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When the Tariffs Come: Ordinary Least Squares as an Attention Mechanism Analysis and Rethinking Trinidad and Tobago's Export Strategy

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Abstract: This study provides a quantitative assessment of the impact of new US tariffs on Trinidad and Tobago's (T&T) non-hydrocarbon exports. Employing a novel hybrid methodology, ordinary least squares as an attention mechanism, the research empirically derives trade impact multipliers, combining the interpretability of traditional regression with the predictive power of neural networks. Analysis of data on the US imports from T&T over the 2001–2024 period reveals that while a substantial US$808 million of T&T's exports are subjected to tariffs, the direct impact of the tariffs is concentrated in non-hydrocarbon sectors, with a projected loss of approximately US$10 million. The manufactured goods section (Standard of International Trade Classification 6) is the most vulnerable, facing an estimated US$86 million decline. These findings highlight the exposure of T&T's export base. Consequently, the study advocates for the adoption and promotion of green packaging to serve as a non-price tool. The idea is that by aligning with global sustainability standards, green packaging can help T&T's exporters mitigate tariff disadvantages and reduce their vulnerability to trade policy shifts.

Keywords: ordinary least squares as an attention mechanism, US tariffs, Trinidad and Tobago exports, green export strategy

1. Introduction

April 2, 2025, was the scheduled date for the implementation of the US "reciprocal" tariff policy, which sought to impose a 10% tariff on countries that are contributing to the US balance of trade deficit.

The President of the United States asserted that April 2 was "Liberation Day" and declared that the United States would be implementing measures to reduce its dependence on imports. He stated that the US local manufacturing industries would be revitalized, national economic sovereignty restored, and a path toward prosperity would be established.

Furthermore, the President characterized the policy measures as "historic," announcing the implementation of a minimum baseline tariff of 10% upon all US trading partners. Additionally, higher tariffs were imposed on specific trading partners, including China and the European Union (EU). The President further noted that the tariffs would be set at approximately half of the rates that the US faces from its trading partners, framing the action as "kind." However, the implementation of the baseline tariffs was postponed and took effect from August 7, 2025.

Trinidad and Tobago (T&T), a small twin-island state located in the Caribbean, is also affected by the new 15% baseline tariff. T&T has been a part of the Caribbean Basin Initiative (CBI)[1] since 1984. Under the CBI, the United States gives certain Latin American and Caribbean (LAC) recipient nations[2] one-way preferential access to its market. This means that while LAC countries are still able to apply tariffs and quotas on US goods, Caribbean countries are granted duty-free and quota-free access to the US market.[3]

The US–Caribbean Basin Trade Partnership Act in 2000 and the Trade Act of 2002 both increased the unreciprocated preferential trade provided by the Caribbean Basin Economic Recovery Act. Due to this, there are no tariffs on a large number of goods that the Caribbean countries that are the beneficiaries export to the United States.

T&T's primary export destination, the United States, may be impacted by the recent round of tariffs. However, the impact remains unknown and unquantified. The imposition of tariffs necessitates a rethinking of T&T's approach to trade. This

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[1] CBI was initiated through the Caribbean Basin Economic Recovery Act (CBERA).

[2] The beneficiary countries of the CBERA are as follows: Antigua and Barbuda, Aruba, the Bahamas, Barbados, Belize, the British Virgin Islands, Curaçao, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and T&T.

[3] There is also a provision under the World Trade Organization (WTO) rules for member countries to apply for a waiver to offer unreciprocated preferential trade agreements preferences to developing countries.

re-evaluation should not merely focus on mitigating the immediate economic impact but also consider the broader context of global environmental concerns and the growing demand for sustainable practices. Therefore, it is indeed logical, and even imperative, that any revised trade strategy incorporates green and sustainable elements.

In this context, green packaging, which includes the use of biodegradable and recyclable materials such over materials such as plastic and Styrofoam, emerges as an important issue for several compelling reasons. First, environmentally conscious consumers are increasingly prioritizing sustainable products and packaging. Second, adopting green packaging might be key for a small player like T&T to survive the new trade war as environmentally conscious consumers may buy products affected by the tariffs. This may potentially offset the potentially negative effects of tariffs by appealing to this growing market segment.

The corresponding research question would be, "What is the potential impact of the US tariffs on T&T's exports to the US market?" Note, when assessing T&T's export to the United States, Standard of International Trade Classification (SITC) 3 and 5 are excluded. This is because they are hydrocarbon-based and downstream hydrocarbon-based industries and are exempt from import taxes.

A supplementary research question would be, "What would be the direct impact of tariffs on T&T's GDP?"

Additionally, to address the issue of green packaging, a corresponding research question would be, "How can the adoption and promotion of green packaging help T&T build export resilience?" Here, the export resilience refers to the mitigation of the decline in exports to the US market.

As such, this study seeks to (i) quantify the impact of the US tariffs on T&T's exports to the US, (ii) estimate the impact of the US tariffs on T&T's GDP, and (iii) explore green packaging as a policy mechanism to mitigate the decline in exports to the US market.

The remainder of this study is structured as follows. Section 2 provides a literature review. Section 3 outlines the data and the methodology for the study. Section 4 presents the results. Section 5 facilitates a discussion. Section 6 concludes this study.

2. Literature Review

In 1947, drawing on the lessons learned from the global economic damage caused by trade protectionism and tariff wars prior to World War II, 23 countries, including the United States, initiated the General Agreement on Tariffs and Trade (GATT) as a platform for multilateral negotiations aimed at liberalizing and boosting global trade [1–3]. To this end, GATT members— and, since 1995, the members of the later-created World Trade Organization (WTO)—gradually reduced their import tariffs and quotas, creating a multilateral system of trade liberalization [4–6]. This trade liberalization, in conjunction with the general principles of the WTO, has since constrained the WTO members' ability to unilaterally set tariffs higher than what they have committed to [7–9].

Under Article XXVIII bis GATT, GATT members have held several rounds of multilateral trade negotiations since 1947 to lower import tariffs and bind them at a certain level, while committing not to raise applied import tariffs higher than the set ceiling of bound tariffs [10]. GATT members have successfully reduced their import tariffs on industrial products during the various rounds of negotiations. During the first rounds (1948–1962), tariffs fell on average by 36%, during the Kennedy Round (1964–1967) by 37%, during the Tokyo Round (1973–1979) by 33%, and during the Uruguay Round (1986–1994) by 38%. The latter round also included negotiations on agricultural goods, resulting in a "tariffication package" that converted former non-tariff barriers into agricultural trade tariffs [11–13].

All current 166 WTO members have set tariff ceilings for imports of industrial and agricultural products under the World Customs Organization's Harmonized Commodity Description and Coding System (HS), although not all WTO members have set tariff ceilings for all products [14]. Pursuant to Article II GATT, these import tariff ceilings are set out in what are referred to as "schedules of concessions" annexed to the revised GATT 1994, which was incorporated in the Marrakesh Agreement establishing the WTO [15].

