



RESEARCH

Beyond Tariffs: A CGE Analysis of Sri Lanka–Singapore Trade Relationships

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ABSTRACT

This study examined the economic impacts of the Sri Lanka–Singapore trade relationship by comparing the effects of unilateral tariff liberalization and non-tariff barrier reduction through improvements in import efficiency. Using the Global Trade Analysis Project (GTAP) computable general equilibrium model, the analysis focused on machinery sector under two policy scenarios, partial tariff elimination and trade facilitation (import efficiency improvements) aimed at maintaining constant aggregate imports in each scenario. The results indicated that trade facilitation generates significantly large economic benefits for Sri Lanka than tariff reductions. An 8% improvement in import efficiency, in the machinery sector, led to substantial increases in real GDP, welfare, exports, and industrial output. In contrast, tariff elimination produced only marginal gains and, in some cases, negative welfare effects due to adverse impacts on terms of trade and government revenue. Allocative efficiency (US\$ 3.07 million) and technical efficiency (US\$ 9.13 million) emerged as the primary drivers of welfare gains under trade facilitation, while reductions in market prices further enhanced consumer welfare. The machinery sector, characterized by strong backward and forward linkages, responded more significantly to efficiency improvements. Additionally, trade facilitation increased government revenue by expanding the import base, whereas tariff reductions reduced fiscal income. Overall, the study highlighted that reducing non-tariff barriers through trade facilitation is more effective than tariff liberalization in enhancing welfare and competitiveness. These results underscored the importance of prioritizing efficiency-enhancing reforms to maximize the benefits of trade relations in developing economies like Sri Lanka.

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INTRODUCTION

Non-Tariff Measures (NTMs) have become increasingly important in shaping global trade as tariffs fall through multilateral and regional liberalization. NTMs are policy measures, other than ordinary customs tariffs, that can affect international trade by altering the quantity traded, prices, or both. They include a broad range of regulatory and administrative requirements, such as sanitary and phytosanitary (SPS) measures, technical barriers to trade (TBT), import licensing, quotas, conformity assessment procedures, customs formalities, and other border-related regulations implemented to achieve legitimate public policy objectives, including the protection of human, animal, and plant health, safety, and the environment (UNCTAD, 2013; WTO, 2016). In this study, the analysis focuses on the trade facilitation component of NTMs, represented by improvements in customs clearance, documentation procedures, and border processing. Unlike tariffs, which are transparent, price-based, and revenue generating measures, NTMs operate through regulatory and administrative channels such as licensing, testing, conformity assessment, and customs procedures. While often designed to protect health, safety, or the environment, these measures impose significant documentation, compliance, and time costs that restrict market access and raise import prices (Beghin *et al.*, 2015). Evidence shows that NTMs can be more trade-restrictive than tariffs, especially in developing countries where administrative delays and institutional inefficiencies amplify their impact (Disdier & Fontagné, 2010; Kee *et al.*, 2009). Because NTMs consume real resources rather than generating fiscal revenue, they produce larger welfare losses through compliance costs and reduced allocative efficiency (Anderson & Neary, 2005). Studies by UNCTAD (2013) and the World Bank (2018) further demonstrate that streamlining border procedures can yield welfare gains exceeding those from additional tariff cuts. In this context, Sri Lanka being a

highly import-dependent economy has historically relied on trade agreements centered on tariff reductions to enhance trade flows. However, given the persistence of procedural bottlenecks, customs delays, and regulatory inefficiencies, the effective gains from such agreements are often constrained. Therefore, evaluating and reducing NTMs is particularly critical for Sri Lanka, as improvements in import efficiency are likely to generate larger and more sustainable welfare gains than tariff liberalization alone.

The increasing importance of NTMs in global trade has generated substantial empirical attention, particularly as tariff barriers have declined through multilateral and regional liberalization. In developed regions such as the European Union, NTMs have been shown to exert both restrictive and facilitating effects depending on their harmonization and implementation (Disdier & Fontagné, 2010; Beghin *et al.*, 2015). Similarly, in the Association of Southeast Asian Nations (ASEAN), trade facilitation[†] reforms, including customs modernization and regulatory convergence, have significantly reduced transaction costs[‡] and enhanced participation in global value chains (Itakura, 2014; Hoekman & Shepherd, 2019). Evidence from East Asia further emphasizes that improvements in logistics performance and reductions in procedural barriers play a critical role in strengthening export competitiveness (Wignaraja, 2019).

Within this context, Sri Lanka reflects many of the structural challenges observed in developing economies. Despite ongoing tariff liberalization, the country continues to face significant non-tariff barriers, including licensing requirements, repeated inspections, customs delays, and overlapping regulatory procedures (World Bank, 2018; WTO, 2016). In Sri Lanka, import clearance and related procedures typically take around 3–5 days, combining border compliance (approximately 72 hours) and documentary requirements

[†] **Trade Facilitation:** Refers to the simplification, modernization, and harmonization of international trade procedures including customs clearance, documentation, and border processes to reduce trade costs, improve efficiency, and expedite the movement of goods across borders (World Trade Organization, 2015).

[‡] **Transaction Costs:** The costs associated with conducting and completing an economic exchange, including expenses related to information gathering, negotiation, documentation, compliance, transportation, and enforcement of contracts, which increase the overall cost of trade beyond the price of goods themselves.

