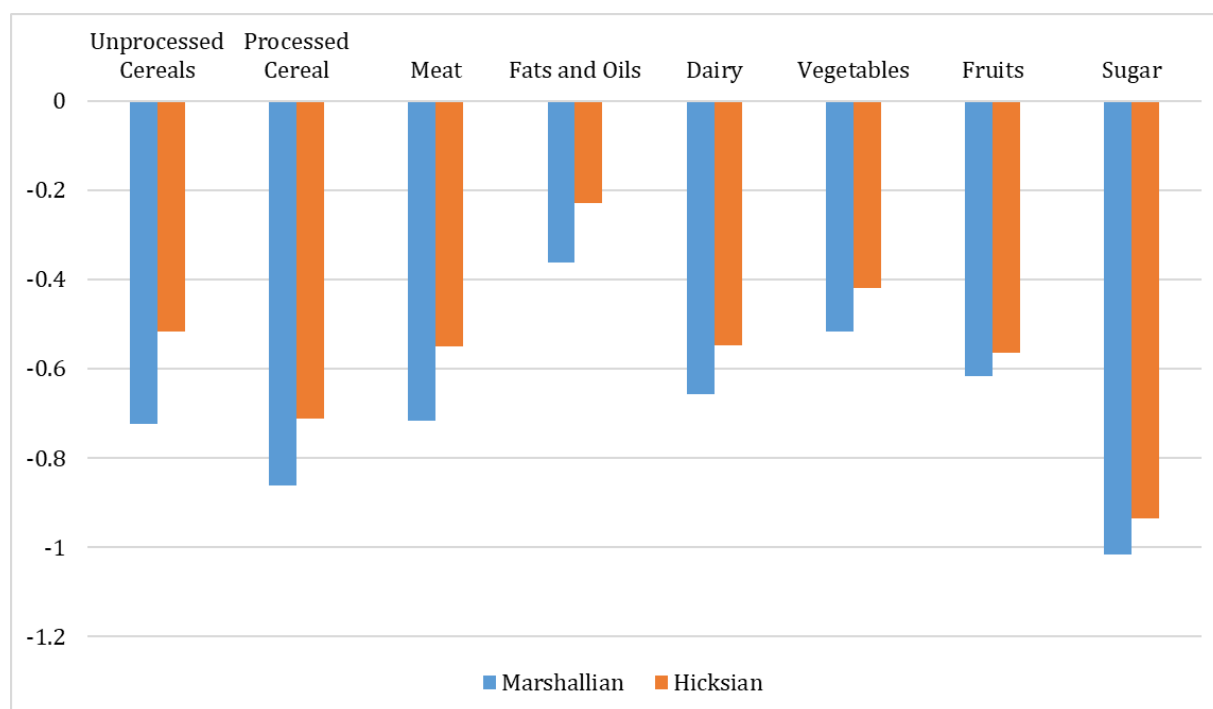


Figure 5.6. Marshallian and Hicksian own-price elasticities for import food.

5.5.3. Projected Price Change induced by IMO-Midterm Measures

The projected import price changes under different scenarios (flexibility mechanism, High Levy, and Low Levy + Flexibility mechanism) for 2030, 2040, and 2050 are presented in Figure 5.7. These price changes provide insights into potential cost variations across food groups. The assumption is that exporters and importers will each absorb 50% of the price increase, as it was modelled in the UNCTAD (2024) scenario. This assumption is subject to a large uncertainty, so we also model a scenario where 90% of the price increase is passed onto the consumer, which represents a worst-case scenario where the supply is particularly inelastic, and the Caribbean consumers bear most of the cost increase.

The expected price trends for imported food categories in the Caribbean from 2030 to 2050 show gradual increases across all sectors. For meat, the price is expected to rise modestly from 0.1% in 2030 to 0.8% by 2050, indicating consistent growth over time. Dairy products are forecasted to experience a steady price increase, from 0.2% in 2030 to 1.1% by 2050, with a slightly faster rise between 2030 and 2040 compared to the later years. Vegetables and fruits are expected to see significant price hikes, with vegetables rising from 1.0% in 2030 to 4.7% by 2050, exhibiting the steepest price growth and increased volatility. Fruit prices are also projected to rise from 0.8% in 2030 to 3.8% by 2050, with variations across different scenarios. Unprocessed cereals are expected to follow a steady price increase, rising from 0.8% in 2030 to 3.6% by

2050, while processed cereals are likely to experience more gradual growth, moving from 0.3% in 2030 to 1.4% by 2050. Fats and oils are expected to have controlled price growth, rising from 0.2% in 2030 to 1.0% by 2050, and sugar is anticipated to increase from 0.2% in 2030 to 1.4% by 2050, with stable and predictable changes. These trends suggest ongoing but manageable price increases in the region's food imports over the forecasted period.