WTO members have agreed to a maximum tariff (ceiling) for every traded product. These maximum tariffs are known as "bound tariffs" [14]. A product's bound tariff can be lowered, but it cannot be raised beyond the set ceiling. Raising import tariffs unilaterally is thus a violation of WTO rules. The idea behind this principle is that tariff ceilings are locked in to prevent WTO members from raising them in the future, thus sustaining a trend of a gradual lowering of import tariffs. If a WTO member wishes to raise a bound tariff beyond its ceiling, multilateral re-negotiations under Article XXVIII GATT are required to rebalance the past trade concessions made under the reciprocity principle [16].

The WTO is built on the foundational principle of promoting fair, predictable, and nondiscriminatory trade among its member nations. Two key principles that underpin this goal are the Most Favored Nation (MFN) principle and the National Treatment principle [17]. Together, they ensure that no country receives unfair advantage or disadvantage in international trade, thereby supporting a level playing field across the global trading system.

The MFN principle, as outlined in Article I of GATT, requires that any favorable treatment granted to one WTO member must be extended to all other members [18]. For example, if a country lowers a tariff on a specific product for one trading partner, that same tariff rate must apply to imports of the same product from all other WTO members. The aim is to prevent discriminatory practices and ensure uniformity in trade relationships. Thus, the application of MFN prevents selective favoritism and ensures that all members benefit equally from trade concessions, promoting multilateralism over bilateral favoritism [19].

MFN obligations extend beyond tariffs to include other border and internal measures that might affect trade. This means that a country may neither favor imports from one source over another nor impose more restrictive regulations on the same goods simply based on their origin [19, 20].

The National Treatment principle, detailed in Article III of GATT, complements the MFN principle by focusing on how goods and services are treated once they enter a country's market [21, 22]. Under this rule, WTO members must treat imported and domestically produced goods equally in terms of internal taxes, regulations, and other legal requirements. For example, once a product is imported and it clears customs, it must not be subjected to higher sales taxes, more burdensome regulations, or any form of domestic discrimination compared to similar locally produced products.

National Treatment also applies to trade in services and the protection of intellectual property under other WTO agreements like the General Agreement on Trade in Services and the Agreement on Trade-Related Aspects of Intellectual Property Rights

[23]. The aim is to ensure that once foreign goods or services enter a market, they are not disadvantaged by domestic policies that favor national producers.

While the MFN principle is an integral foundation of the WTO system, assuring equal treatment in tariff concessions among all members, the WTO framework does allow for specific exceptions to this rule. These exceptions allow countries to establish preferential trading arrangements under specific conditions without violating WTO obligations [14, 24]. The primary objective is to accommodate deeper integration among certain countries and to support the development needs of poorer nations, while maintaining the overall integrity of the multilateral trading system.

One major exception to MFN treatment arises when WTO members form customs unions or free trade agreements (FTAs) under Article XXIV of the GATT. These arrangements permit members to grant each other lower tariffs than those offered to the rest of the WTO membership, provided the agreement covers "substantially all the trade" among the participating countries [25]. For example, the EU is a customs union where internal tariffs have been eliminated and a common external tariff applies to nonmembers. Similarly, the United States–Mexico–Canada Agreement (USMCA), an FTA, allows these three countries to apply preferential tariffs to one another.[4] These trade agreements are not in breach of MFN requirements as long as they aim for significant trade coverage, commonly interpreted as at least 90% of bilateral trade, and do not result in higher tariffs for nonparticipating countries.

In addition to these regional integration efforts, the WTO also permits nonreciprocal trade preferences for developing and least-developed countries under the GATT's Enabling Clause, adopted in 1979 [26–28]. This provision allows developed countries to unilaterally grant preferential market access to products from developing countries without extending the same treatment to all WTO members. A prominent example of this is the Generalized System of Preferences, under which countries like the United States and members of the EU offer reduced tariffs or duty-free access on imports from selected developing countries. These schemes aim to promote economic development by enhancing export opportunities for poorer nations, while not requiring them to offer reciprocal market access in return.

The Caribbean has historically benefited from nonreciprocal preferential trade arrangements. One key example is the one-way preferential treatment that the Caribbean receives in the United States under the CBI. Since the preferential treatment (in CBI) was not offered to all countries, the United States had to request waivers under paragraph 1 of Article I of GATT and paragraphs 1 and 2 of Article XIII of GATT to maintain the program. The first waiver was granted in 1985 under the original GATT framework, and subsequent waivers have been secured through the WTO. The most recent WTO waiver lasts up to September 2025.

[4]The Agreement between the United States of America, the United Mexican States, and Canada (USMCA) is a free trade agreement among the United States, Mexico, and Canada, in effect from July 1, 2020. It replaced the North American Free Trade Agreement (NAFTA) implemented in 1994. USMCA is primarily a modernization of NAFTA, namely, concerning intellectual property and digital trade, and borrows language from the Comprehensive and Progressive Agreement for Trans-Pacific Partnership, of which Canada and Mexico are signatories. Key changes from its predecessor include increased environmental and working regulations, greater incentives for automobile production in the United States, more access to Canada's dairy market, and an increased duty-free limit for Canadians who buy US goods online.

In 2025, the United States introduced a series of tariffs, including a notable 10% across-the-board tariff on imports. These tariffs are part of a broader strategy to encourage manufacturers to return their production operations to the United States. However, these tariffs may have significant repercussions for trading partners, particularly smaller nations that rely heavily on exports to the US market. Assessing the impact of these tariffs is important because they directly influence the value of exports from partner countries to the United States. Higher tariffs are likely to reduce countries' exports to the United States, resulting in lower export revenues. While some researchers have investigated the impact of the tariffs on their country [29–31], such research remains lacking in T&T due to the limited econometric ability of the public policy authorities.

Notably, between 2010 and 2024, the Government of the Republic of Trinidad and Tobago (GORTT) spent more than it collected in public revenue, resulting in recurring fiscal deficits. This pattern contributed to an accumulation in public debt [32]. Therefore, new tariffs in the United States can cause a decline in export revenue and worsen T&T's foreign exchange earnings. The impact of the tariffs on exports should be of interest to the new political administration in T&T as it must face the country's economic challenges and should make informed decisions on trade diversification, revenue strategies, debt management, and economic activity.

Therefore, this study intends to fill this gap by embarking on research to quantify the impact of the US tariffs on T&T's exports and the direct impact on T&T's GDP.

3. Methodology and Data

3.1. Impact on trade

This study adopts a similar approach to [29] in assessing the impact of tariffs. However, unlike Greenidge, who relied on predetermined impact multipliers, this study derives the impact multipliers empirically. Greenidge import impact multipliers are displayed in Table 1 [29].

1) Step 1: estimating price impact multipliers

The first step involves calculating the price impact multipliers. These are derived by regressing US imports from T&T, classified by SITC Revision 4 at the single-digit level, on the Import Price Index (End Use): All Imports Excluding Fuels (IREXFUELS). The regression model for each product category is specified as:

$$SITC_i = \alpha_0 + \beta_{it} \bullet IREXFUELS + \varepsilon_t \quad (1)$$

where $SITC_i$ represents the trade value of the US imports from T&T for each single-digit category i.