(about 48–58 hours) based on World Bank Doing Business indicators (World Bank, 2018). By comparison, in Singapore a leading global logistics and port hub import border compliance requires only 33 hours, while documentary compliance takes approximately 3 hours, resulting in a total import processing time of less than two days (World Bank, 2020). These inefficiencies increase transaction costs and undermine trade competitiveness, thereby constraining the potential benefits of trade agreements. However, existing literature on Sri Lanka has predominantly focused on tariff policies and sectoral trade performance, with limited attention to the economy-wide impacts of NTMs. In particular, there is a lack of studies that incorporate NTMs into computable general equilibrium (CGE)[§] frameworks to assess their effects on welfare, resource allocation, and productivity. The Sri Lanka–Singapore Free Trade Agreement (SLSFTA), signed in 2018, provides an important case for addressing this gap. As the most comprehensive agreement of Sri Lanka with a highly efficient and globally integrated economy, the SLSFTA extends beyond tariff liberalization to include trade facilitation, regulatory cooperation, and services integration.

Accordingly, a key research gap exists in the empirical evaluation of NTMs in Asia, particularly for small, import-dependent economies^{**} such as Sri Lanka, where the relative importance of tariff versus non-tariff reforms remains underexplored. This study addresses this gap by modeling NTMs as import-augmenting efficiency shocks within a CGE framework, enabling a systematic

comparison of tariff liberalization and trade facilitation measures. Aggregate import responses under tariff liberalization and trade facilitation are broadly comparable when policy shocks are calibrated to achieve similar trade effects. This suggests that improvements in import efficiency can generate import expansion equivalent to tariff reductions, highlighting trade facilitation as an alternative channel for enhancing trade performance.

The primary objective of this study is to evaluate the relative contributions of unilateral tariff liberalization and non-tariff efficiency improvements to welfare of Sri Lanka under the Sri Lanka–Singapore trade relationship. Specifically, the study seeks to determine whether the gains from the trade relationship are driven primarily by unilateral reductions in import tariffs or by improvements in import efficiency in Sri Lanka arising from the reduction of non-tariff barriers such as customs delays, licensing procedures, and regulatory compliance costs^{††}. To address this central research question, the analysis employs the Global Trade Analysis Project (GTAP)^{##}, CGE framework, which allows for an economy-wide assessment of policy impacts. Within this framework, tariff changes are modeled as tariff shocks (tms)^{§§}, while non-tariff measures are incorporated as import-augmenting technical change (ams)^{***} shocks, capturing efficiency gains that reduce the real resource cost of importing. By systematically comparing these scenarios across key sectors, the study evaluates their effects on GDP, trade flows, sectoral performance, prices, and welfare.

[§] **A computable general equilibrium (CGE)** model is an economy-wide quantitative framework that simulates how different sectors, households, and governments interact in response to policy changes, capturing the simultaneous adjustments in prices, production, trade, and welfare across the entire economy.

^{**} **Import-Dependent Economy:** An economy that relies heavily on imports of goods and services particularly intermediate and capital goods to sustain production, consumption, and economic growth due to limited domestic capacity or resource constraints.

^{††} **Regulatory Compliance Costs:** The expenses incurred by firms to meet government-imposed rules and standards, including costs related to documentation, testing, certification, inspections, licensing, and administrative procedures required for importing, exporting, or production.

^{##} **GTAP (Global Trade Analysis Project):** An internationally recognized multi-country, multi-sector computable general equilibrium (CGE) model and database used to analyze the

economic impacts of trade policies, including tariffs, non-tariff measures, and productivity changes, within a consistent global framework

^{§§} **tms (Tariff Shock):** In the GTAP framework, a TMS shock represents a change in import tariffs, capturing policy-induced variations in the tax imposed on imported goods. It affects the domestic price of imports by creating a price wedge between world and domestic prices and generates government revenue through tariff collection

^{***} **ams (Import-Augmenting Technical Change):** In the GTAP framework, an AMS shock represents a change in import efficiency by reducing the real resource cost associated with importing goods. It captures improvements in trade facilitation such as faster customs clearance, streamlined documentation, and reduced regulatory delays thereby lowering the effective price of imports without generating government revenue.

The reminder of the paper is organized as follows. Section 2, describe the modelling framework which is based on the standard GTAP model, the database used, and the simulated shocks for the analyses. The results of the study are presented and discussed in section 3 and section 4 concludes. The policy recommendations under section 5.

METHODOLOGY

For this study, the GTAP version 10A database was utilized, providing a comprehensive and internally consistent global dataset widely applied in trade policy analysis (Aguiar *et al.*, 2019; Hertel, 1997). To ensure analytical tractability while preserving policy relevance, the database was aggregated into 10 regions^{†††} in Sri Lanka, Singapore, China, Malaysia, Indonesia, India, Pakistan, the United States, Russia, and the Rest of the World 15 production sectors, and 5 primary factors of production (land, skilled labor, unskilled labor, capital, and natural resources). The regional aggregation explicitly distinguishes Sri Lanka and Singapore as separate economies while incorporating their key trading partners, thereby capturing bilateral as well as broader multilateral trade linkages (Ianchovichina & Walmsley, 2012).

The sectoral aggregation was designed to isolate the machinery sector and the paper and publishing sectors as focal industries, while grouping remaining sectors to capture economy-wide interactions. This approach is consistent with CGE modeling practices that emphasize sectoral disaggregation for industries of policy sensitive sectors (Francois & Reinert, 1997). The machinery sector includes nuclear reactors, boilers, mechanical appliances, and industrial machinery used in manufacturing and textile production, reflecting its capital- and technology-intensive nature. The paper and publishing sector encompasses paperboard, cut paper products, printed materials, and related items, representing a resource and knowledge-based industry.

The selection of these sectors is motivated by their relatively high share in bilateral trade

between Sri Lanka and Singapore and their sensitivity to both tariff and non-tariff measures. Previous studies highlight that sector specific effect aggregation improves the accuracy of policy simulations by capturing heterogeneity in trade elasticities and regulatory barriers (Kee *et al.*, 2009; UNCTAD, 2013). Accordingly, this aggregation framework enables a more precise assessment of the differential impacts of tariff reductions and trade facilitation (modeled as non-tariff measures) on trade flows, production, and welfare between the two countries.

