DOI: http://doi.org/10.4038/sjae.v21i1.4637 *SJAE, Vol.21, No.1, 2020*

The Impact of Non-Tariff Measures on Sri Lankan Tea Trade: A Bayesian Inference of the Gravity Model

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ABSTRACT

Sri Lankan tea industry is confronting the danger of losing key markets on the grounds of exceeding the Maximum Residual Levels (MRLs) in chemicals permitted by the European Union. This study assesses the impact of Non-tariff measures on Sri Lankan tea exports because of MRLs stipulated for the pesticide, Endosulfan. This study employs a Bayesian version of the Gravity equation using a Multi-level Mixed Model, because of the additional advantages that Bayesian analysis provides. Panel data from 2003 to 2017 for fourteen prime destinations of Ceylon tea were considered for this study. The estimated coefficient of MLR for Endosulfan suggests that a 1% increase in the regulatory stringency on Endosulfan (tighter restrictions on pesticide) can result in a 0.67% (approximately US$ 8,907,708.15 in 2020) decrease and a 1% increase in the tariff rate is prompt to a 0.03% (approximately US$ 398, 852.60 in 2020) decline in the value of tea exports. Compared to the tariff, the MRL is associated with a higher impact on trade. Therefore, the negative impact of MRLs is found to outweigh the impact of import tariffs, highlighting the greater role that non-tariff measures play.

Keywords: *Bayesian analysis, Gravity model, Maximum Residual Level, Multilevel mixed model, Non-tariff measures, Tea exports*

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Introduction

Non-Tariff Measures (NTMs), for example, sanitation norms, especially Sanitary and Phytosanitary (SPS) measures have become a great barrier to trade in food and agricultural products throughout the world. Whilst traditional trade barriers such as average tariff rates for agricultural products have been declining over the past decade, the SPS measures and other Technical Barriers to Trade (TBT) have increasingly become stringent. The global average tariff rates for agricultural products declined from 14.6% to 10.8% between 1996 and 2009, whereas the number of SPS notifications for agricultural products (HS01-HS24) expanded extensively from 136 in 1996 to 564 in 2009 all over the world (Wei et al., 2012). The increasing number of stricter SPS notifications shows that food safety standards have become a trade barrier for the exports of food and agricultural produce to developed nations in the present trading condition. Furthermore, these stricter SPS standards might negatively affect the producers or exporters in developing countries. Forcing an import ban, restrictively expanding production and marketing costs, or divert trade from one trading partner to another by setting down guidelines are such barriers that separate across potential suppliers or prompting cost accelerations or raise boundaries for every potential supplier (Petrey & Johnson, 1993; Thilmany & Barrett, 1997; Roberts, 1998). Importing countries have the power to inhibit trade if the exporting countries do not satisfy the importing country's regulations.

Non-tariff measures are characterized as policy measures that influence international trade other than through the application of tariffs (UNCTAD, 2013). Sanitary and phytosanitary measures and TBT are two major non-tariff mechanisms, and there were 688 SPS and 801 TBT measures initiated or in force in 2003, which increased to 1,195 SPS and 1,622 TBT measures in 2014 (Hwang & Lim, 2017). As of August 2016, 14,123 SPS measures and 21,399 TBT measures have been notified to World Trade Organization. Further, Asia is the region most affected by bilateral SPS (282), followed by Latin America and the Caribbean (276). Moreover, Asia imposed the highest number of TBT (4,948) followed by Europe (2,337) (Kang & Ramizo, 2017). The increased NTMs may be related to a higher demand for safe food from high-income countries (Okello & Roy, 2007) measures intended to protect human health (i.e., SPSs) account for 52% of total NTMs. The remaining 48% are export-related measures (17%), price control measures (12%), TBT (12%), and pre-shipment inspections (7%) (UNCTAD, 2017). As per the standards of the World Trade Organization (WTO), governments are permitted to apply SPS measures to secure human, animal, and plant health and TBT to protect the environment or certify the quality. Additionally, governments have the right to either specify the SPS measures via their regulations or to follow international standards. The World Trade Organization's SPS agreement specifies procedures and criteria for the assessment of risk and determination of appropriate SPS protection levels.

Hence, SPS measures can block and restrict the trade of agricultural products, especially affecting developing countries that cannot satisfy restrictive regulations because of lower technology, awareness, and capital (Disdier et al., 2008; Crivelli & Gröschl, 2012; UNCTAD, 2013). According to the evidence of recent studies, food safety standards have significantly affected exports of agricultural commodities from developing to developed countries. For instance, Wilson and Otsuki (2004), revealed that a 10 percent increase in restrictions via pesticide (Chlorpyrifos) regulations leads to a 16.3 percent decrease in banana imports. Furthermore, about US$ 7 billion worth of Chinese exports were affected by SPS and TBT measures in 2001(Chen et al., 2008). In early 2002, the European Union (EU) started to ban imports of Chinese animal-derived food, seafood, and aquatic products. As a result of that, during the second half of the year 2002, there was a 70 percent slump in China's aquatic product exports (Findlay et al., 2008). Moreover, around 90 percent of China's foodstuff exporters, domestic produce, and animal by-products were affected by foreign technical trade barriers and endured losses totaling US$ 9 billion in 2002 (Chen et al., 2008). This indicates the negative impact of stringent SPS measures on agricultural exports of the developing countries that rely on the exports of agricultural commodities.