IREXFUELS denotes the import price index for all goods in the United States excluding fuels. This index is used since T&T's export of fuels is exempt from import taxes.

β_{it} is the parameter that is estimated to show the impact on imports with respect to prices at the single-digit level. As such, the β_t serves as the price impact multiplier for each product category.

2) Step 2: computing the tariff impact

According to the approach of [29], once there are elasticities, the tariff impact on imports is calculated using the following formula:

$$impact_i = import_i \times 10\% \times \beta_{it} \quad (2)$$

Table 1
Import impact multipliers

Product group	Baseline multiplier	High substitution multiplier	Details
Rum and other alcoholic beverages	0.90	1.10	Baseline assumes moderate elasticity due to brand loyalty (e.g., Barbadian rum); high substitution scenario reflects competition from USMCA-exempt producers like Mexico.
Jewelry and precious metals	1.10	1.20	Baseline reflects high global competition and price sensitivity; high substitution scenario assumes buyers easily switch sources for luxury goods.
Machinery	1.00	1.15	Baseline assumes moderate impact as capital goods may be deferred; high substitution assumes US buyers switch to lower-cost suppliers.
Manufacturing	1.05	1.20	Baseline assumes sensitivity due to commoditization; high substitution reflects high elasticity and ease of replacing small-volume exports.
Other non-energy exports	0.95	1.05	Baseline reflects mixed elasticity; high substitution assumes a moderate shift away from niche or specialized products.

where $import_i$ is the trade value of the imports at the SITC single-digit level and

β_{it} is the price impact that was computed in Step 1.

In [33] estimation of the impact of a change in tariffs on imports, they used the following equation:

$$\Delta M_1 = \frac{-t}{1+t} * e^D_{M1} * M_i \tag{3}$$

where e^D_{M1} refers to the elasticity of demand of imports from region 1,

t is the tariff, and

M_1 is the imports from region i.

Therefore, the tariff impact should be:

$$\frac{-t}{1+t} \tag{4}$$

This is based on the premise that in a scenario without tariffs, the price of a good is P. With a tariff t, the domestic price becomes P(1 + t). Therefore, if the tariff is removed, the price returns to P.

Therefore, the percentage change in price due to the tariff removal should be given by:

$$\frac{P - P(1+t)}{P(1+t)} = \frac{P - P - Pt}{P(1+t)} = \frac{-Pt}{P(1+t)} = \frac{-t}{1+t} \tag{5}$$

Therefore, Equation (2) should be:

$$impact_i = import_i \times \frac{-t}{1+t} \times |\beta_{it}| \tag{6}$$

where $t = 15\%$.

Note, the absolute value of the beta coefficient $|\beta_{it}|$ is used since the beta coefficient is likely to be negative, reflecting a negative relationship between price and the quantity imported, which is expected in demand curves. The absolute value is used since the components $\frac{-t}{1+t}$ would have a negative sign.

$$impact_i = import_i \times \frac{-0.15}{1+0.15} \times |\beta_{it}| \tag{7}$$

$$impact_i = import_i \times \frac{-0.15}{1.15} \times |\beta_{it}| \tag{8}$$

$$impact_i = import_i \times -0.1304 \times |\beta_{it}| \tag{9}$$

Equation (9) is used to compute the impact of the tariffs on the imports.

3.2. The direct impact on GDP

Following [29], the impact on GDP is as follows:

$$impact_{GDP} = \frac{\Delta exports_i}{nominal\ GDP} \times 100 \tag{10}$$

where $\text{impact}_{\text{GDP}}$ is the impact on nominal GDP,

$\Delta\text{exports}_\text{i}$ is the change in exports, and

nominal GDP is the nominal GDP.

3.3. Ordinary least squares as an attention mechanism

β_{it} in Equation (01) can be estimated through a regression.

Coulombe [34] presented an approach that used ordinary least squares (OLS) as the attention mechanism in a transformer network. Traditionally, OLS is understood as a method that minimizes the sum of squared residuals by projecting the response vector y onto the column space of the design matrix X_{train}.

Let $X_{train} \in \mathbb{R}^{N \times P}$ denote the training design matrix. Let $y \in \mathbb{R}^N$ be the corresponding vector for observations indexed from $i = 1$ to N. The OLS estimator is subsequently expressed as:

$$\hat{\beta} = (X'_{train} X_{train})^{-1} X'_{train} y \tag{11}$$

For out-of-sample predictions on test data indexed from $j = N+1$ to $N + J$, with feature matrix $X_{test} \in \mathbb{R}^{J \times P}$, the predicted values are obtained as:

$$\hat{y}_{test} = X_{test}\hat{\beta} = X_{test}(X'_{train} X_{train})^{-1} X'_{train} y \tag{12}$$

A less commonly emphasized interpretation of OLS is that it can be viewed as a proximity-based estimator, which is similar in spirit to nearest neighbors or kernel smoothing techniques. To display this, consider the eigen-decomposition of $(X'_{train} X_{train})^{-1}$.

$$(X'_{train} X_{train})^{-1} = UA^{-1}U' \tag{13}$$

where U is the orthogonal matrix of eigenvectors. Additionally, A is the diagonal matrix of eigenvalues of $X'_{train}X_{train}$. From utilizing this decomposition, the prediction may be expressed as:

$$\hat{y}_{test} = X_{test}UA^{-1}U'X_{train}y \tag{14}$$

Additionally, a factor A^{-1} can be written as $A^{-1/2}A^{-1/2}$, which results in:

$$\hat{y}_{test} = \underbrace{X_{test}\ UA^{-1/2}}_{F_{test}} \cdot \underbrace{A^{-\frac{1}{2}}U'X'_{train}\ y}_{F'_{train}} = F_{test}\ F'_{train}\ y \tag{15}$$

Here, F_{test} and F_{train} represent standardized factor scores obtained from the test and training data accordingly. These scores form an orthonormal representation in $\mathbb{R}^P$, such that:

$$F'_{train}F_{train} = I_P \tag{16}$$

Despite this identity not automatically holding for F_{test}, since the eigenvectors and eigenvalues come exclusively from the training data.

Due to this restriction, the OLS predictions can be viewed from the perspective of a similarity-weighted average over the training responses.

$$\hat{y}_j = \sum_{i=1}^{N} (F_j, F_i)\, y_i \tag{17}$$

where (F_j, F_i) represents the Euclidean inner product between the transformed test observation F_j and the training observation F_i. This inner product measures their alignment in the transformed space and acts as a similarity metric.

The weight assigned to each training example i when predicting for test case j is given by:

$$\omega_{ji} = \left\|F_j\right\| \bullet \|F_i\| \bullet cos\left(\theta_{ji}\right) \tag{18}$$

where θ_{ji} is the angle between F_j, F_i, and $cos\left(\theta_{ji}\right)$. This is equal to $\frac{\langle F_j, F_i\rangle}{\left\|F_j\right\| \bullet \|F_i\|}$. Thus, large weights arise either as a result of strong alignment (which means a large cosine similarity) or large norms of the training examples. Importantly, the norm of the test point F_j affects the scale of the weights and not their relative magnitudes for a given target.