Adjustment to the GTAP baseline

Import tariff

Within the GTAP model framework, import tariffs are represented by the variable *tms*, which denotes the ad valorem tax imposed on imports from a specific trading partner. Changes in tariff policy are introduced into the model through shocks to the *tms* variable, representing reductions or eliminations of import duties between countries. These changes affect the effective prices of imported goods relative to domestic products, thereby influencing trade flows, sectoral production, and welfare outcomes (Hertel, 1997; Corong *et al.*, 2017). By simulating adjustments to the *tms* variable, the model captures the effects of unilateral tariff liberalization on trade, domestic production, and consumer welfare.

Import tariff is the most direct trade policy instrument and are represented in GTAP by the import tax rate (*tms_{irs}*) on commodity *i* imported by region *s* from region *r*. The domestic price of imported goods is given by:

$$P_{mis} = P_{wir} \times (1 + tms_{irs}) \dots \dots (1)$$

P_{mis} Domestic price of imported good *i* in country *s*

P_{wir} World (export) price of good *i* from country *r*

tms_{irs} Ad valorem tariff rate

A reduction in tariffs (negative *tms* shock) simulates trade liberalization and reduces domestic prices, while a positive shock

^{†††} **Regions:** In the context of economic modeling (e.g., GTAP), “regions” refer to countries or groups of countries aggregated

into a single unit for analysis, representing distinct geographic and economic entities within the model.

captures protective or distortionary effects. This mechanism directly affects the cost of imported food commodities and the competitiveness of domestic producers.

NTMs measures

In the CGE and GTAP modeling framework, the welfare implications of NTMs are typically assessed through *ams* shocks. The *ams* variable in GTAP captures improvements in import efficiency, representing policy-induced reductions in trade costs or procedural delays at the border (Hertel, 1997; Corong *et al.*, 2017). A positive *ams* shock increases the effective quantity of imports for a given expenditure, thereby simulating the welfare gains associated with streamlined customs processes, reduced documentation costs, or enhanced trade facilitation. For instance, recent GTAP-based studies by Khan *et al.* (2020) and Nie (2023) used *ams* shocks to evaluate the trade and welfare effects of FTAs, showing that efficiency-based reforms often yield larger welfare gains than tariff elimination alone.

In GTAP, the import efficiency/trade facilitation (*ams*) parameter adjusts the effective quantity of imports available for domestic use without changing the nominal tariff rate^{***}.

$qms_{irs} = ams_{(irs)} \times qm_{irs}$
 qms_{irs} Effective (augmented) imports^{§§§} of commodity *i* from source *s* to destination *r*,
 qm_{irs} Actual (measured) imports^{****}

ams_{irs} Import-augmenting technical change (efficiency term)

If $ams > 1$, trade facilitation improves- fewer resources are wasted in the import process. If $ams < 1$, there are inefficiencies i.e., due to NTMs or customs barriers.

In the GTAP model, the (*ams*) scales the effective quantity of imports available to the economy. An increase in *ams* raises the efficiency with which imports are utilized, so that a given quantity of physical imports generates a larger number of effective imports. This mechanism captures the effects of trade facilitation measures such as reduced customs delays, streamlined documentation, and improved border procedures, which lower iceberg trade costs and increase the productivity of imported goods within the economy (Hertel, 1997)

The import price equation incorporating efficiency *ams* is:

$$pms_{irs} = pwm_{(irs)} \times (1 + tm_{(irs)}) \div ams_{irs} \quad (3)$$

$pms_{(i,r,s)}$: domestic market price of imports from *s* to *r*, $pwm_{(i,r,s)}$: world (border) price, $tm_{(i,r,s)}$: import tariff rate, $ams_{(i,r,s)}$: trade facilitation parameter

Hence, an increase in *ams* effectively reduces import prices, even if tariffs remain constant. In GTAP, percentage (log) changes are used. Thus, the change in the import price due to trade facilitation is,

$$pms_{irs} = pwm_{(irs)} + tm_{(irs)} - ams_{irs} \quad (4)$$

Where lowercase variables represent percentage changes (i.e., pms = % change in domestic import price).

Therefore, a positive shock to *ams* (i.e., +5%) is interpreted as a reduction in trade costs or NTMs, A standard **policy simulation command** for NTM reduction (import efficiency gain) looks like this:

. Shock $ams("i", "r", "s") = 5;$

^{***} Nominal Tariff Rate: The statutory tax rate imposed on the value of imported goods at the border, expressed as a percentage of the import price, without accounting for indirect effects on production costs or value added.

^{§§§} **Effective (Augmented) Imports:** The quantity of imports adjusted for efficiency in the import process, where improvements in trade facilitation (e.g., reduced delays and compliance costs) increase the effective availability of

imported goods for a given physical volume, as captured by import-augmenting technical change (AMS) in CGE models.

^{****} **Actual (Measured) Imports:** The observed physical or monetary value of imported goods recorded in trade statistics, reflecting the real quantity or value of imports entering an economy, without adjustment for efficiency or trade cost factors.

This means, A 5% improvement in trade facilitation for commodity i , in importing region r , From exporting region s .

The total (effective) import demand incorporating ams becomes:

$$qms_{ir} = \sum_{sams} irs \times qm_{(irs)}$$

An improvement in ams shifts the import demand curve outward, since the same world price now yields a higher effective import availability equivalent to a non-tariff barrier reduction.