The Maximum Residual Level (MRL) is the most used general standard for measuring the impact of non-tariff measures on agricultural products. According to the World Trade Organization's SPS agreement, MRLs set limits especially for food products that contain harmful substances such as fertilizers, pesticides, chemicals, and heavy metals. Controlling the harmful substances in food products is the main reason behind setting these MRLs. Most of the countries follow the Codex or establish their regulations. Exporting countries that already have stricter MRLs compared with the importing countries can easily compete with the importing countries' MRLs. In 2002, with the tightening of the MRLs of the pesticide Chlorpyrifos in spinach from 0.1 ppm to 0.01ppm, Japan blocked imports of frozen spinach worth around US$ 30 to US$ 35 million, which accounted for 99 percent of Japan's annual imports (40,000 to 50,000 mt) of spinach from China after finding the pesticide residues (Chen et al., 2008).

Tea is the world's second most popular beverage and one of the major agricultural commodities traded worldwide. Tea is subjected to international food safety standards, global harmonization of MRLs by regional regulations, and international organizations, including Codex Alimentarius, and the EU. Pesticide MRLs in tea is recognized as a major non-tariff barrier since the 1990s (FAO, 2016). To address that matter, 'Working Group on MRLs in Tea' was established by the Food and Agriculture Organization in 2005 and helps to fix or harmonize MRLs at a realistic level (Hwang & Lim, 2017). In the EU's case, Murina and Nicita (2017) found that 17 different types of SPS measures harmed low-income countries' exports of tea, coffee, and spices by more than US$ 600 million in 2010. Trade disruptions for these products were the largest among the 21 agricultural products covered by the study. Wei et al. (2012) revealed that China’s tea exports have been considerably influenced by the MRLs of pesticides (Endosulfan, Fenvalerate, and Flucythrinate) imposed by importing countries. In addition, this study found that a 1% increase in the regulatory stringency (ppm) on Endosulfan and Fenvalerate (tighter restriction on the pesticide) can lead to a 22% decrease in tea export from China.

Sri Lankan Tea Trade and Pesticide MRLs

Sri Lanka with 150 years of excellence in the tea industry has played an important role in terms of its contribution to the national output, employment generation, and net foreign exchange earnings from its origin in 1867. Sri Lanka is the world’s fourth-largest producer of tea and the third-highest valued tea exporter in the world in 2018. The tea export earnings account for two percent of Sri Lanka's GDP. Also, Sri Lanka accounted for 12.1% of global tea exports (Sri Lanka Export Development Board, 2020).

Sri Lanka remains a key producer of superior quality tea in the global tea arena. However, its competitive global position is eroding nowadays. In line with other commodities, the prices of tea declined substantially in the world market. The position was aggravated as the fall in prices coincided with the turmoil faced by markets such as Russia, the Middle East, and Ukraine, which accounts for over 65% of exports of Ceylon Tea (Sri Lanka Tea Board, 2015). The overall performance of this industry was affected by economic sanctions, currency depreciation, and war followed by geopolitical uncertainties. Sri Lanka’s exports thus declined from 289.59 kg million in 2019 to 285.09 kg million in 2020, a 1.55 % decrease in volume (Figure 1). The lowest tea export quantity (271.77 kg million) was recorded in 2018. Further, this was a decrease of 15.09 kg million or 5.2% compared to the year 2017.

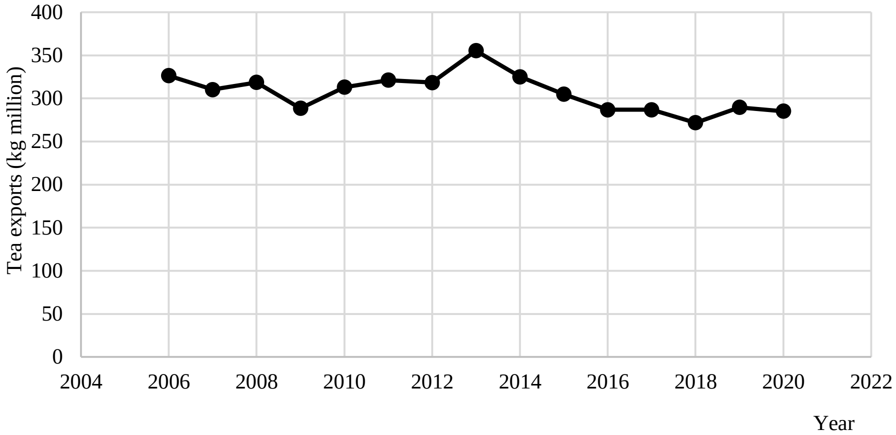

Figure 1: Tea export quantities from Sri Lanka (kg million) for the period of 2004 – 2022 (Source: Annual International Trade Statistics - UN Comtrade)

Even though the lowest tea export quantity was recorded in the year 2018 due to the rejection of several tea shipments, considerably high export earnings (US$ 1.425 billion) were recorded compared to 2019. Export earnings in 2020 totalled US$ 1.33 billion as against US$ 1.32 billion in 2019 (Figure 2).