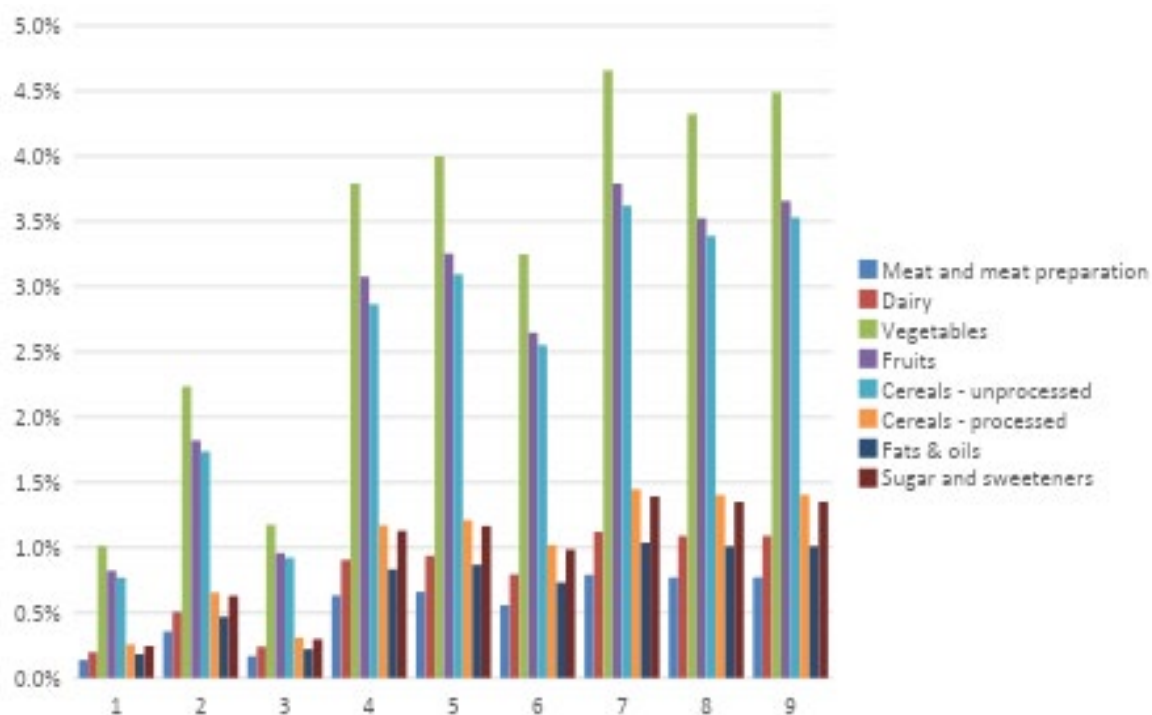


Figure 5.7. Change in the price of imported food

5.5.4. Welfare Impact of IMO Mid-term Measures

In this section, the welfare impact of the price increases under 3 scenarios considered for 2030, 2040, and 2050 is assessed using compensating variation (CV), which measures the amount of money required to offset the negative effects of higher food prices and maintain the original level of consumer welfare. By calculating CV for each year, we can estimate the income adjustments needed to compensate Caribbean consumers for the increased costs of imported food because of these mid-term measures. It must be noted that the CV calculation in this section assumes that the increase in transport cost is distributed evenly (50%) between the exporter and importer. A second scenario looks at the impact if the importer would bear 90% of the price shock. The results of the CV for both possibilities are presented in Figure 5.8.

The estimated CV or welfare losses due to price increases under the three IMO mid-term measures indicate a significant economic impact on Caribbean importers. Under

the scenario where 50% of the cost shock is passed onto importers, the projected welfare losses vary considerably across the different measures and years. For the flexible (24) scenario, the average estimated CV loss starts at US\$33.02 million in 2030, rising substantially to US\$239.47 million by 2040 and further to US\$481.05 million in 2050. The high-levy (26) scenario presents even higher expected losses, with an estimated average CV of US\$77.17 million in 2030, increasing to US\$252.94 million by 2040 and reaching US\$455.36 million by 2050. The flex + low levy (32) scenario results in losses of US\$39.29 million in 2030, US\$209.53 million in 2040, and US\$466.81 million in 2050.

When considering the scenario where 90% of the cost increase is absorbed by importers, the estimated welfare losses become significantly more pronounced. Under the flexible (24) scenario, the average CV loss is projected at US\$59.37 million in 2030, escalating to US\$429.36 million by 2040 and reaching US\$861.54 million in 2050. The high-levy (26) measure results in an even steeper increase, with average losses starting at US\$138.60 million in 2030, climbing to US\$453.35 million in 2040, and soaring to US\$815.98 million in 2050. The flex + low levy (32) scenario places a substantial economic strain on importers, with projected average welfare losses of US\$70.63 million in 2030, a sharp rise to US\$375.89 million in 2040, and a peak of US\$836.19 million in 2050. The comparison between the 50% and 90% cost-absorption cases highlights the significant economic risk Caribbean countries face if most shipping cost increases are transferred to importers.