Simulation experiment

Evaluate the import tariff effect-policy variable “ tms ”. In contrast to exogenous variable, endogenous variables are determined within the model and adjust automatically in response to the policy shocks introduced through the exogenous variables. These endogenous variables include key economic indicators such as commodity prices, sectoral output, trade flows, household consumption, wages, investment, and welfare measures. When the tariff variable (tms) is reduced, the model recalculates the new equilibrium conditions across markets. Lower tariffs reduce the domestic price of imported goods relative to domestically produced goods, which influences consumer demand and production decisions. As a result, imports may increase, domestic production patterns may adjust, and resource allocation across sectors may change. These adjustments ultimately affect welfare through several transmission channels, including Allocative Efficiency (AE^{+++}) improvements, Terms of Trade (TOT^{+++}) effects, and changes in the Investment Savings (IS^{ssss}) balance. This framework enables the model to capture the

broader economy-wide consequences of tariff liberalization.

Evaluate the trade facilitation effect-policy variable ams

In the GTAP model, an ams shock is used to represent improvements in import efficiency associated with reductions in non-tariff barriers. The ams parameter enters the Armington import demand structure as a shift factor that enhances the effective productivity of imported goods. A positive ams shock implies that, for a given level of expenditure, a larger quantity of “effective” imports is obtained, or equivalently, that fewer real resources are required to deliver imports to the domestic market. This captures the effects of trade facilitation measures such as faster customs clearance, reduced documentation costs, and streamlined regulatory procedures. Unlike tariff (tms) shocks, ams does not generate government revenue; instead, it reduces iceberg-type trade costs, thereby lowering the effective price of imports, improving AE and TE , and increasing welfare through more efficient resource use and enhanced competitiveness.

The domestic import ams shock applied in the NEM scenario is calibrated to ensure import neutrality relative to the tariff reduction scenario. Specifically, a 50% reduction in import tariffs results in a modest increase in aggregate import volume of approximately 0.02%. To replicate this outcome through non-tariff channels, an equivalent import efficiency improvement is introduced via an ams shock. Within the GTAP framework, ams represents import-augmenting technical change that reduces the real resource cost of importing. Accordingly, the ams parameter is iteratively adjusted until the resulting increase in aggregate imports matches that observed under the tariff reduction scenario. The simulation results indicate that an

+++ Allocative Efficiency (AE) refers to the extent to which resources are distributed across sectors to maximize total economic welfare, given prevailing prices and policy distortions. In the GTAP model, it captures welfare gains or losses arising from the removal or introduction of taxes and trade distortions, which affect how efficiently resources are allocated in the economy.

+++ Terms of Trade (TOT) refers to the ratio of export prices of a country to its import prices, indicating how many imports can be obtained per unit of exports. In the GTAP model, it reflects

welfare changes arising from price shifts in international trade, where an improvement in TOT increases a purchasing power of a country, and a deterioration reduces it.

ssss Savings and Investment ($S-I$) refers to the balance between national savings and total investment expenditure in an economy. In the GTAP model, it captures welfare effects arising from changes in capital accumulation, returns to investment, and the allocation of global savings, which influence income and long-term economic performance

approximately 8% increase in import efficiency applied to the machinery sector is sufficient to generate a comparable 0.02% expansion in aggregate import volume.

This calibration approach ensures consistency between policy scenarios by aligning their trade volume effects, thereby enabling a meaningful comparison between tariff liberalization and trade facilitation. It also provides a practical interpretation of *ams* shocks as efficiency equivalent policy instruments, where improvements in customs procedures, documentation, and logistics can produce trade outcomes similar to those achieved through tariff reductions.

Policy Scenario 1- TEM: Partial tariff elimination in machinery sector

This scenario simulates a 50% reduction in import tariffs on machinery products imported from Singapore to Sri Lanka. The objective is to assess how partial liberalization in a capital and sectors of technology intensive industries affects import flows, sectoral output, and overall welfare of Sri Lanka

Policy Scenario 2- NEM: Non-tariff elimination in machinery sector

Here, an 8% increase in import efficiency by reducing non-tariff measures is introduced for machinery products from Singapore to Sri Lanka, modeled as an *ams* shock. This scenario captures the potential gains from trade facilitation measures.

The selection of a 50% tariff reduction and an 8% improvement in trade facilitation as policy shocks is grounded in both empirical relevance and practical policy feasibility. First, Sri Lanka has already initiated partial para-tariff reforms most notably the government's decision to reduce the PAL**** by 50% indicating a political and administrative preference for incremental rather than full liberalization. A 100% tariff elimination, while theoretically informative, is rarely implemented in real-world trade policy, particularly in developing economies where tariff revenue remains an important fiscal instrument and where sensitive sectors require gradual adjustment. Therefore, modelling approach of 50% tariff cut provides a realistic and policy-consistent representation of plausible future reforms under the trade relationship between two countries.

An 8% improvement in trade facilitation, operationalized as an *ams* shock, reflects realistic constraints in reducing non-tariff barriers (NTBs). In practice, NTMs such as customs procedures, documentation requirements, technical conformity assessments, and administrative delays cannot be fully eliminated, even in highly efficient economies, due to regulatory obligations and institutional capacity constraints. Empirical evidence suggests that reforms in these areas occur gradually, as governments must balance efficiency gains with safety, quality, and compliance standards (Hoekman & Shepherd, 2019; WTO, 2015).

Table 1. Description of policy scenarios used in the machinery sector analysis

Name of the Scenario		Objective of the simulation
TEM	<i>tms</i>	To evaluate import tariff effect on machinery sector
NEM	<i>ams</i>	To evaluate the non-tariff effect on machinery sector

**** **PAL (Ports and Airports Levy):** A para-tariff imposed on imports in Sri Lanka, charged as a percentage of the CIF (cost, insurance, and freight) value of goods,

functioning as an additional border tax alongside customs duties.