According to the recent findings, Sri Lanka's tea industry is facing a risk of losing a key market for its high and medium grown teas as tea exports to Japan remain close to zero during the year 2018 amid Japanese authorities rejected several tea shipments worth approximately one LKR billion (Fernando, 2018). Exceeding the default residual level imposed by Japanese authorities on 2-methyl-4-chloro phenoxy acetic acid (MCPA), a widely used substitute weedicide by planters to Glyphosate was the main reason behind these tea export rejections. Following the discovery of MCPA in tea export for the first time, the Japanese authorities imposed a default maximum residue level (MRL) of 0.01 ppm for MCPA in 2017 as a temporary measure before completely banning the chemical until they come up with a standard MRL. This will have a negative impact on future tea exports and the goodwill of Ceylon tea. If Sri Lanka loses the Japanese market, the average prices will come down drastically. Meanwhile, European tea importers, especially Germany, have rejected several tea shipments from Sri Lanka on the grounds of exceeding the MRLs in chemicals allowed by the EU (Fernando, 2018). In addition, residue levels for Diuron, another weedicide used by Sri Lankan tea cultivators due to the ban on the use of Glyphosate have been tightened by the EU. Therefore, the prevailing situation of the Sri Lankan tea industry raised red signals to the Sri Lankan tea trades in the current trading environment.

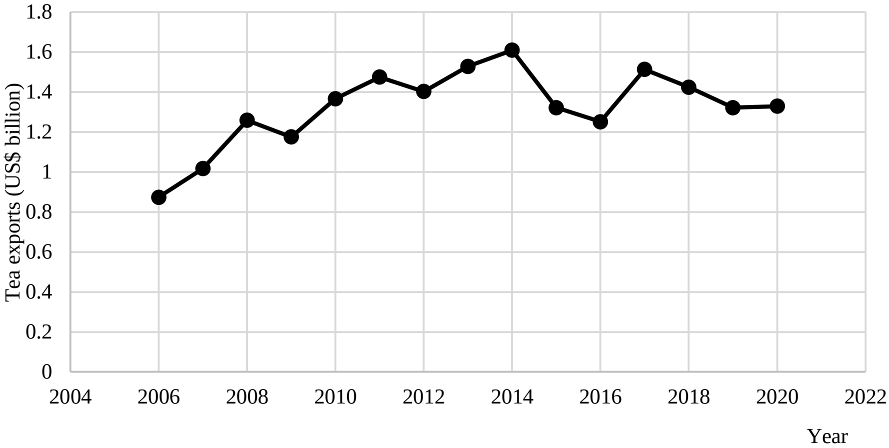

Figure 2: Value of tea exports from Sri Lanka (US$ billion) for the period of 2004 – 2022 (Source: Annual International Trade Statistics – UN Comtrade)

The influence of NTMs on the Sri Lankan tea trade by giving special attention to MRLs is scarce in the literature. In this background, it is prudent to evaluate the possible impacts of MRLs and agrochemicals commonly used in tea production in Sri Lanka, because it will have a severe repercussion on tea exports if importing countries continue to stipulate such MRLs. Therefore, this study will add value to the existing literature by attempting to quantify the impact of MRLs on Sri Lankan tea exports by using a Bayesian version of the Gravity equation. Further, the findings will also enable policymakers to identify the need of addressing the causes of these potential threats to safeguard the Sri Lankan tea trade.

The remainders of the paper are organized as follows. The next section of this paper outline the econometric model and model estimation. Section 3 describes the data and data sources and data analysis using Bayesian Estimation. The Results and Discussion are described in section 4 followed by conclusions at the end.

Methodology

Econometric Model

Mixed-Effects Models

Both fixed effects and random effects are categorized under the mixed-effects models (Shoari and Dubé, 2017). The fixed effects are estimated directly and correspond to standard regression coefficients. The random effects are not directly estimated (although they may be obtained post estimation) but are summarized according to their estimated variances and covariances. Random effects may take the form of either random intercepts or random coefficients, and the grouping structure of the data may consist of multiple levels of nested groups. As such, mixed-effects models are also known as multilevel models and hierarchical models (STATA Reference Manual, 2013).

Linear Mixed-Effects Models

Kohli et al. (2015) stated that mixed-effects models for continuous responses, or linear mixed-effects models, are a generalization of linear regression which allows the presence of random deviations. In matrix notation,

$$\mathbf{y} = \mathbf{X\beta} + \mathbf{Zu} + \boldsymbol{\varepsilon} \qquad (1)$$

Where, **y** is the $n \times 1$ vector of responses, **X** is an $n \times p$ design/covariate matrix for the fixed effects **β**, and **Z** is the $n \times q$ design/covariate matrix for the random effects u. The $n \times 1$ vector of errors **ε** is assumed multivariate normal with mean 0 and variance matrix $\sigma_{\varepsilon}^{2}\mathbf{R}$.

Pinheiro and Bates (2000) described that the fixed portion of (1), **Xβ**, is analogous to the linear predictor from a standard Ordinary Least Square regression model with **β** being the regression coefficients to be estimated. For the random portion of (1), **Zu**+ε, it was assumed that **u** has variance-covariance matrix **G** and that **u** is orthogonal to ε so that

$$Var\begin{bmatrix}\mathbf{u}\\ \varepsilon\end{bmatrix} = \begin{bmatrix}\mathbf{G} & 0\\ 0 & \sigma_{\varepsilon}^{2}\mathbf{R}\end{bmatrix}$$

The random-effects (**u)** are not directly estimated (although they may be predicted) but instead are characterized by the elements of **G**, known as variance components, that are estimated along with the overall residual variance $\sigma_{\varepsilon}^{2}\mathbf{R}$ and the residual-variance parameters that are contained within **R** (STATA Reference Manual, 2013).