3.3.1. A review of the attention mechanism

The attention mechanism is an important component of transformer networks. The standard attention mechanism can be expressed as:

$$Attention(Q, K, V) = softmax\left(\frac{QK'}{\sqrt{P}}\right)V \tag{19}$$

where Q is the query vectors that show what the model is currently looking for,

K is the key vectors that show the stored information, and

V is the values vector that possesses the actual content that will be aggregated and weighted based on relevance.

The similarity between queries and keys is computed using a scaled dot product, where the scaling factor $\sqrt{P}$ helps prevent vanishing/exploding gradients as a consequence of high-dimensional feature spaces. The corresponding similarity scores are sent through a softmax function, which normalizes them over the inputs

$$softmax(z_i) = \frac{e^{z_i}}{\sum_{\tau=1}^{N} e^{z\tau}} \tag{20}$$

This guarantees that the final output is a weighted sum of values, with the corresponding weight derived by how well each key matches the associated query.

3.3.2. Attention as a kernel method

An alternative perspective to view attention is from the view of a kernel method. This can be expressed as:

$$Attention(Q, K, V) = \Gamma V \tag{21}$$

where each weight is $\gamma_{i\tau}$.

$$\gamma_{i\tau} = \frac{k(q_i, k_\tau)}{\sum_{\tau=1}^{N} k(q_i, k_\tau)} \tag{22}$$

and k(•, •) is a kernel function that measures the similarity between a query q_i and a key k_τ.

Notably, discussions around attention rarely link to a classical regression. Nevertheless, given the equivalence between kernel ridge regression and infinite-dimensional basis expansions, it is reasonable to expect a bridge between attention and linear regression under certain conditions.

3.3.3. Combining OLS with attention

Out-of-sample forecasts from OLS can be expressed in an attention manner. This suggests a shared structure between linear regression and attention mechanisms.

Therefore, the Q, K, V of a typical attention mechanism may be denoted by:

$$Q = X_{test}W_Q \tag{23}$$

$$K = X_{train}W_K \tag{24}$$

$$V = y \bullet \omega_v \tag{25}$$

Substituting these values in:

$$Attention(X_{test}, X_{train}, y; W) = g\left(X_{test}W_Q W'_K X'_{train}\right) y \cdot \omega_v \tag{26}$$

where g(•) is a general transformation.

If the following is set:

g(•) as the identity function;

$W_Q W'_K = (X'_{train}X_{train})^{-1}$, or similarly $W_Q = W_K = UA^{-1/2}$;

$\omega_v = 1$.

Therefore, the attention mechanism can be expressed as:

$$\begin{aligned} Attention(X_{test}, X_{train}, y; W) &= X_{test}(X'_{train}X_{train})^{-1}X'_{train}y \\ &= X_{test}\hat{\beta} \end{aligned} \tag{27}$$

3.4. Data

The data on the US imports from T&T was obtained from the World Integrated Trade Solution (WITS) database. This data is collected at the SITC single-digit level over the 2001–2024 period. The single-digit SITC classification is used because it identifies and excludes T&T's tariff-exempt hydrocarbon and downstream hydrocarbon industries from the analysis. This broad level of aggregation captures the entire and downstream hydrocarbon industries within two divisions: SITC 3 (mineral fuels, lubricants, and related materials) and SITC 5 (chemicals and related products, nes) for downstream products. By isolating these two categories, the analysis can focus specifically on the non-hydrocarbon (both upstream and downstream) exports, which are subject to potential US import tariffs.

The data on the US import price index, which includes all imports excluding fuels (IREXFUELS), was obtained from the Federal Reserve Bank database.

4. Results

First, the impact multipliers are estimated with OLS as an attention mechanism. The results of the beta coefficients for the price index (IREXFUELS) regressed on the respective single-digit SITC classification.[5] The estimated beta coefficients are in Table 2.

Table 2
Estimated beta coefficients from the OLS as an attention mechanism

Dependent variable	Estimated beta coefficient of IREXFUELS	Wald *p*-values
SITC0	–1.1046	0.0473
SITC1	–1.1016	0.0055
SITC2	–1.1527	0.0037
SITC4	–1.0611	0.0474
SITC6	–1.0102	0.0000
SITC7	–1.1116	0.0212
SITC8	–1.0692	0.0129
SITC9	–1.0609	0.0464

Note: All the *p*-values were less than the 5% significance level, indicating that the coefficient was statistically significant from 0.

[5]For example, IREXFUEL (the independent variable) is regressed on SITC0 (the dependent variable).

Next, the impact of the tariff on the US imports from T&T is computed.

4.1. Impact on trade

Based on the trade value of imports in 2024, the results indicate that US$808,481,070 worth of goods stand to be affected by the tariffs. The total impact is a US$108,010,490 decline in US imports from T&T.

This can be decomposed as follows. A US$8,470,710 decline in SITC 0 (food and live animals), a US$890,490 decline in SITC 1 (beverages and tobacco), a US$983,600 decline in SITC 2 (crude materials except food/fuel), a US$25,420 decline in SITC 4 (animal/vegetable oil/fat/wax), a US$86,395,770 decline in SITC 6 (manufactured goods), a US$599,870 decline in SITC 7 (machinery/transport equipment), a US$3,406,800 decline in SITC 8 (miscellaneous manufactured arts), and a US$7,237,830 decline in SITC 9 (commodities nes). This is seen in Table 3 and Figure 1.

4.2. Impact on GDP

Next, the impact on T&T's nominal GDP is estimated. Data on T&T's nominal GDP is available from the Central Bank of Trinidad and Tobago (CBTT) up to 2024. T&T's real GDP for 2024 was TT$154,917 million (US$23,833.384 million) (see Table 4).

Following [29] and applying Equation (10), the direct impact of the decline on trade on T&T's GDP is computed as follows:

$$impact_{GDP} = \frac{US\$108,010,490}{\text{US}\$23,833,384,000} \times 100 \tag{28}$$

$$impact_{GDP} = 0.45\%.$$

4.3. Limitations

The estimation of the potential impact of the US tariffs on the US imports from T&T is based on the 2024 imports. Ideally, this should be done on the 2025 imports. However, at the time of writing, the year 2025 was not complete. Therefore, the actual 2025 imports are not known. As a result, the impact is estimated.