A closer examination of the minimum and maximum estimated welfare losses further illustrates the economic uncertainty surrounding these policy measures. Under the 50% cost pass-through scenario, the lower-bound estimates for the flexible (24) measure range from US\$27.95 million in 2030 to US\$394.84 million in 2050, while the upper-bound values reach US\$38.09 million in 2030 and US\$567.26 million in 2050. Similarly, for the high-levy (26) scenario, the minimum projected loss is US\$65.34 million in 2030, rising to US\$373.77 million in 2050, with the upper limit reaching US\$89.01 million in 2030 and peaking at US\$536.95 million by 2050. Under the 90% cost pass-through scenario, the lower-bound losses range from US\$50.25 million in 2030 to US\$707.19 million in 2050 for the flexible measure, whereas the high-levy scenario exhibits losses between US\$1,17.36 million in 2030 and an extreme upper-bound of US\$962.14 million in 2050. The flex + low levy (32) scenario shows minimum losses of US\$33.26 million in 2030 to US\$383.16 million in 2050, with maximum losses ranging from US\$45.32 million in 2030 to US\$550.46 million in 2050. These figures emphasize the substantial financial pressure imposed by increased transport costs, further reinforcing the need for policy interventions to mitigate adverse effects on Caribbean food security.

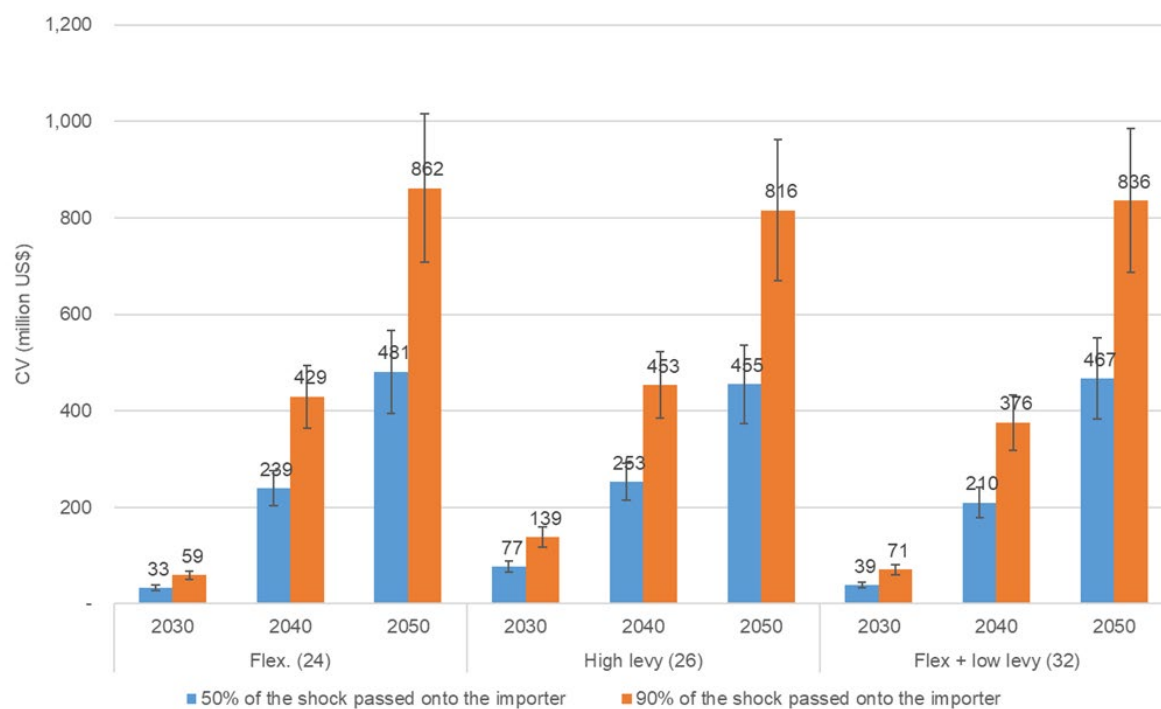


Figure 5.8. Welfare loss (CV) due to price increase

Examining the CV across specific imported food categories, when 50% of the price shock is passed onto importers, certain trends emerge (Figure 5.9). In the flexible (24) scenario, the CV for unprocessed cereals increases from US\$8.97 million in 2030 to US\$131.09 million in 2050, reflecting consistently the highest (approximately 27%) of total estimated welfare losses. Meat also sees a sharp rise, from US\$5.85 million in 2030 to US\$88.90 million in 2050. Among other categories, processed cereals exhibit a notable increase from US\$5.70 million in 2030 to US\$68.79 million in 2050. Fruits, dairy, and sugar follow a similar upward trend, with fruits reaching US\$37.90 million, dairy US\$32.39 million, and sugar US\$32.80 million by 2050. Under the high-levy (26) scenario, unprocessed cereals increase from US\$20.65 million in 2030 to US\$123.60 million in 2050, with meat and vegetables also seeing significant growth. The flex + low levy (32) scenario presents a similar pattern, though the overall magnitude of CV losses is slightly lower compared to the high-levy case.