Table 2. Description of base tax rate and post simulation tax rate

Name of the scenario	Policy Variable	Base year rate ^{††††}	Shock value	Post simulation ^{####} rate
TEM	<i>tms</i>	8.42	-50%	4.21
NEM	<i>ams</i>	1.00 ^{§§§§}	8%	1.08

In the context of Sri Lanka, average import clearance and procedural delays range between 75–120 hours, representing a significant implicit trade cost. An 8% reduction in these delays (for example, from 96 hours to approximately 88 hours) captures a moderate yet achievable improvement in border efficiency. This aligns with global evidence indicating that trade facilitation reforms such as customs automation, risk-based inspections, and digital documentation typically reduce processing times by 5–30% in the short to medium term (World Bank, 2018; OECD, 2018). Within the GTAP framework, such improvements are represented as reductions in iceberg trade costs^{*****} through AMS shocks, which increase the effective availability of imports.

Accordingly, the use of an 8% *ams* shock represents a practical and policy-consistent assumption, capturing meaningful but feasible gains in customs performance, regulatory coordination, and border processing. It avoids the unrealistic assumption of complete NTM elimination while remaining consistent with observed reform outcomes under modern trade facilitation initiatives and free trade agreements.

RESULTS AND DISCUSSION

Welfare effects on the Sri Lankan economy under different scenarios

The results presented in the table 3 highlight the welfare effects of two policy scenarios and provide a decomposition into AE, TOT, TE, and IS impacts for both Sri Lanka and Singapore. The analysis suggests that import efficiency exert a substantial positive influence on welfare of Sri Lanka, as measured by the EV. For instance, NEM increases EV of Sri Lanka by approximately US\$ 7.91 million, underscoring the importance of reducing trade costs in capital intensive industrial sectors. Conversely, TEM scenario results in decline US\$ 2.17 million in EV, suggesting that traditional tariff liberalization alone may not yield significant welfare gains, particularly in economies where NTMs and trade inefficiencies dominate overall costs.

Singapore, by contrast, experiences welfare gains under both scenarios, with the most pronounced effect arising from an 8% increase in trade facilitation, which enhances its EV by US\$ 8.97 million. Smaller but positive increases are also observed in other scenarios reflecting already advanced trade facilitation infrastructure of Singapore and the high responsiveness of economy to incremental efficiency gains. These findings are consistent with global evidence, where studies have shown that trade facilitation measures often generate larger welfare gains than tariff reductions, especially for developing economies (Hoekman & Nicita, 2011; Portugal-Perez & Wilson, 2012; WTO, 2020).

^{††††} **Base Rate:** The initial or benchmark value of a variable in the model's base year equilibrium, used as the reference point against which all simulated changes are measured.

^{####} **Post-Simulation Rate:** The value of a variable after the model simulation, reflecting the new equilibrium outcome following the application of policy shocks, measured relative to the base rate.

^{§§§§} **AMS Base Rate:** In the GTAP model, the AMS base rate refers to the initial (benchmark) level of import-augmenting technical efficiency embedded in the database. It is typically normalized to unity (or zero in percentage-change form), implying no initial distortion, and serves as the reference point from which AMS shocks measure improvements in import efficiency

^{*****} **Iceberg Trade Costs:** A modeling concept in international trade where a portion of goods “melts away” during transportation or transaction, meaning that more than one unit must be shipped for one unit to arrive; it represents all trade-related costs (e.g., transport, time delays, administrative barriers) as a proportional loss of goods rather than explicit monetary costs.

Table 3. Welfare decomposition under the tariff elimination and non-tariff elimination scenarios

Scenario	Country	Change in welfare components (USD million)				
		AE	TOT	TE	IS	EV
TEM	Sri Lanka	0.77	-1.01		-1.93	-2.17
	Singapore	0.35	4.55		-0.18	4.83
NEM	Sri Lanka	3.07	-0.71	9.13	-3.58	7.91
	Singapore	0.64	8.66		-0.33	8.97

In terms of AE, both countries record positive changes under all scenarios, though the magnitude is particularly significant for Sri Lanka. NEM yields an AE gain of US\$ 3.07 million. For Singapore, machinery import efficiency enhances AE by US\$ 0.64 million, underscoring the broader benefits of lowering resource misallocation through improved trade logistics and reduced import-related inefficiencies. These results align with findings from Anderson and van Wincoop (2004) and Deardorff (2014), who argue that reductions in trade frictions improve resource allocation by enabling economies to exploit comparative advantages more effectively.

The TOT effect shows divergent outcomes, Sri Lanka experiences negative TOT changes under both scenarios, reflecting its weaker bargaining power and higher vulnerability to external shocks in global markets. This is consistent with Jacks *et al.* (2011), who highlight that smaller, import-dependent economies often face adverse TOT shifts when liberalizing trade.

Regarding the IS effect, results are negative across both scenarios. This suggests that while efficiency gains may free resources for investment, sector-specific liberalization in relatively small markets may not significantly stimulate capital accumulation.

Finally, TE improves substantially in Sri Lanka under machinery import efficiency reforms, reinforcing arguments in the literature that trade liberalization can enhance productivity through greater access to efficient inputs and technology diffusion (Amiti & Konings, 2007).

Increasing import efficiency directly enhances TE within the economy because it reduces the real resource cost of obtaining imported inputs. In many sectors, particularly machinery, chemicals, and intermediate manufacturing, firms rely heavily on imported capital goods, components, and technologies. When the process of importing these inputs becomes faster, cheaper, and more predictable, firms can access higher-quality inputs in a timely manner, avoid production downtime, and reduce unnecessary storage or inventory costs. This improvement in input availability enables firms to produce more output with the same amount of labor and capital, thereby raising TE.