5. Discussion

The imposition of US tariffs in 2025 is computed at a US$108,010,490 decline in US imports from T&T, based on

Table 3
Impact of the tariff on the US imports from T&T (US$ 1,000)

	Elasticity	Tariff	Imports (2024)	Absolute value of elasticity (|β|)	Trade impact
SITC0	–1.1046	–0.1304	$58,808.11	1.1046	–$8,470.71
SITC1	–1.1016	–0.1304	$6,199.05	1.1016	–$890.49
SITC2	–1.1527	–0.1304	$6,543.74	1.1527	–$983.60
SITC4	–1.0611	–0.1304	$183.71	1.0611	–$25.42
SITC6	–1.0102	–0.1304	$655,854.56	1.0102	–$86,395.77
SITC7	–1.1116	–0.1304	$4,138.42	1.1116	–$599.87
SITC8	–1.0692	–0.1304	$24,434.88	1.0692	–$3,406.80
SITC9	–1.0609	–0.1304	$52,318.60	1.0609	–$7,237.83
			$808,481.07		–$108,010.49

Figure 1
Decline of US imports from T&T by sector

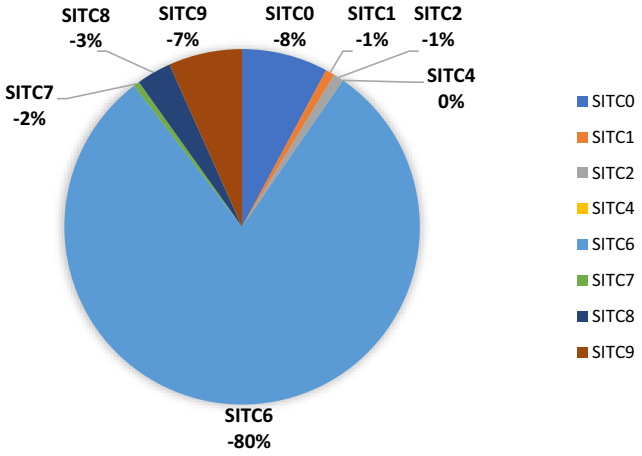

Table 4
T&T's nominal GDP

Date	GDP at market prices – total ($TT Mn)
2012	$174,546.70
2013	$184,004.90
2014	$188,902.80
2015	$171,177.80
2016	$157,549.90
2017	$161,676.50
2018	$161,745.90
2019	$159,321.30
2020	$141,713.60
2021	$163,403.00
2022	$192,562.40
2023	$172,059.90
2024	$154,917.00
value in USD	$23,833.384

2024 trade values. This highlight of the potential trade (exports from T&T) disruption. This reduction signifies a direct loss of export revenue, impacting various exporting sectors of the T&T economy.

The most significant decline, a US$86,395,770, is projected in SITC 6, which encompasses manufactured goods. The tariffs would directly raise the cost of the products produced in this sector as they enter the US market, rendering them less competitive compared to domestic or other tariff-free alternatives.

The agricultural (primary and agro-processing) sector, represented by SITC 0 (food and live animals), SITC 1 (beverages and tobacco), SITC 2 (crude materials except food/fuel), and SITC 4 (animal/vegetable oil/fat/wax), is also projected to experience an aggregated decline of over US$10 million. While these sectors may not represent the largest portion of T&T's exports to the United States, every dollar decline in exports to the US economy represents less foreign exchange earned by T&T. The tariffs would increase the cost of T&T's agro-processed products in the US market, potentially reducing demand and negatively affecting T&T's agro-processors. The decline in SITC 7 (machinery/transport equipment) and SITC 8 (miscellaneous manufactured arts) would further impact T&T's ability to diversify its export base and participate in global value chains.

The calculated 0.43% direct impact on T&T's GDP, while seemingly small, represents a negative economic shock. The impact on GDP is a reflection of the direct loss in export revenue, but it doesn't fully capture the indirect and multiplier effects. Reduced export earnings would lead to lower income for businesses in export-oriented industries. This, in turn, would worsen T&T's foreign currency shortage problem. Furthermore, the government's revenue from export-related taxes would also decline, potentially causing the government to increase borrowing to maintain public spending.

Quantifying the impacts on exports and GDP should be important for the GORTT as it can help inform policy decisions. The GORTT needs to understand the magnitude of the potential losses to develop effective mitigation strategies. This could include exploring alternative export markets and negotiating preferential trade agreements with other countries or regions.

Given the recent change in T&T's government, this analysis is particularly timely. The new administration needs to quickly grasp the potential implications of these US tariffs and develop an appropriate policy response. The lack of prior research on this issue for T&T by the public authorities leaves T&T vulnerable to economic shocks.

Given the potential impact of the tariffs on US imports from T&T, two policy actions immediately emerge as potential responses. They are (i) a retaliation with protectionist policy (such as local content policy (LCP) in the hydrocarbon sector and (ii) the diversification of T&T's export markets.

1) Pursue local content policy

The situation facing T&T presents a complex dilemma at the intersection of global trade politics and domestic economic policy. The US' inclination toward protectionist policies, even if not explicitly targeting T&T with the most severe measures, stands as a significant signal. For a small economy like T&T, the temptation to respond in kind with protectionist measures might arise, particularly in strategic sectors such as hydrocarbons. More specifically, there is a temptation to respond with an LCP, which is a form of protectionism as it favors the development of local industries over foreign competitors. Certainly, the idea of pursuing a stronger LCP within the T&T hydrocarbon sector, which seeks to capture more value-added domestically, should hold intuitive appeal for any government seeking to maximize the benefits derived from its hydrocarbon resources.

However, the crucial caveat resides in the monumental difference in economic power between T&T and major players such as the United States or China. T&T is not an economic powerhouse capable of engaging in a tit-for-tat trade war with the United States without suffering disproportionate consequences. The United States remains a significant trading partner for T&T. In fact, the United States is T&T's largest export market, accounting for over 40% of T&T's exports. Any aggressive protectionist measures by T&T aimed at the United States could trigger retaliatory tariffs, which could worsen the impact of the 10% tariff announced on "Liberation Day." Furthermore, the limited size and diversification of T&T's economy make it particularly vulnerable to such a trade war.

Notably, the 2025 Liberation Day tariffs fundamentally contravene the WTO framework by systematically violating its core principles, as they impose arbitrary, across-the-board increases and targeted supplementary duties that breach the MFN obligation by discriminating between trading partners, exceed legally

Table 5
T&T's exports to different markets trade value (in US$1,000) 2024

	Total	Africa	South America	Central America	United States	CARICOM	Canada	European Union
2022	11529005	16824.34	1101964	19191.33	4862417	743007	135225.1	2564929
2023	7820043	31796.81	960176.2	9183.015	2674905	1120623	101160.4	1357337
2024	6966713	16928.07	702120.9	50838.83	3149339	784277.1	85192.57	1243556

Table 6
T&T's exports to different markets share 2024

	Africa	South America	Central America	United States	CARICOM	Canada	European Union
2022	0.15%	9.56%	0.17%	42.18%	6.44%	1.17%	22.25%
2023	0.41%	12.28%	0.12%	34.21%	14.33%	1.29%	17.36%
2024	0.24%	10.08%	0.73%	45.21%	11.26%	1.22%	17.85%

bound tariff commitments without formal renegotiation, and abandon the requirement for customs valuation to be based on a good's actual transaction value in favor of politically motivated assessments that constitute an national security exceptions for protectionist aims. Moreover, the lifeblood of T&T's hydrocarbon sector development has been, and continues to be, foreign direct investment [35]. The capital, technology, and expertise brought in by international energy companies are necessary for exploring, extracting, and processing its oil and natural gas resources. While an aspect of local content is undoubtedly desirable and can foster domestic capacity building, imposing overly stringent local content requirements carries the risk of deterring foreign investment. Multinational energy companies operate on a global scale, and they will allocate their capital to jurisdictions that offer the most favorable investment climate.