When 90% of the price shock is absorbed by importers, the impact across food categories is considerably more severe (Figure 5.10). In the flexible (24) scenario, unprocessed cereals surge from US\$16 million in 2030 to US\$234 million in 2050, while meat follows a similar trajectory, reaching US\$161 million in 2050. Processed cereals, vegetables, and fruits also experience substantial increases, with processed cereals rising to US\$124 million and fruits to US\$67 million in 2050. Under the high-levy (26) scenario, unprocessed cereals jump to US\$221 million in 2050, with meat, vegetables, and processed cereals displaying significant cost burdens. The flex + low

levy (32) scenario follows a comparable trend, with unprocessed cereals reaching US\$228 million and meat increasing to US\$155 million in 2050. In all scenarios, unprocessed cereals lead to the largest decrease in CV, followed by meat, vegetables and processed cereals. The importance of unprocessed cereals in the CV loss is due to two factors: first, they represent a large share of total expenditures; and second, their import price is one of the worst impacted food groups in the sample. Across all scenarios, the shift from a 50% to 90% cost-absorption level dramatically amplifies the financial pressure on importers, emphasizing the urgent need for policy interventions to mitigate rising food insecurity risks in the Caribbean.

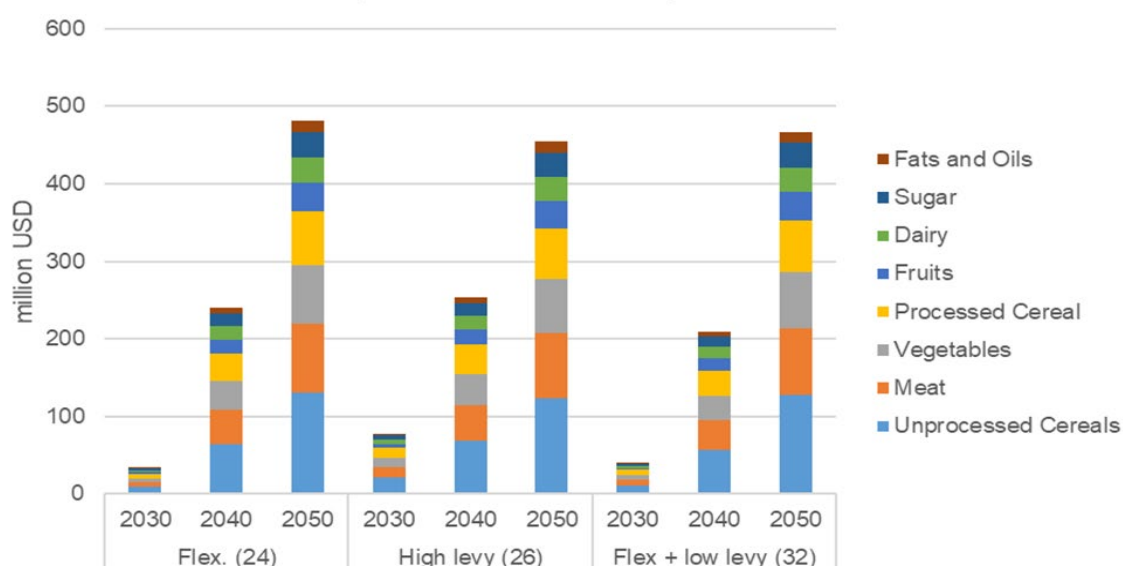


Figure 5. 9. Welfare loss (CV) due to price increase by food category (50% of price shock passes to importer).