In clustered-data situations, it is convenient not to consider all *n* observations at once but instead to organize the mixed model as a series of *M* independent groups (or clusters)

$$\mathbf{y_i} = \mathbf{X_j}\boldsymbol{\beta} + \mathbf{Z_j}\mathbf{u_j} + \boldsymbol{\varepsilon}_\mathbf{j} \quad (2)$$

Where, $j = 1, \ldots, M$, with cluster j consisting of n_j observations. The response $\mathbf{y_j}$ comprises the rows of y corresponding with the j^{th} cluster, with $\mathbf{X_j}$ and ε_j defined analogously. The random-effects $\mathbf{u_j}$ can now be thought of as *M* realizations of a $q \times 1$ vector that is normally distributed with mean 0 and $q \times q$ variance matrix Σ (STATA Reference Manual, 2013).

Model Estimation

The vast majority of the empirical literature on the trade effects of non-tariff measures (NTMs) is based on gravity equations (Li & Beghin, 2012). In the context of the Sri Lankan agri-food trade, Sandaruwan et al. (2020) most recently investigate the changes in the structure of NTMs imposed by importing countries on Sri Lankan seafood products and to determine the effects of NTMs on seafood exports from Sri Lanka using a gravity model. Further, Karandagoda et al. (2014) analyzed the possibility of food safety and quality standards acting as a non-tariff barrier vis-à-vis global tea trade, and against major tea exporting nations, with particular focus on the ISO 22000 food safety metasystem and the food safety standards associated with the Maximum Residue Levels (MRL) using the Gravity Model approach. Therefore, the gravity model is used for this research to estimate the impact of SPS measures on Sri Lankan tea export by stipulating MRLs for Endosulfan, which is used frequently as a pesticide for tea production.

The size of bilateral trade flows between any two countries can be approximated by the "gravity equation" by analogy with Newton's universal law of the theory of gravitation (WTO, 2012). According to Tinbergen (1962), the gravity model of bilateral trade flows between the two countries is proportional to their Gross Domestic Product (GDP) and inversely related to the geographical distance between them. The basic gravity model given below was first proposed by Tinbergen (1962):

$$E_{ij} = R\frac{Y_i^{\beta_1} Y_j^{\beta_2}}{D_{ij}^{\beta_3}} \tag{3}$$

$$\ln E_{ij} = \beta_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 D_{ij} + \varepsilon_{ij} \tag{4}$$

Where; E_{ij} monetary value of tea exports from exporting country *i* to importing country *j*. Y_i and Y_j are the respective economic sizes (GDPs) of the two countries, D_{ij} is the geographical distance between the two countries, and *R* is the constant of proportionality. This non-linear function was linearized by taking natural logarithms (equation 4) to enable estimation.

The detailed model used in this research is as follows:

$$\ln E_{ijt} = \alpha_0 + \alpha_1 \ln GDP_{it} + \alpha_2 \ln GDP_{jt} + \alpha_3 \ln Dist_{ij} + \alpha_3 \ln POP_{it} + \alpha_4 \ln POP_{jt}$$
$$+ \alpha_5 \ln MRL_{jt} + \alpha_6 \ln(tariff_{ijt} + 100) + \alpha_7 D_{GAT_{jt}} + \varepsilon_{ijt} \tag{5}$$

Where, *i* denotes the exporter of tea (Sri Lanka), *j* denotes the importer of tea, and *t* is the trading year. In equation (5) α_m denotes the coefficients of the input variables; E_{ijt} is the real monetary value of tea exports from Sri Lanka (exporting country *i*) to importing country *j* in year *t; GDP_{it}* and GDP_{jt} are the real GDP of the exporting country (Sri Lanka) *i* and importing country *j* in year *t* respectively. The GDP of Sri Lanka and the GDP of importing country *j* are used as the mass factor in the gravity model in this study. The importing country's GDP captures the purchasing power and the market size of the importing country, simply the demand-side effect for tea. This mass factor is expected to have a positive effect on Sri Lankan tea export. The variable, $Dist_{ij}$, denotes the geographical distance between the importing country *j* and exporting country *i* (Sri Lanka) in kilometers. Variables POP_{it} and POP_{jt} denote the population of the exporting country (Sri Lanka) *i* and the population of the importing country *j* respectively. MRL_{jt} denotes the maximum residual level imposed by the importing country *j* for the pesticide Endosulfan in tea; $tariff_{ijt}$ denotes the most favoured nation (MFN) applied tariff instituted by the importing country *j* for exporting country *i* (Sri Lanka) in percentage (percent). We included tariff barriers in the gravity equation to distinguish the impact of non-tariff barriers on trade from that of tariffs. Because there are zero tariffs in several countries, 100 is added to the original tariff value, $tariff_{ijt}$ following Wilson and Otsuki (2004). MRL_{jt} and $tariff_{ijt}$ are used as resistance factors in the model. The notation *D* denotes the dummy variable whilst $DGAT_{it}$ denotes the importing country is a member of GATT/WTO.

Data and Data Sources

Panel data from 2003 to 2017 were used for the analysis. In a panel, country-pair heterogeneity can be controlled by using country-pair fixed effects. This study collected data from several sources. Table 1 summarizes the description of the data and data sources used in this analysis. Fourteen prime destinations for Ceylon tea (Iraq, Turkey, Russia, Iran, United Arab Emirates, Azerbaijan, Syria, China, Chile, Japan, Germany, Saudi Arabia, USA, and the UK) were considered for this study. The dependent variable (*Eijt*) is the monetary value of tea exports from Sri Lanka to an importing country in 2010 constant US dollars specified by the HS code 0902. Geographical distance between the two countries, GDP of the exporting country (Sri Lanka) and importing countries, population of the exporting country (Sri Lanka) and importing countries, GATT/WTO membership of the importing country, tariff instituted by the importing countries, and MRL imposed by the importing country for the pesticide Endosulfan were considered as explanatory variables of this study.