The emergence of neighboring Guyana as a significant player in the oil and gas sector further amplifies this risk. Guyana, with its recent commercial discoveries, presents a compelling alternative for foreign energy investors. If T&T creates an environment perceived as overly bureaucratic, costly, or restrictive due to excessive local content demands, these investors may very well shift their focus and capital to Guyana, leading to a stagnation or even decline in investment in T&T's crucial energy sector. This would not only hinder future development and production but also impact government revenues, job creation, and the overall economic outlook for T&T.

Therefore, while the impulse to pursue policies that benefit local industries and increase domestic value capture is understandable, the GORTT must tread cautiously.

2) Diversification of export markets

As the United States threatens to impose tariffs on T&T, the country can seek to diversify its exports in additional markets. T&T can look toward markets, such as Africa, Central America, and South America.

T&T as a member of the Caribbean Community (CARICOM) entered into bilateral trading agreements with several countries, such as Venezuela (1993), Colombia (1994), Cuba (2000), Dominican Republic (2001), and Costa Rica (2004). As a member of the Caribbean Forum (CARIFORUM),[6] it also entered into a regional preferential trade agreement with the EU, particularly, the Economic Partnership Agreement in 2008. Additionally, T&T receives unreciprocated preferential access to the Canadian market under the Caribbean–Canada Trade Agreement (CARIBCAN)[7].

As can be seen in Table 5, in 2024, T&T's exports to Africa was US$16,928,067, which was 0.24% of T&T's total exports; T&T's exports to Central America was US$50,838,834, which was 0.73% of T&T's total exports; and T&T's exports to South America was US$702,120,868, which was 10.08% of T&T's total exports. These minimal shares suggest that the aforementioned markets remain significantly underexplored markets for T&T.

Table 6 shows T&T's exports to different markets, as a percentage of its total exports. T&T exports to the United States in 2024 was US$3,149,339,322, which was 45.21% of T&T's total exports; T&T's exports to CARICOM was US$784,277,146, which was 11.26% of T&T's total exports; T&T's exports to Canada was US$85,192,572, which was 1.22% of T&T's total exports; and T&T's exports to the EU was US$1,243,556,375, which was 17.85% of T&T's total exports.

There is a reason for such export shares.

5.1. Comparative advantage

T&T exports a narrow basket of goods to various markets. To assess T&T's relative export strength, the International Revealed Comparative Advantage (IRCA) index is computed. The formula for the index is as follows:

$$IRCA = \frac{(X_{ij}/X_{wj})}{(\sum X_i/\sum X_w)} \tag{28}$$

where X_{ij} is country i's export of commodity j, X_{wj} is world exports of commodity j, ΣX_i is total exports of country i, and ΣX_w is total world exports.

The index takes a value from 0 to $+\infty$. A value greater than one indicates that a country has a comparative advantage in that product. A high value, often considered greater than 5, signals a very strong specialization, frequently tied to natural resources like oil. Conversely, a value less than 1 means a country is at a comparative disadvantage in that product.

[6]CARIFORUM is an economic bloc consisting of CARICOM and the Dominican Republic. These countries negotiated collectively with the EU for the EPA.

[7]A WTO waiver is also required for Canada to offer unreciprocated preferences under CARIBCAN.

Table 7
T&T's IRCA

Product (SITC Rev 4)	IRCA
SITC 11—Beverages	1.19
SITC 33—Petroleum, petroleum products and related materials	2.14
SITC 34—Gas, natural and manufactured	28.50
SITC 51—Organic chemicals	6.91
SITC 52—Inorganic chemicals	21.12
SITC 56—Fertilizers (other than those of group 272)	15.43
SITC 67—Iron and steel	3.19

Table 7 displays the SITC double-digit product groups in which the IRCA is greater than 1, suggesting that T&T has export strength in the corresponding area.

As can be seen in Table 7, the IRCA index indicates that T&T has a comparative advantage in a few product groups. These product groups are as follows: SITC 11 (beverages), SITC 33 (petroleum, petroleum products and related materials), SITC 34 (gas, natural and manufactured), SITC 51 (organic chemicals), SITC 52 (inorganic chemicals), SITC 56 (fertilizers), and SITC 67 (iron and steel). This export strength reveals that T&T's trade is driven by its hydrocarbon natural resource endowments.

T&T's exports of hydrocarbon-derived products to the United States are not under threat. The products under threat are essentially the non-hydrocarbon exports. However, T&T seems to be weak in such an area. T&T must consider this if it considers diversifying its exports.

Small states are acutely vulnerable to trade shocks from major partners, a core tenet of the literature on small open economies [36–38].

Their limited market size, concentrated export profiles, and high degree of openness make them "price-takers" with negligible power to influence terms of trade or deter protectionist measures. As seen with the 2025 US tariffs, a single policy shift by a dominant trading partner can induce a negative shock, directly reducing export revenue. This vulnerability is compounded by the fact that small economies often lack the diversified industrial base to absorb such shocks internally.

The academic discourse on small states further highlights that overcoming this vulnerability through export diversification is a profound challenge. The case of T&T illustrates that horizontal diversification, creating new, non-resource export sectors, is not a mere change in export destinations, but a generational policy undertaking. The existing trade structure, locked in by decades of hydrocarbon specialization, creates a path that is difficult to break. Redirecting established bulk commodity exports is unviable due to mismatched infrastructure and demand in new markets. Building competitive new industries requires overcoming barriers related to scale, access to capital, and global market entry. This aligns with the literature suggesting that for resource-rich small states, diversification is less a trade policy issue [39, 40]; De Remer et al. 2025) and more a complex process of building entirely new comparative advantages, a task fraught with high costs and a long time.

Consequently, T&T should rethink its approach to the US market.

5.2. Green export strategy

In recent years, the United States has made notable strides toward a sustainable and environmentally conscious policy direction that encourages manufacturers to shift toward more sustainable packaging. This movement is encouraging the use of more biodegradable and recyclable materials in manufacturing and packaging as part of a broader circular economy approach. The policy direction is being set through a combination of federal strategies, procurement policies, and recycling targets.

At the federal level, the US Environmental Protection Agency (EPA) has developed two complementary frameworks, namely, the 2021 National Recycling Strategy and the National Strategy to Prevent Plastic Pollution. These policy reports, which are influenced by the work of the Save Our Seas 2.0 Act and years of circular economy lobbying, seek to keep materials in circulation for as long as possible, minimize waste, and encourage resource recovery. For manufacturers, this sends a policy signal to shift toward more sustainable materials, especially in packaging.

A notable federal policy shift is the federal government's decision to phase out the procurement of single-use plastics across federal operations. Announced in July 2024, the US federal government stated its intention to phase out the procurement of single-use plastics in food service events and packaging operations by 2027 and all other operations by 2035. Since the US federal government is the largest single purchaser of goods and services in the country, this policy direction is likely to significantly influence supply chains and encourage sustainability in manufacturing and packaging.