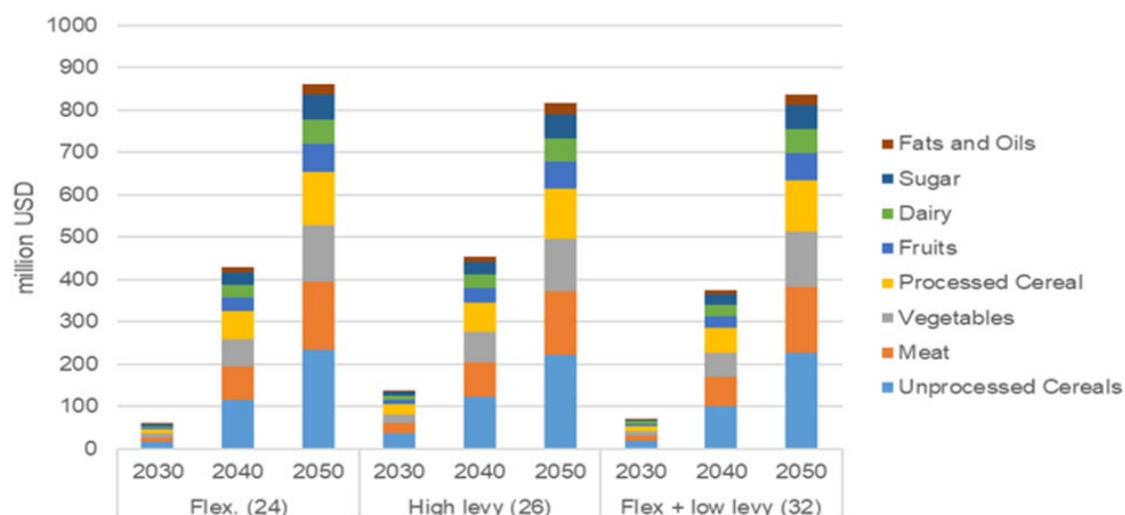


Figure 5.10. Welfare loss (CV) due to price increase by food category (90% of price shock passes to importer).

5.5.5. Impact of IMO Mid-term Measures on Import Quantity

The price increases caused by the IMO mid-term measures is expected to lead to noticeable declines in the import quantities of key food commodities across all scenarios and years (see Figure 5.11). In 2030, the price increases caused by the IMO mid-term measures are expected to lead to moderate declines in import quantities across all food commodities. Unprocessed cereals might experience the sharpest drop under Scenario 26, with a predicted reduction of 60.5 thousand tonnes (-1.41%), followed by Scenario 32 at 31.6 thousand tonnes (-0.74%) and Scenario 24 at 27.2 thousand tonnes (-0.6%) (Figure 5.11, 2030). Fats and oils show a similar pattern, with Scenario 26 causing a decline of 9.1 thousand tonnes, while Scenario 24 records a decrease of 4.1 thousand tonnes. Vegetables are also heavily affected, with Scenario 26 leading to a reduction of 11.8 thousand tonnes compared to 6.1 thousand tonnes under Scenario 32. Across most commodities, Scenario 26 consistently shows the steepest reductions for this year.

By 2040, the decline in import quantities is expected to intensify. Unprocessed cereals are expected to see the most substantial reduction under Scenario 26, with a drop of 212.5 thousand tonnes, while Scenario 24 records 191 thousand tonnes and Scenario 32 shows 177 thousand tonnes. Fats and oils follow a similar trend, with Scenario 26 causing a decline of 33.3 thousand tonnes, Scenario 24 at 29.9 thousand tonnes, and Scenario 32 at 27.2 thousand tonnes (Figure 5.11, 2040). Vegetables continue to face significant declines, with Scenario 26 reducing imports by 41.3 thousand tonnes, slightly higher than Scenario 24 at 38.6 thousand tonnes. While Scenario 26 maintains its prominence in causing the largest short-term declines, Scenario 24 shows increasingly competitive impacts in the long term.

In 2050, the declines in import quantities are expected to become even more pronounced, highlighting the projected long-term impact of the IMO mid-term measures. Unprocessed cereals are expected to experience the most significant reductions, with Scenario 24 projected to record the largest drop of 392.1 thousand tonnes (Figure 5.11, 2050). Scenario 26 is expected to follow closely at 371.8 thousand tonnes, while Scenario 32 may cause a reduction of 382 thousand tonnes. Fats and oils are predicted to exhibit a similar pattern, with Scenario 24 leading to a decline of 61.5 thousand tonnes, compared to 58.4 thousand tonnes under Scenario 26 and 59.9 thousand tonnes under Scenario 32. For vegetables, substantial reductions are forecasted, with Scenario 24 expected to show the largest fall of 77.7 thousand tonnes, followed by Scenario 26 at 72.6 thousand tonnes and Scenario 32 at 75.2 thousand tonnes (Figure 5.11, 2050). Across all commodities, Scenario 24 is projected to have the most significant long-term impact, reflecting its delayed but considerable influence on import volumes.