Table 1: Description of the data and data sources

Variable name	Description	Data source
Exports (E_{ijt})	The monetary value of tea exports (HS code-0902) from Sri Lanka to an importing country in 2010 constant US dollars.	United Nations Commodity Trade Statistics Database (COMTRADE) of the United Nations Conference on Trade and Development (UNCTAD).
Distance ($Dist_{ij}$)	Bilateral distance between the capital cities of Sri Lanka and the importing countries in kilometers (km).	Institute for Research on the International Economy (CEPII).
Population-exporter (POP_{it}) Population-importer (POP_{jt})	Exporting country's (Sri Lanka) population and Importer countries' population.	Institute for Research on the International Economy (CEPII).

Table 1 contd…: Description of the data and data sources

Variable Name	Description	Data Source
GDP-exporter (GDP_{it}) GDP-importer (GDP_{jt})	Gross Domestic Product of the exporting country (Sri Lanka) and Gross Domestic Product of Importer countries. GDP data were adjusted into real values using GDP deflator values at 2015 constant US dollars.	Institute for Research on the International Economy (CEPII).
GATT-import ($D_{GAT_{it}}$)	Dummy variable used to indicate whether importing countries were members of GATT trade agreement.	World Trade Organization website.
MRLs (MRL_{jt})	Maximum Residual Level imposed by the importing country for the pesticide Endosulfan in tea measured in ppm.	Codex database, USDA MRL database, and each country's respective national government regulatory agency.
Tariff average (%) ($tariff_{ijt} + 100$)	Tariff data for tea (HS code is 0902) are the MFN applied duties instituted by the importing country j on tea from Sri Lanka in percentage terms.	Trade Analysis Information System (TRAINS) of the UNCTAD for WITS.

Table 2 summarizes the descriptive statistics of the variables used in the analysis.

Table 2: Descriptive statistics of the variables

Variable	Mean	SD	Min	Max
Exports (in 2010 constant US$)	$5.830*10^{7}$	$5.540*10^{7}$	706345.200	$2.430*10^{8}$
Distance (km)	6979.324	3699.513	3289.130	15884.590
Population-exporter	20.369	0.631	19.173	21.444
Population-importer	165.785	334.756	3.369	1386.000
GDP-exporter (GDP deflator values in 2015 constant US$)	$5.460*10^{10}$	$2.140*10^{10}$	$2.400*10^{10}$	$8.540*10^{10}$
GDP-importer (GDP deflator values in 2015 constant US$)	$2.790*10^{12}$	$4.500*10^{12}$	0.000	$1.890*10^{13}$
GATT-import	0.662	0.474	0.000	1.000
MRLs (ppm)	21.572	9.884	0.010	30.000
Tariff average (%)	23.29175	46.77479	0.000	145.000

Data Analysis

Bayesian Estimation

This study employs a Bayesian version of the gravity equation, because of the additional advantages that Bayesian analysis provides. It assumes that the population parameters of the model have a distribution rather than a point estimate, and these distributions of parameters of interest can be simulated using Markov Chain Monte Carlo (MCMC) sampling. The properties of these distributions can be used to make probabilistic statements about the parameters. This kind of analysis enables the use of prior information and predicts outcomes. In the Bayesian econometric framework, a posterior distribution of parameters of interest is obtained using the likelihood (data) and a prior distribution as (Turner and Shederberg, 2014);

$$\pi(\boldsymbol{\theta}/\mathbf{y}) = \frac{f(\mathbf{y}/\boldsymbol{\theta})\pi(\boldsymbol{\theta})}{m(\mathbf{y})} \tag{6}$$

$$\pi(\boldsymbol{\theta}/\mathbf{y}) \propto f(\mathbf{y}/\boldsymbol{\theta})\pi(\boldsymbol{\theta}) \tag{7}$$

The notation $\boldsymbol{\theta}$ is the unknown quantity of interest (parameter vector), **y** is observed data; $f(y|\boldsymbol{\theta})$ denotes the data generating model; $\pi(\boldsymbol{\theta})$, is the prior $\pi(\boldsymbol{\theta}|y)$ denotes the posterior distribution. This model allows specifying the prior distribution, $\pi(\boldsymbol{\theta})$ using information contained in previous work and related economic theories. This allows a more 'updated' version of the posterior, which incorporates prior information about the parameters of the model. The use of Bayesian methods has an additional advantage over sampling theory where predictive distributions will be available for inference.

Bayesian multilevel models estimate random effects together with other model parameters. Multilevel models are more difficult to simulate because of the existence of high-dimensional random-effects parameters. They typically require longer burn-in periods to achieve convergence and larger MCMC sample sizes to obtain precise estimates of random effects and variance components.

Because of the limited knowledge in parameters of the regression model, normal priors with a mean 0 and a precision of 10,000 were used for all model parameters except for tariff. Since the tariff is expected to have a negative impact a priori, the posterior distribution of the parameter for the tariff was censored above zero using a uniform prior whose upper limit was set to zero. Then the computer was set to sample sequentially from the distributions until convergence is achieved and the convergence was assessed by observing trace plots.