Furthermore, the EPA's National Recycling Goal sets the target of increasing the recycling rate in the United States by 50% by 2023. This goal, announced at the 2020 America Recycles Summit, is a component of a broader recycling strategy that mandates the need for clearer labeling, standardized recycling definitions, and stronger end-markets for recyclable materials.

Apart from the US federal policy direction, in March 2022, progress was made at the international community level when the United Nations Environment Assembly adopted Resolution 5/14 to develop a legally binding global treaty on plastic pollution. This resolution tasked the United Nations Environment Programme with the responsibility for convening an Intergovernmental Negotiating Committee (INC) to develop an international framework that addresses plastics' entire life cycle.

The first session (INC-1) was held in Punta del Este, Uruguay, in November 2022, followed by INC-2 in Paris, France,

in June 2023. The third session (INC-3) was held in Nairobi, Kenya, in November 2023, and the fourth session (INC-4) was held in Ottawa, Canada, in April 2024. The first part of the fifth session (INC-5.1) occurred in Busan, the Republic of Korea, in November–December 2024. The second part of the fifth session (INC-5.2) is scheduled for August 2025 in Geneva, Switzerland.

Thus, there is a clear signal that the United States, and increasingly, the international community, is shifting toward environmentally conscious practices. In this context, going green emerges as a key strategy for manufacturing companies seeking to remain competitive amid rising protectionism. Green packaging, for instance, can serve as a product differentiator in markets where tariffs increase the baseline cost of imported goods. Environmentally conscious consumers are increasingly willing to pay a premium for products that demonstrate sustainability [41–43]. Therefore, companies that adopt green practices as well as green packaging may be better positioned to maintain or even expand their market share in the United States amid protectionist politics. Green packaging, also known as sustainable packaging, embodies to the use of sustainable materials and production processes that support the protection of the environment. This includes packaging made from materials that break down naturally, can be recycled, or can be composted, which can help cut down on waste in landfills and carbon emissions. Green packaging seeks to reduce the ecological impact across the whole packaging life cycle, encompassing raw material procurement, manufacturing, utilization, and disposal, while preserving essential protective and functional attributes for products.

Green packaging encompasses the implementation of sustainable processes and materials throughout the entire packaging process. This encompasses utilizing renewable or recycled materials, minimizing package volume and weight to decrease transportation emissions, and engineering for reuse or enhanced recyclability. It frequently integrates advances including plant-derived polymers, microbiological packaging, recycled paper and cardboard, and water-based inks. Furthermore, green packaging highlights energy-efficient production methods and the removal of hazardous or nonbiodegradable materials.

To promote green packaging in its manufacturing exports to the United States and address the problems presented by the Liberation Day tariffs, the GORTT should initially include green packaging mandates in its national export development strategy. As US consumers and retailers increasingly demand ecologically friendly products, complying with their tastes can provide a competitive advantage. T&T must emphasize boosting awareness among local manufacturers about the growing value of sustainability in US markets and how green packaging may serve as a market differentiation.

Second, trade facilitation offices and trade attachés in the United States can play a key role in promoting green packaging. These representatives should collect and distribute information on US consumer trends, retail expectations, and environmental labeling regulations pertaining to packaging. One of their responsibilities should be to advise T&T manufacturers on the certifications, materials, and design specifications that American consumers want. Particularly for small and medium-sized businesses that do not have the capacity to independently monitor international legislation, real-time advice from trade specialists can help close knowledge gaps.

Third, T&T should improve the enabling environment to obtain globally recognized testing and certification for green packaging for its local manufacturers. The cost and difficulty of international product certification are a persistent challenge for exporters. In addition to investing in recognized local laboratories that can test packaging materials for biodegradability, recyclability, and compliance with US food and safety regulations, the GORTT should expedite the implementation of the National Quality Policy. With the help of these facilities, local businesses may verify their packaging claims locally, cutting costs and time to market while gaining the trust of US consumers.

Fourth, T&T manufacturers should get capacity-building assistance to improve their understanding and application of sustainable packaging techniques. Technical support and educational initiatives on global labeling standards, eco-friendly packaging design, and the procurement of sustainable materials are a few examples of this. Manufacturers can be guided to embrace innovations like plant-based packing materials and recycled paper that lower material use and transportation costs, qualities highly valued in US green supply chains, by working with packaging experts, academic institutions, and business development agencies.

Lastly, T&T's green manufacturing skills need to be better marketed strategically. Videos and brochures are examples of professional promotional tools that could emphasize T&T exporters' usage of green packaging. These resources can be used to highlight T&T's commitment to environmental principles around the world at business-to-business meetings, US trade exhibitions, and virtual trade missions. Through appealing directly to US merchants and consumers who value environmentally friendly supply chains, it encourages US consumers to purchase T&T-manufactured products, which, despite having a higher price due to the tariffs, would have green packaging.

Thus, the goal is for the green packaging to help reduce the elasticity of the import demand for T&T-manufactured exports to the United States.

The next section concludes this study.

6. Conclusion

This study was undertaken to examine the potential impacts of newly imposed US tariffs on T&T's exports and evaluate the role of sustainable practices, specifically green packaging, in building export resilience.

The first research question was, "What is the potential impact of the US tariffs on T&T's exports to the US market?"

The findings show that US$808,481,070 worth of T&T's goods are exposed to the US tariffs. This is not a significant portion of the country's exports to its largest trading partner. The impact is not evenly distributed across all product categories. Rather, it is concentrated in non-hydrocarbon sectors, revealing structural weaknesses in T&T's export diversification. The estimated loss in exports amounts to US$108,010,490, with the largest decline, US$86,395,770, occurring in SITC 6 (manufactured goods). Other affected product categories include a US$8,470,710 decline in SITC0 (food and live animals), a US$890,490 decline in SITC1 (beverages and tobacco), a US$983,600 decline in SITC 2 (crude materials except food/fuel), a US$$25,420 decline in SITC 4 (animal/vegetable oil/fat/wax), a US$599,870 decline in SITC 7 (machinery/transport equipment), a US$3,406,800 decline in SITC 8 (miscellaneous manufactured arts), and a US$7,237,830 decline in SITC 9 (commodities nes).

These figures highlight the tangible risk that trade protectionism poses to T&T's economic stability, particularly in non-energy goods that lack international competitiveness or resilience. Moreover, it reflects how vulnerable small open economies are to policy shifts in major trading partners. The concentration of

affected exports in lower value-added sectors also demonstrates the limitations of T&T's current export strategy.

The second research question was, "What would be the direct impact of tariffs on T&T's GDP?"

The estimated GDP of T&T for 2024 is TT$162,901.45 million or approximately US$25,061.76 million. The reduction in export revenue due to the US tariffs is forecasted to result in a 0.3004% contraction in GDP. Given that the impact stems largely from reductions in exports of non-energy goods.