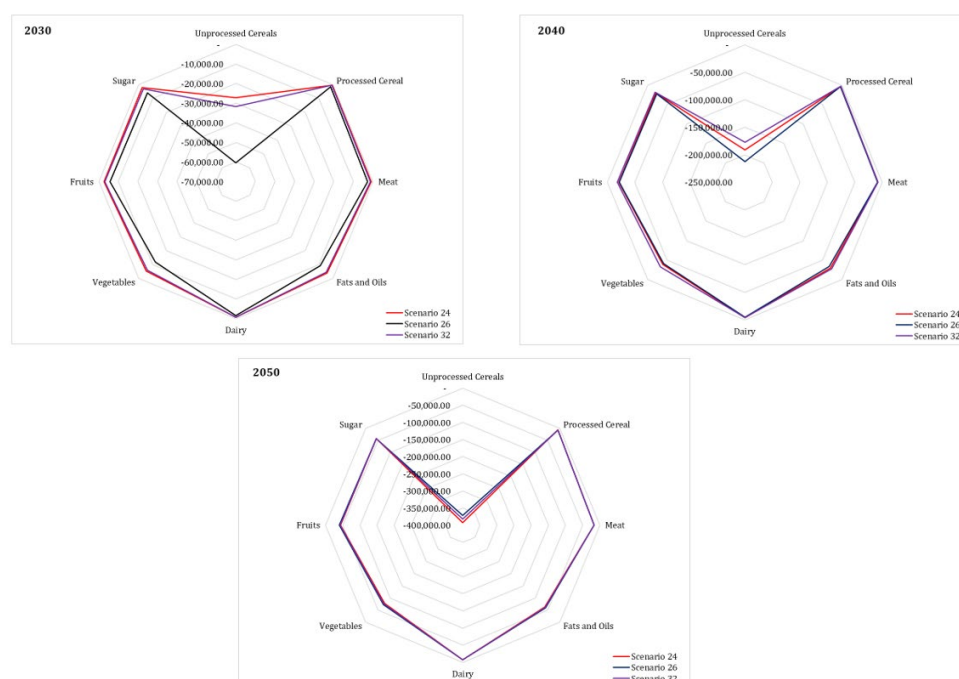


Figure 5.11. Forecasted decrease in imported food volume by commodity.

The effects of the IMO mid-term measures on food imports could have significant implications for food security in the Caribbean region, as the reduction in import quantities, especially for key food commodities such as unprocessed cereals, fats and oils, and vegetables, may lead to potential shortages and price increases. The varying degrees of decline across scenarios suggest that certain commodities will be affected more than others, which could exacerbate food insecurity in the region. For instance, the larger reductions in unprocessed cereals and fats and oils could hinder food availability and access, particularly for vulnerable populations. In the long run, the

Caribbean might face more challenges in ensuring stable food supply and affordability, requiring strategic measures to enhance domestic production and resilience to external shocks.

5.5.6. Welfare loss and revenue distribution

In the short-run (2030), the revenue received under different distribution scenarios varies significantly, impacting the extent to which welfare losses resulting from the mid-term measures for the Caribbean can be offset. Under the high-levy (26) scenario, when revenues are distributed to all developing countries, the total revenue generated is US\$449.06 million (Figure 5.12), while the estimated welfare loss for the Caribbean is US\$77.17 million (50% pass-through) / US\$138.60 million (90% pass-through). This suggests that revenue generation under this scheme is more than adequate to cover welfare losses as it relates to the Caribbean. When revenues are allocated specifically to SIDS and LDCs, the total revenue increases substantially to US\$1.65 billion (Figure 5.12), which is far beyond the estimated welfare losses for the Caribbean, indicating significant surplus funds that could mitigate economic burdens. Under the flex + low levy (32) scenario, when revenues are distributed to all developing nations, the total revenue generated is estimated at US\$66.42 million (Figure 5.12), while welfare losses for the Caribbean are US\$39.29 million (50% pass-through) / US\$70.63 million (90% pass-through). This suggests that the revenue is sufficient to maybe compensate for the 50% cost scenario but falls slightly short under the 90% pass-through case. However, when revenues are allocated specifically to SIDS and LDCs, the total revenue increases to US\$243.91 million, which is more than adequate to cover both levels of welfare losses for the Caribbean. In contrast, under the flexible (24) scenario, no revenue is generated, yet the Caribbean still experiences significant welfare losses of US\$33.02 million (50% pass-through) / US\$59.37 million (90% pass-through). This highlights the economic strain imposed by the IMO measures in the absence of a compensatory revenue mechanism.