Overall, the results emphasize that import efficiency or trade facilitation reforms, particularly in high-value sectors such as machinery, deliver larger and more sustainable welfare gains for Sri Lanka than tariff elimination alone. For Singapore, while gains are positive across all dimensions, the incremental nature of improvements reflects its already high level of trade efficiency.

Decomposition of allocative efficiency effect of Sri Lanka

The results presented in the table 4 indicate AE gains across policy scenarios, with NTM reductions generating substantially larger improvements than tariff liberalization. Specifically, under import efficiency enhancements modeled through ams shocks, AE increases markedly, reaching US\$ 3.07 million in the NEM. In contrast, the tariff reduction scenario yields only marginal AE gains of US\$ 0.58 million. This disparity reflects the fundamental difference in how

these policy instruments affect resource allocation.

The decomposition further shows that the import tax component contributes significantly to AE under *ams* scenarios, amounting to US\$ 2.17 million. Although *ams* shocks do not directly alter tax rates, they increase import volumes by reducing trade-related inefficiencies, thereby amplifying the welfare gains associated with existing tax distortions. Conversely, under tariff reductions (*tms* shocks), while lower tariffs stimulate import demand, the simultaneous reduction in the tax wedge limits the overall AE gains.

These findings are consistent with the theoretical literature, which emphasizes that reductions in trade costs rather than tariffs alone enhance resource allocation by allowing economies to better exploit comparative advantage and reduce distortionary losses (Anderson & van Wincoop, 2004; Deardorff, 2014; Hertel, 1997). Consequently, trade facilitation measures tend to generate larger AE improvements than conventional tariff liberalization.

Sectoral effect of TOT in Sri Lanka

Both policy scenarios generate negative TOT effects for Sri Lanka. In particular, the machinery-related import tax scenario records the large deterioration in TOT, amounting to approximately US\$ -1.01 million. This adverse outcome is primarily driven by sectoral contributions from textiles (US\$ 0.25 million) and other manufacturing sectors (US\$ 0.39 million), suggesting that decreased import tax in machinery intensifies import demand and lowers export prices relative to import prices. Such effects are consistent with CGE-based trade theory, where tariff liberalization can lead to a relative price decline in exports for small open economies, thereby worsening TOT (Hertel, 1997; Anderson & Neary, 2005).

Similarly, the NEM scenario yields a negative TOT effect (US\$ 0.71 million). Sectoral decomposition reveals that textiles, machinery, and other sectors contribute negatively to TOT. Overall, the findings highlight that trade facilitation reforms may generate welfare gains through efficiency channels, even when TOT effects are unfavorable, particularly in import-dependent economies (Kee *et al.*, 2009; World Bank, 2018).

Table 4. Decomposition of AE tax effect of Sri Lanka under the tariff elimination and non-tariff elimination scenarios

Scenario/Tax	Tax effect (US\$ million)				Total effect
	Import tax	Export tax	Input tax	Product tax	
TEM	0.58	0.07	0.21	0.01	0.77
NEM	2.17	0.05	0.55	0.03	3.07

Table 5. Sectoral effect of TOT under the tariff elimination and non-tariff elimination scenarios in Sri Lanka

Scenario/Sector	Sectoral effect (US\$ million)				Total effect
	Textiles	Other	Machinery	Paper	
TEM	-0.25	-0.39	-0.04	-0.00	-1.01
NEM	-0.18	-0.29	-0.03	-0.04	-0.71

Decomposition of IS effect in Sri Lanka

The decomposition of the IS effect indicates that, both policy scenarios generate negative contributions to welfare through the IS channel in Sri Lanka. Under the TEM scenario, the IS effect is marginally negative (US\$ 1.93 million), driven by decrease in both the price of composite capital goods⁺⁺⁺⁺⁺ (US\$ 0.019 million) and the price of savings^{*****} (US\$ 0.019 million). This suggests a slight deteriorates in the relative return to investment and capital accumulation. Similarly, the machinery imports efficiency (NEM) scenarios exhibit negative IS effects, with both components prices of capital goods and savings declining. The NEM scenario shows the large negative impact (US\$ 0.036 million for each component).

These findings reflect the interaction between trade policy shocks and global capital markets within the CGE framework. Reductions in trade costs or tariffs can lower the price of imported capital goods, which, while beneficial for production, may reduce the value of savings relative to investment, thereby generating negative IS effects (Hertel, 1997; McDougall, 1993). Moreover, in small open economies, increased import demand and shifts in relative prices can weaken the IS balance, particularly when domestic investment does not adjust proportionately (Ianchovichina & Walmsley, 2012). Overall, the evidence suggests that while efficiency improvements can enhance welfare through other channels, their impact on the IS balance may remain limited or negative unless accompanied by supportive macroeconomic and investment policies.

Table 6. Decomposition of IS effect under the tariff elimination and non-tariff elimination scenarios in Sri Lanka

Scenario	Price of composite capital goods	Price of savings
TEM	-0.0190	-0.0190
NEM	-0.036	-0.036