Results and Discussion

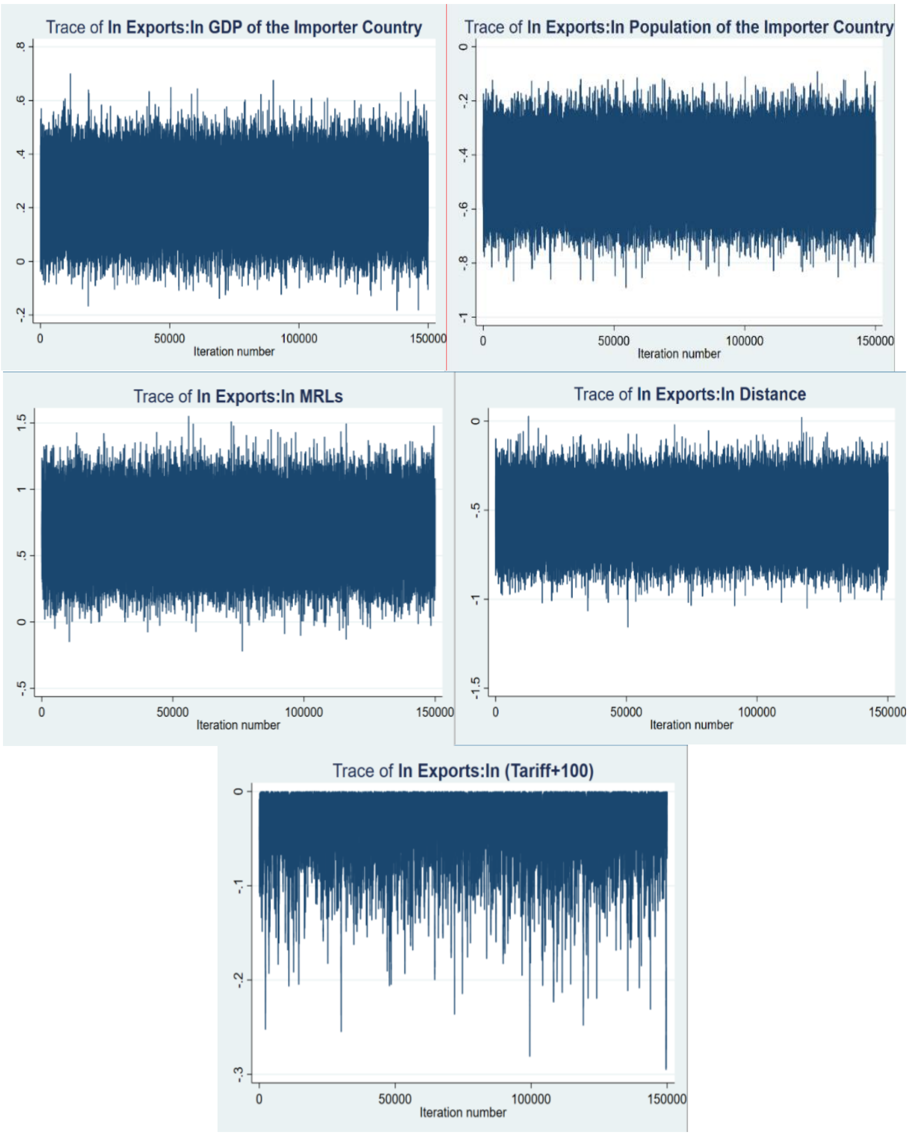

Figure 3: Trace plots for significant regression parameters in gravity model

The Metropolis-Hasting sample was iterated 150,000 times with 10,000 iterations discarded as 'burn-in' to remove any impact of the starting values given to initiate the Markov chain. The convergence of the Markov Chain needs to be verified to make inferences about the estimated parameters. To do this, trace plots were observed (Figure 3). There was no increasing or decreasing pattern (or wide fluctuations) in the trace plots of the variables ln*GDPjt*, ln*POPjt*, ln*Distij*, ln*MRLjt*, and ln(*tariffijt+100*), and they are distributed around the mean value of each parameter estimated. Therefore, convergence has occurred.

Posterior Means and Significance of Coefficients

The results of the gravity model estimation for the Sri Lankan Tea Exports are reported in Table 3 where posterior means of coefficients, standard deviation, and their significance level are reported.

Table 3: Posterior means of the gravity model

Variable	Mean	SD	Equal-tailed credible interval	
			5%	95%
$\ln GDP_{jt}$	0.241*	0.093	0.057	0.425
$\ln GDP_{it}$	0.972	0.547	-0.099	2.040
$\ln POP_{jt}$	-0.467*	0.090	-0.644	-0.289
$\ln POP_{it}$	0.452	6.932	-13.159	14.002
$\ln Dist_{ij}$	-0.539*	0.121	-0.776	-0.300
$\ln MRL_{jt}$	0.676*	0.188	0.307	1.047
$\ln(tariff_{ijt}+100)$	-0.033*	0.033	-0.122	-0.001
$D_{GAT_{it}}$	0.132	0.487	-0.828	1.085
α_0	-10.093	9.762	-29.340	9.174

*=significant at 5 percent level (p=0.05). Note: - Importing Countries' Gross Domestic Product (GDP), - Exporting country's GDP, -Importing countries' population, - Exporting country's population, - Geographical distance between importing country and Sri Lanka, - Maximum Residual Levels imposed by importing country on Endosulfan, - tariff instituted by importing country, - GATT/WTO membership of the importing country.