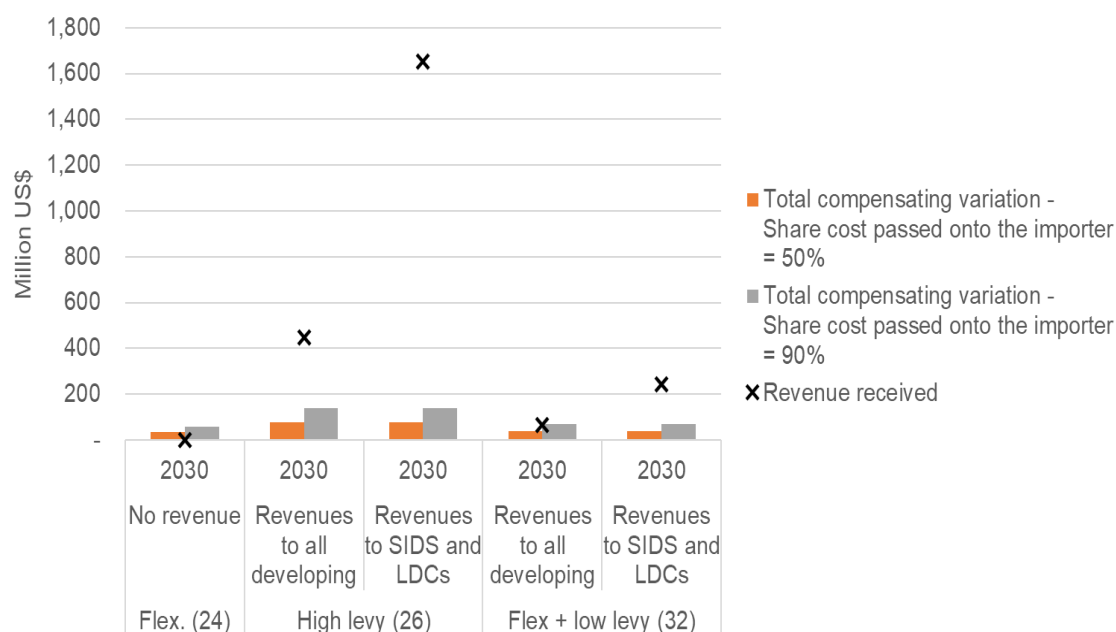


Figure 5.12. Short-term welfare loss vs revenue received.

In the long-run (2040 and 2050), the ability of revenue distribution to offset welfare losses for the Caribbean becomes more uncertain as welfare losses grow. Under the high-levy (26) scenario, when revenues are distributed to all developing countries, the total revenue that is expected to be distributed is US\$314.02 million in 2040 and US\$37.23 million in 2050 (Figure 5.13), while the estimated welfare losses for the Caribbean rise to US\$252.94 million (50% pass-through) / US\$453.35 million (90% pass-through) in 2040, and US\$455.36 million (50%) / US\$815.98 million (90%) in 2050. This suggests that while revenue is nearly sufficient to cover welfare losses in 2040, it is entirely inadequate by 2050. However, when revenues are allocated specifically to SIDS and LDCs, the total revenue increases to US\$1.06 billion in 2040 and US\$160.52 million in 2050 (Figure 5.13), providing greater relief in 2040 but still falling short in 2050. For the flex + low levy (32) scenario, revenues allocated to all developing countries are US\$94.79 million in 2040 and US\$16.60 million in 2050 (Figure 5.13), while welfare losses for the Caribbean climb to US\$209.53 million (50%) / US\$375.89 million (90%) in 2040 and US\$466.81 million (50%) / US\$836.19 million (90%) in 2050, meaning the revenue received does not sufficiently cover losses in either period. However, when distributed to SIDS and LDCs, the Caribbean's share increases to US\$321.21 million in 2040 and US\$73.19 million in 2050 (Figure 5.13), allowing for more adequate compensation in 2040 but falling significantly short in 2050. However, under the flexible (24) scenario, no revenue is generated in either 2040 or 2050, yet welfare losses for the Caribbean continue to grow, reaching US\$239.47 million (50%) / US\$429.36 million (90%) in 2040, and US\$481.05 million (50%) / US\$861.54 million (90%) in 2050. This further highlights the economic vulnerability of the Caribbean in the absence of a compensatory mechanism.

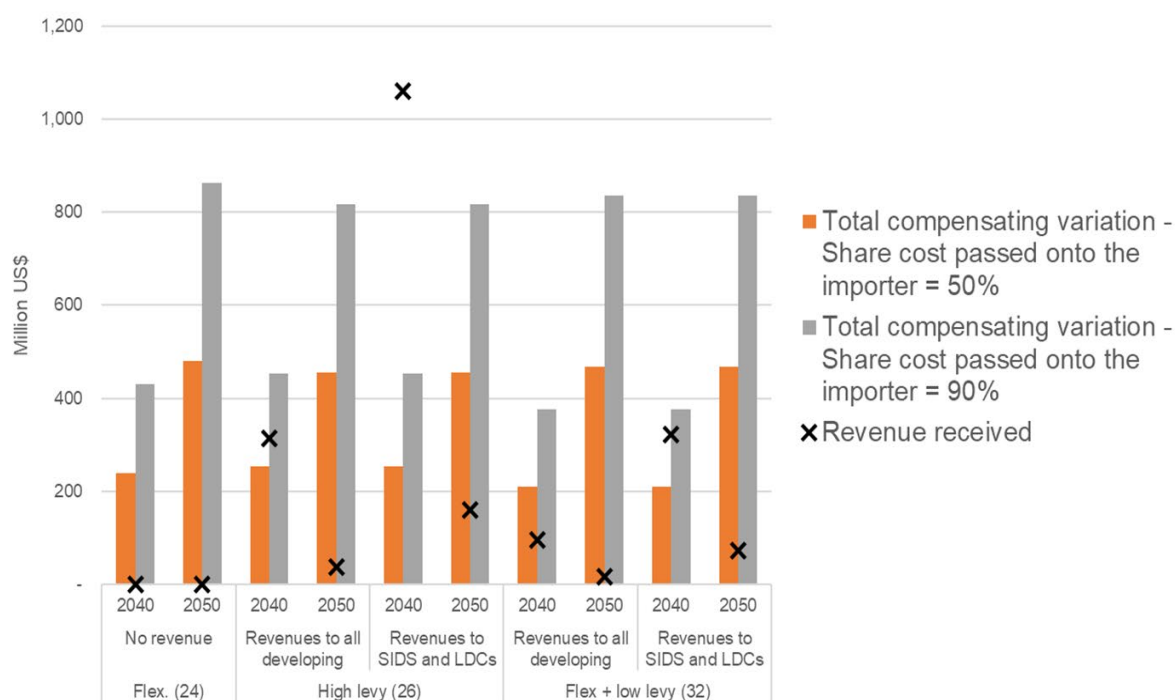


Figure 5.13. Long-term welfare loss vs revenue received.