Changes in tax revenue of Sri Lanka

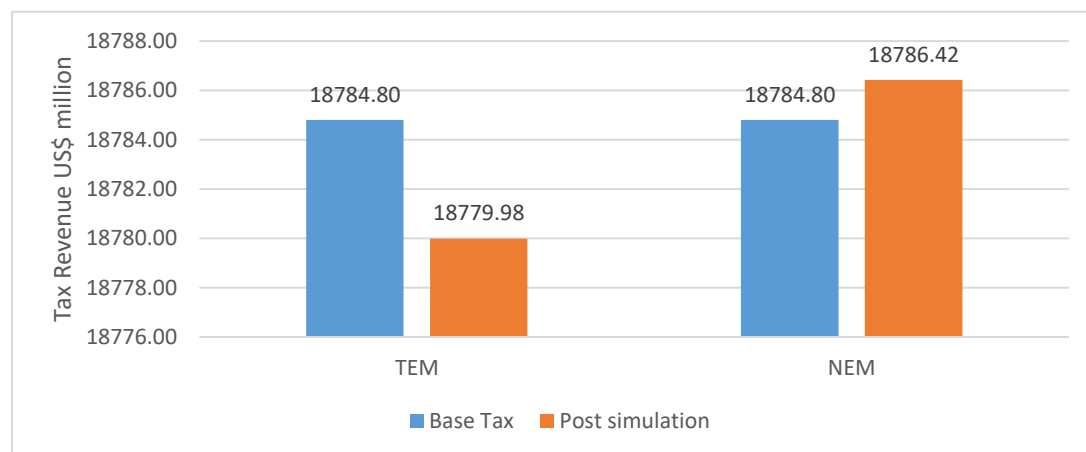


Figure 1: Changes in tariff revenue under the tariff elimination and non-tariff elimination scenarios in Sri Lanka

⁺⁺⁺⁺⁺ **Composite Capital Goods:** An aggregate measure of investment goods in economic models, representing a combination of domestically produced and imported capital goods used to form the total capital stock in the economy.

^{*****} **Price of Savings:** In CGE models such as GTAP, the price of savings represents the cost of mobilizing funds for investment, reflecting the price of the composite capital good and indicating how changes in the economy affect the value of savings used to finance investment.

The results in figure 1 illustrate the fiscal implications of tariff liberalization and trade facilitation across the two simulation scenarios. As expected, partial tariff elimination in both TEM sectors leads to a decline in government tax revenue. Under the TEM scenario, tax revenue decreases from the base value of US\$ 18,784.80 million to US\$ 18,779.98 million. This outcome is consistent with standard trade theory, where reductions in import tariffs directly reduce government revenue derived from border taxes (Anderson & Neary, 2005; Hertel, 1997).

In contrast, improvements in import efficiency through trade facilitation (ams shocks) generate an increase in tax revenue. Under NEM, tax revenue rises to US\$ 18,786.42 million. These gains are driven by the expansion of import volumes resulting from lower trade costs, which enlarges the tax base even in the absence of changes in tariff rates. This finding aligns with empirical evidence suggesting that trade facilitation reforms can enhance revenue collection by improving compliance, reducing evasion, and increasing trade flows (Portugal-Perez & Wilson, 2012; World Bank, 2018).

Overall, the results indicate that while tariff reductions may weaken fiscal revenues in the

short run, efficiency-enhancing reforms can offset these losses by stimulating trade and broadening the effective tax base.

Changes in aggregate export

Table 7 presents the export performance of Sri Lanka and Singapore under two distinct simulation scenarios, highlighting the role of import efficiency improvements and tariff liberalization in shaping trade outcomes. The results indicate that enhancements in import efficiency within the machinery sector generate positive, albeit modest, effects on aggregate exports in both economies. Specifically, exports from Singapore are projected to increase by approximately 0.003%, while exports of Sri Lanka expand by 0.026%. This outcome reflects the critical role of imported machinery as intermediate inputs that enhance production efficiency, support technological upgrading, and promote export diversification an effect widely documented in the literature on trade and productivity (Amiti & Konings, 2007; Athukorala, 2017).

Similarly, the simulation results show that the TEM leads to marginal improvements in export performance for both countries. Under this scenario, exports of Sri Lanka increase by 0.036%, while exports of Singapore rise by

Table 7. Percentage changes in aggregate exports under the tariff elimination and non-tariff elimination scenarios

Country/Scenario	% Changes in aggregate exports	
	TEM	NEM
Sri Lanka	0.036	0.026
Singapore	0.001	0.003

Table 8. Percentage changes in industry output under the tariff elimination and non-tariff elimination scenarios

Country/Scenario	% Changes in industry output	
	TEM	NEM
Sri Lanka	0.0130	0.035
Singapore	0.0015	0.003

0.001%. These relatively small gains suggest that, although tariff reductions lower input costs and improve market access, the overall export response remains limited. This is consistent with existing empirical evidence indicating that the effectiveness of tariff liberalization is often constrained by non-tariff barriers, structural rigidities, and limited absorptive capacity within domestic industries (Hoekman & Shepherd, 2015).

Changes in industry output of Sri Lanka

The simulation results (Table 8) demonstrate that NEM has the potential to enhance the industrial output of country by 0.035% in Sri Lanka, underscoring the critical role of efficient trade facilitation in supporting industrial development. Notably, both scenarios examined in the analysis reveal a positive effect on industrial output in both Sri Lanka and Singapore, though the magnitude of these effects varies. The findings highlight that reducing trade-related inefficiencies can stimulate industrial performance by lowering input costs, improving access to intermediate goods, and fostering competitiveness (Anderson & van Wincoop, 2004; Hoekman & Nicita, 2011).

Overall, the results are consistent with empirical evidence suggesting that trade facilitation measures often deliver greater industrial benefits than tariff reductions alone, particularly in developing economies where behind the border barriers impose significant trade costs (Shepherd, 2016; Deardorff, 2014). For Sri Lanka, these findings underscore the importance of prioritizing policies that improve import efficiency in key industrial sectors as a means of boosting output and enhancing long-term industrial competitiveness.

Changes in market price

The simulation results (Table 9) highlight the differential effects of tariff elimination and import efficiency improvements on market prices in Sri Lanka and Singapore. NEM reduces domestic prices of Sri Lanka level by approximately 0.036%, underscoring the role of efficiency reforms in lowering consumer

costs. In contrast, the same policy exerts a slight positive effect on market prices of Singapore, reflecting structural asymmetries such as differences in market size, reliance on imported intermediates, and absorption capacity.