Results of the gravity model show that importing country's GDP (GDP_{jt}), importing country's population (POP_{jt}), geographical distance between the importing country and Sri Lanka ($Dist_{ij}$), maximum residual levels imposed by the importing country for the pesticide Endosulfan (MRL_{jt}) and the tariff instituted by importing country ($tariff_{ijt}+100$) to be significantly affecting the monetary value of Sri Lankan tea exports (E_{ijt}), because the 95% credible intervals do not include zero. The estimated coefficient for importing country's GDP (GDP_{jt}) is positive. It reflects that rising incomes in importing countries increase the countries' demand for tea from Sri Lanka. The coefficients of the exporting country's GDP *(GDP_{it})* and population of the exporting country/ Sri Lanka *(POP_{it})* have positive signs but are not statistically significant. Distance *($Dist_{ij}$)* and tariff *($tariff_{ijt}+100$)* yield negative and statistically significant coefficients, implying that increases in distances *($Dist_{ij}$)* and tariffs *($tariff_{ijt}+100$)* are expected to increase the trading costs of countries. In other words, tariffs *($tariff_{ijt}+100$)* show that higher rates of tea import tariffs are associated with lower exports of tea from Sri Lanka.

Contrary to our expectation, $DGAT_{jt}$ or the GATT/WTO, membership of the importing country was not significant. Normally, trade agreements facilitate trade and have a positive impact on tea exports. Nevertheless, according to this study, the variable $DGAT_{jt}$ gave the correct sign indicating the positive relationship but was not statistically significant.

The results revealed that expected signs were received for all the estimated parameters except for the population of the exporting country *(POP_{it})* variable. However, the other two parameters, GDP of the exporting country *(GDP_{it})* and GATT/WTO membership of the importing country *($DGAT_{jt}$)* gave the expected positive signs but were not statistically significant because the 95% credible interval included zero. The following histogram shows the distribution of the coefficient of the $\ln GDP_{it}$ parameter (Figure. 4).

The X-axis in the histogram is the value of the coefficient. Observation of the histogram in Figure 4 shows that the majority of the mass is to the right of zero. Since the area under the curve gives probability, the probability of the coefficient value becomes more than zero can be easily calculated by calculating the area to the right of zero. This is the probability of the coefficient being positive although the credible interval included zero. Table 4 reports these estimates, probability values, standard deviations, and associated MCMC standard errors of the posterior probabilities of the parameters $\ln GDP_{it}$ and $DGAT_{jt}$.

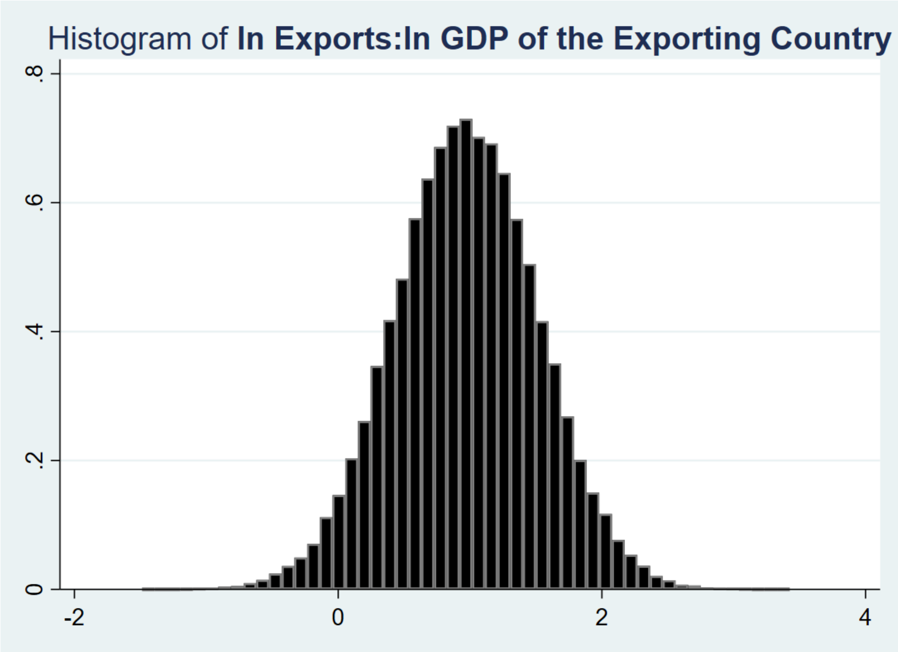

Figure 4: Histogram of the coefficient distribution of the parameter in GDP of the exporting country

Table 4: Posterior probabilities of the parameters

Variable	Probability	Standard Deviation	Standard Error (MCSE)
Probability of coefficient of $\ln GDP_{it}$ >0	0.963	0.190	0.001
Probability of coefficient of $D_{GAT_{it}}$ >0	0.610	0.488	0.002

This means that the probability of the coefficient of lnGDP_{it} being more than zero is 0.96. It means there is a 96% chance that this value is positive and not zero, although the credible interval included zero. Therefore, the parameter lnGDP_{it} can also be considered significant. Furthermore, Sri Lanka's GDP (GDP_{it}) was used as the mass factor in the model. This factor captures the supply-side impact on tea exports from Sri Lanka. Therefore, Sri Lankan tea exports increase with the increase in the GDP of Sri Lanka.