5.6. Conclusion

The analysis of the IMO mid-term GHG mitigation measures and their impact on food security in the Caribbean highlights the region's vulnerability to rising import costs and potential disruptions in food supply. The findings suggest that while revenue generated from carbon levies can offset some of the welfare losses, the effectiveness of such mitigation depends on how the revenues are distributed. The high-levy (Scenario 26), particularly when revenues are allocated to SIDS and LDCs, appears to provide the most substantial compensation for welfare losses, offering some relief for food-importing nations. However, in the long run (2040 and 2050), revenue generation is insufficient to fully mitigate rising welfare losses, particularly under the flexible (Scenario 24), where no revenue is generated, leaving food insecurity concerns unaddressed. The results indicate that without intervention, rising shipping costs due to carbon levies could lead to higher food prices, import reductions, and increased food insecurity across the region. A well-structured carbon levy, designed with targeted revenue distribution mechanisms, can play a critical role in mitigating the adverse impacts of the IMO's mid-term measures on food security. To enhance food security resilience, policy efforts should focus on diversified agricultural strategies, improved food affordability mechanisms, and regional cooperation. The following policy recommendations are proposed:

- **Revenue Redistribution for Food Security:** A portion of the carbon levy revenue should be allocated to support food security initiatives in vulnerable Caribbean nations, particularly SIDS and LDCs, ensuring that funds are used to subsidize essential food imports or support local agriculture.
- **Targeted Food Assistance Programs:** Cash transfers and food vouchers should be implemented to support low-income households affected by rising food prices, ensuring continued access to basic nutrition.
- **Investment in Agricultural Infrastructure:** Strengthening irrigation systems, storage facilities, and transportation networks will help reduce post-harvest losses and improve domestic food production, reducing reliance on imports.
- **Support for Local Food Production:** Subsidies and incentives should be provided to farmers to encourage the cultivation of staple foods, particularly unprocessed cereals, fruits, and vegetables, which are most affected by import price fluctuations.
- **Diversification of Trade and Regional Cooperation:** Enhancing regional food trade agreements among Caribbean nations can help improve food availability and reduce reliance on external markets.
- **Public Awareness and Sustainable Agriculture:** Education campaigns should be launched to promote sustainable food consumption and backyard farming initiatives, empowering communities to enhance self-sufficiency.
- **Research and Development for Climate-Resilient Crops:** Investment in agricultural R&D is crucial for developing climate-resilient crops and sustainable farming practices, reducing vulnerability to external shocks.

Ultimately, the Caribbean's ability to mitigate the long-term impacts of the IMO's GHG measures will depend on proactive policy measures, strategic investment in food systems, and coordinated regional action. By leveraging carbon levy revenues effectively and fostering domestic food resilience, the region can enhance its food security outlook while contributing to global sustainability efforts.

APPENDIX 1: GDL Model Results

Dependent Variable: EXPENDITURE

Method: Least Squares

Date: 01/25/25 Time: 13:03

Sample (adjusted): 1962 2023

Included observations: 62 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXPENDITURE(-1)	0.678456	0.111505	6.084552	0.0000
POPULATION(-1)	-1621.016	453.8745	-3.571508	0.0007
YEAR(-1)	3.23E+08	89892027	3.588276	0.0007
C	-6.20E+11	1.73E+11	-3.588656	0.0007
R-squared	0.982777	Mean dependent var		1.59E+09
Adjusted R-squared	0.981886	S.D. dependent var		1.47E+09
S.E. of regression	1.98E+08	Akaike info criterion		41.10586
Sum squared resid	2.27E+18	Schwarz criterion		41.24310
Log likelihood	-1270.282	Hannan-Quinn criter.		41.15974
F-statistic	1103.203	Durbin-Watson stat		1.465513
Prob(F-statistic)	0.000000			

Figure 5.A1.1. GDL Model Results

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About Caribbean Shipping Lanes

The Caribbean Shipping Lanes (CSL) Project, housed at the Shridath Ramphal Centre, supports the Caribbean's engagement in International Maritime Organization GHG negotiations. With funding from the United Nations Foundation and support from the University College London and the Belize Port Authority, CSL enhances regional coordination, research, and advocacy for sustainable and climate-resilient maritime policies.



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