TEM yields only minor price effects, with a 0.019% reduction in Sri Lanka and no measurable impact in Singapore. These findings resonate with the broader literature on price pass through, which emphasizes that efficiency driven reforms deliver stronger and more immediate consumer benefits than tariff liberalization, particularly in developing economies with high border costs (Anderson & van Wincoop, 2004; Hoekman & Nicita, 2011; Shepherd, 2016). For Sri Lanka, where welfare is highly sensitive to import prices, such efficiency gains carry significant policy implications, while Singapore's limited responsiveness reflects its already advanced trade infrastructure. Overall, the evidence suggests that targeted efficiency reforms in key sectors represent a more effective policy instrument than tariff reductions for lowering market prices and enhancing consumer welfare.

Effect on GDP of Sri Lanka

This study evaluates three measures of GDP within the GTAP framework: real GDP (qGDP), value GDP (vGDP), and the GDP price index (pGDP), which together capture quantity, value, and price effects of policy shocks (Hertel, 1997). The results indicate (Table 10) that improvements in import efficiency generate stronger real output gains than tariff reductions. Specifically, under the machinery tariff scenario, qGDP increases marginally by 0.001%, whereas the NEM produces a substantially larger increase of 0.015%.

In contrast, vGDP records negative changes in both scenarios TEM (-0.016%), NEM (-0.001%). A comparable trend is observed for pGDP, where values decline under TEM (-0.012%) and NEM (-0.016%). These results suggest that while trade facilitation enhances real economic activity, it may simultaneously reduce price levels, reflect lower production and import costs. Such findings are consistent

Table 9. Percentage changes in aggregate market price under the tariff elimination and non-tariff elimination scenarios

Country/Scenario	% Change in market price	
	TEM	NEM
Sri Lanka	-0.019	-0.036
Singapore	0.001	0.002

Table 10. Percentage changes in GDP in Sri Lanka under the tariff elimination and non-tariff elimination scenarios

GDP/Scenario	% change in GDP	
	TEM	NEM
qGDP	0.001	0.015
vGDP	-0.016	-0.001
pGDP	-0.012	-0.016

with the literature, which highlights that efficiency gains from trade facilitation primarily affect real output, while price adjustments may offset nominal GDP changes (Anderson & van Wincoop, 2004; Hoekman & Nicita, 2011).

POLICY IMPLICATIONS

The policy implications of this study follow directly from the empirical findings, which demonstrate that trade facilitation captured through reductions in non-tariff barriers generates substantially greater economic benefits for Sri Lanka than tariff liberalization alone. First, policymakers should prioritize the reduction of the most binding non-tariff barriers, particularly customs delays, complex documentation requirements, licensing procedures, and overlapping regulatory processes. These constraints significantly increase trade costs and limit the gains from existing trade relationship. Strengthening customs modernization, digitalizing trade procedures (e.g., single window systems), and improving inter-agency coordination would yield immediate efficiency gains.

Second, reforms should be strategically targeted toward high-impact sectors such as machinery, where improvements in import efficiency produce the largest gains in welfare, industrial output, and export performance. Facilitating faster clearance, adopting international standards, and reducing

duplication in testing and certification processes can enhance productivity and competitiveness in these sectors.

Third, the results suggest that trade facilitation can also improve fiscal outcomes by expanding the import base, thereby offsetting revenue losses associated with tariff reductions. This highlights the importance of sequencing reforms, where tariff liberalization is complemented by efficiency-enhancing measures to sustain both economic growth and government revenue.

Finally, the findings underscore the need for a dual policy approach under the trade relationship gradual tariff reduction combined with comprehensive non-tariff reforms. Investments in logistics infrastructure, regulatory harmonization, and institutional capacity building are essential to fully realize the benefits of trade integration. Overall, prioritizing import efficiency improvements will enable Sri Lanka to enhance welfare, strengthen global competitiveness, and achieve deeper integration into regional value chains.

CONCLUSIONS

The findings of this study provide clear evidence that the welfare and trade impacts of the Sri Lanka-Singapore trade relationship are driven more by non-tariff reforms than by tariff liberalization. By comparing tariff elimination and trade facilitation effects in the

machinery sectors, the analysis shows that an 8% improvement in import efficiency generates substantial welfare gains for Sri Lanka, whereas equivalent tariff reductions produce marginal or even slightly negative effects. Allocative efficiency emerges as the primary driver of welfare improvements, with significantly larger gains under trade facilitation in the machinery sector supported by increased import volumes and improved resource allocation. In addition, technical efficiency gains further reinforce these positive outcomes, offsetting the negative effects observed in terms of trade and investment-savings components.

The results also demonstrate that trade facilitation enhances fiscal and macroeconomic performance. Unlike tariff reductions, which reduce government revenue, efficiency improvements expand the tax base by increasing imports, thereby raising tax revenue in the machinery sector. Moreover, trade facilitation significantly boosts aggregate exports, and industrial output in Sri Lanka, while tariff liberalization yields only modest improvements. Market prices decline more substantially under trade facilitation, reflecting reduced trade costs and improved consumer welfare. Similarly, real GDP (qGDP) increases markedly under efficiency gains, with the strongest effect observed in the machinery sector.

For Singapore, welfare gains are positive across all scenarios, with larger effects under trade facilitation, although the magnitude is smaller due to its already advanced trade system.

Overall, the results highlight that targeted trade facilitation reforms particularly in capital and technology intensive sectors are more effective than tariff reductions in enhancing welfare, competitiveness, and economic performance. This underscores the importance of prioritizing non-tariff barrier reduction as a central component of trade policy in Sri Lanka.

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COMPETING INTERESTS

The authors declare that there are no competing interests.

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