Two policy initiatives immediately arise as possible reactions to the US tariffs, namely, (i) a protectionist response (such as LCP in T&T's hydrocarbon industry) and (ii) diversifying T&T's export markets.

The first approach is impractical for T&T. As a small open economy, T&T lacks the economic strength to engage in a trade war with the United States without suffering disproportionate harm. The United States remains T&T's largest trading partner, accounting for 45.21% of its total exports (US$3.15 billion in 2024).

The second idea of diversifying T&T's export markets sounds appealing, but the data suggests otherwise. In 2024, US$16,928,067, or 0.24% of total exports, were sent by T&T to Africa; US$50,838,834, or 0.73% of total exports, were sent to Central America; and US$702,120,868, or 10.08% of total exports, were sent to South America. These small shares imply that the previously stated markets are still mostly unexplored by T&T.

There are structural reasons for T&T's heavy reliance on US trade. T&T's export profile is narrow, with its international revealed comparative advantage concentrated in a few sectors, namely, SITC 11 (beverages), SITC 33 (petroleum, petroleum products and related materials), SITC 34 (gas, natural and manufactured), SITC 51 (organic chemicals), SITC 52 (inorganic chemicals), SITC 56 (fertilizers), and SITC 67 (iron and steel). Thus, T&T's export strength is based on its natural resource endowment of hydrocarbons rather than preferential access to different markets.

Importantly, T&T's hydrocarbon and related products exports are not threatened by the US tariffs. The exports of the non-hydrocarbon sectors, especially manufacturing, are most at risk. Thus, a strategy is needed to build resilience.

This leads to the third research question, "How can the adoption and promotion of green packaging help T&T build export resilience?"

Environmental sustainability requirements are progressively influencing the nature of international trade. Green packaging provides a calculated reaction to changes in the market and in regulations. Green packaging can be a value-added differentiator in markets where consumers care about the environment, since taxes increase the base cost of imported goods. Buyers in the United States and other developed nations are prepared to pay more for goods that exhibit sustainability. T&T's manufacturers can increase product competitiveness and protect their market penetration against protectionist shocks by using environmentally friendly production methods and adopting green packaging.

This study makes an empirical contribution to the literature by implementing the OLS as an attention mechanism framework to estimate the price impact multipliers of the tariff on the US imports of goods from T&T. The aforementioned methodology is new and was introduced this year (2025).

This study also makes an empirical contribution as it computes the impact of the tariffs on T&T's exports and T&T's GDP. The Liberation Day tariffs are a current issue, and no study has computed such effects for T&T.

This study makes a policy contribution as the recommendation to adopt green packaging in T&T's export strategy is a new idea that is not currently implemented by T&T. Although green packaging is proposed as a policy response to build resilience in T&T's exports, this policy direction can be used to help T&T's transition toward a circular and low-carbon economy while supporting the achievement of the Sustainable Development Goals (SDGs), namely, sustainable industrialization (SDG 9), responsible consumption and production (SDG 12), and promoting economic growth that is both inclusive and environmentally sound (SDG 8).

Future research could examine the feasibility and the readiness of T&T to implement green packaging across multiple export sectors, especially in SITC6 (manufactured goods). Such research can also explore the potential of international cooperation and support extended to T&T as the country aspires to use green packaging to advance the circular economy, promote low-carbon development, and build trade resilience.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by the author.

Conflicts of Interest

The author declares that he has no conflicts of interest to this work.

Data Availability Statement

The data that support the findings of this study are openly available in WITS at https://wits.worldbank.org/, the Federal Reserve Bank database, Import Price Index (End Use): All Imports Excluding Fuels (IREXFUELS) at https://fred.stlouisfed.org/series/IREXFUELS, OLS as an attention mechanism at https://github.com/doncharles005/OLSAM, and the CBTT database at https://www.central-bank.org.tt/data-center-block.

Author Contribution Statement

Don Charles: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration.

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Appendix

Explanation of the Attention Weight Calibration and Eigen-Decomposition

Coulombe [34] reframes traditional OLS regression by projecting the response vector y onto the column space of the design matrix X. This is done to make it a proximity-based estimator similar to the attention mechanism in transformer networks. As such, OLS predictions are treated as a similarity-weighted average of training responses, where weights are derived from feature similarities in a transformed space.

The traditional OLS estimates coefficients are:

$$\widehat{\beta} = (X'_{train} X_{train})^{-1} X'_{train} y \tag{11}$$

Out-of-sample predictions are:

$$\hat{y}_{test} = X_{test} U A^{-1} U' X_{train} y \tag{14}$$

Coulombe [34] shows this equals a similarity-weighted average:

$$\hat{y}_j = \sum_{i=1}^{N} (F_j, F_i)\, y_i \tag{17}$$

F_{train} is a transformed factor score from eigen-decomposition.

The dot product $F_j \bullet F_i = \left\|F_j\right\| \bullet \|F_i\| \bullet cos\left(\theta_{ji}\right)$ acts as an attention weight, favoring training examples i similar to the test point j.

This mirrors transformer attentions. Queries $(Q) \approx$ test features, Keys$(K) \approx$ training features, Values $(V) \approx$ responses y. There is no softmax, so it is a restricted (linear) attention.

In the code used for the model, the data is loaded from "Trumptariffs.xls" and uses "SITC0" (y) and "IREXFUELS" (X).

The OLS is first specified as: beta_hat_std = np.linalg.inv(X_std.T @ X_std) @ X_std.T @ y_std.

The hat matrix is specified as: H_std = X_std @ np.linalg.inv(X_std.T @ X_std) @ X_std.T.

The predictions are specified as: y_pred_attention_std = H_std @ y_std.

The singular value decomposition (SVD) (for how eigen-decomposition transforms features for attention-like weighting) involves computing weights through the code:

proximity_matrix_std = F_test_std @ F_train_std.T.

Then computing: y_pred_similarity_std = proximity_matrix_std @ y_std.

The eigen-decomposition of A is used to reveal OLS as attention. The SVD of the Gram matrix A (a symmetric, positive semi-definite matrix representing feature covariances) is computed by the following code: U, S, Vt = np.linalg.svd(X_std.T @ X_std, full_matrices=False). This decomposes A into its eigenspace, revealing principal directions of variance in features.

Next is the attention weight calculation. This is done via the following code:

Lambda_inv_half = np.diag(1.0 / np.sqrt(S)). This code creates a diagonal matrix A where each entry is the inverse square root of an eigenvalue from S. By taking the inverse square root, it normalizes the eigenvalue scales.

Next, the standardized training data is projected into the modified eigenspace. This is done by:

F_train_std = X_std @ U @ Lambda_inv_half.

Next, the test factors are set equal to training (in-sample mode; for true out-of-sample, recomputed with test X using the same U and Lambda). This is done by: F_test_std = F_train_std.

Next, the attention weights are computed. The attention matrix from the decomposed space is equivalent to the hat matrix projection. This is computed by:

proximity_matrix_std = F_test_std @ F_train_std.T.

Next, the attention weights are fully calibrated. The predictions are computed, but they have eigen-transformed similarities. This bridges OLS with the attention mechanism.