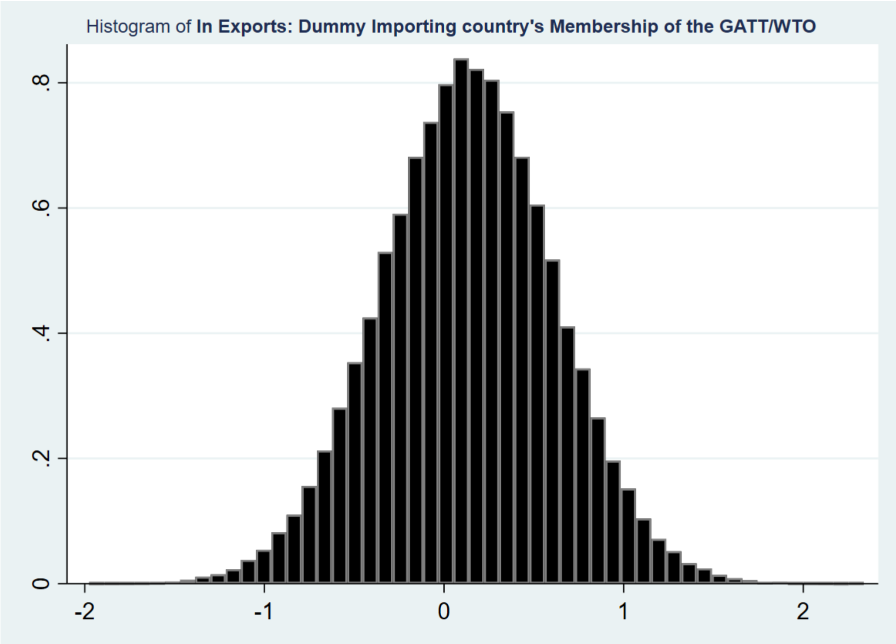

Figure 5: Histogram of the coefficient distribution of the parameter importing country's membership of the GATT/WTO (dummy)

Figure 5 shows that zero comes to the middle of the histogram of DGAT_{jt} and according to the results of Table 4, there is a slightly over 60% chance to get a positive value for the coefficient of the DGAT_{jt} parameter. This finding reflects that trade agreements or the GATT/WTO membership of the importing countries facilitate the tea trade between Sri Lanka and the other trading partners considered in this study.

The most important results, given the goal of the paper, the positive sign and statistical significance of MRL for Endosulfan support the hypothesis that tea safety standards are important factors that have affected Sri Lanka's tea exports. This finding is consistent with Wei et al. (2012). For example, the estimated coefficient of MRL suggests that a 1% decrease in the MRL for Endosulfan (lower the ppm value) can result in a 0.67% (approximately USD 8,907,708.15 in 2020) decrease in Sri Lanka's tea export. As expected, tariffs are shown to have a negative impact on Sri Lankan tea exports. That is, a 1% increase in the tariff rate is found to have led to a 0.03% percent (approximately USD 398, 852.60 in 2020) decrease in the value of Sri Lankan tea export. In comparison with the tariff effect, the MRL is associated with a bit higher trade effect for Sri Lankan tea exports. Additionally, Hwang and Lim, (2017) conducted similar research to evaluate the impacts of differences in SPS measures for the tea trade between 79 exporting countries and 78 importing countries from 1996 to 2015 by designing an index of differences in MRLs for the pesticide Endosulfan. The finding of Hwang and Lim, (2017) is consistent with the findings of this study, but contrary to our findings, by comparison with the tariff effect, the MRL difference index was associated with a bit lower trade effect.

These results show that Sri Lankan tea exports drop when importing countries set stricter standards. This negative impact of MRLs is found to be more than import tariffs, implying that NTM acts as a trade barrier for Sri Lankan tea export. According to literature, NTMs tend to hinder agri-food trade (e.g., Gebrehiwet et al., 2007; Ferro et al., 2013; Ferro et al., 2015). Further, as for specific types of NTMs, more frequently the literature concludes that MRLs are barriers to trade (e.g., Otsuki et al., 2001a, b; Wilson & Otsuki 2004; Scheepers et al., 2007). Further, in another study that specifically focused on the tea trade, Yue et al. (2010) found that stricter pesticide residue standards would bear severe negative implications on the trade in developing countries and particularly would lead to a considerable decrease in their exports. Findings of this study also evident that interestingly, even when all variables were included in the model, most of them have the expected signs, and many of them are statistically significant.

Conclusions

Although Sri Lanka is the world's fourth-largest producer of tea and the third-highest value-added tea exporter in the world, it has been observed a declining trend in the tea export growth rate since 2014. The SPS notifications on Sri Lanka's exports, particularly with developed countries such as Japan and some countries in the EU have been emerging. The objective of this paper is to assess the impact of tea safety standards on Sri Lanka's tea exports. To achieve this objective, a gravity model was used to examine the impact of tea safety standards adopted by 14 of Sri Lanka's major tea importers between 2003 and 2017. The results indicate that the MRL of the pesticide Endosulfan, imposed by importing countries has significantly affected Sri Lanka's tea exports. A 1% increase in the regulatory stringency (lower the ppm value) on Endosulfan (tighter restrictions on the pesticide) can lead to a 0.67% decrease in tea export from Sri Lanka. Although tariffs on tea remain an important factor that affects Sri Lanka's tea exports, the MRLs of certain pesticides can significantly limit Sri Lanka's tea exports rather than tariffs because the impact from stricter MRLs is larger than the impact from tariffs. Specifically, Japan and the EU have been expanding the categories and numbers of pesticides regulated over time. These policy changes have largely contributed to the decrease in the growth rates of

Sri Lanka's tea export since 2014. These findings conclude that increasing tighter restrictions from developed countries for food safety standards will be detrimental to developing countries like Sri Lanka and will confront more prominent difficulties in exporting food products. By contrast, an existing pattern of inter-industry trade implies Sri Lankan tea faces a tougher standard in certain destinations, including Japan, which sets a lower MRL benchmark and this will damage the loyalty of the Ceylon tea and the quality of Ceylon tea. Accordingly, there is an urgent need for regulatory policies to address the causes of this potential threat to safeguard Sri Lanka's tea sector.

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