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DOES A LONG-RUN RELATIONSHIP EXIST BETWEEN TRADE OPENNESS AND CARBON DIOXIDE EMISSIONS IN SRI LANKA?

Sarojini Maheswaranathan[1+]
Thangamani Bhavan[2]

[1,2]*Department of Economics, Faculty of Commerce and Management, Eastern University, Sri Lanka.*
[1]*Email: maheswaranathans@esn.ac.lk Tel: +94774371659*
[2]*Email: bhavant@esn.ac.lk Tel: +94777066326*

(+ Corresponding author)

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ABSTRACT

In recent years, the process of globalization has provided a great deal of support to international trade, which has led to the increase in global trade volume. However, as far as the negative characteristics of international trade flows are concerned, the extensive production and trade needed to meet global demands have led to higher energy consumption and higher carbon dioxide (CO_2) emissions. Sri Lanka has been trading since 1977, so the objective of this study is to investigate the existence of the relationship between trade and carbon dioxide emissions in Sri Lanka. Using annual time series data running from 1980 to 2014, this study employs Johansen's cointegration method for econometric analysis. The findings of the study derived from the analysis revealed that the intended variables are likely to move together in the long run. The study suggests that reprocessing emissions, pollution prevention actions, and the introduction of low carbon technology in trade can mitigate carbon dioxide emissions.

Contribution/Originality: The negative consequences of openness of trade in Sri Lanka have not been widely discussed in the literature. The focus of this study on the negative characteristics of trade and how much trade openness affects the environment in Sri Lanka is a valuable addition to the existing literature on trade.

1. INTRODUCTION

Trade openness under globalization settings has witnessed significant positive impacts on the economic performance of countries that have been actively involved in international trade and the global economy. The countries may have experience in poverty eradication, employment generation, potential resource utilization, improving the balance of payments, and attracting foreign direct investment with the involvement in international trade (Koffi, Gahé, & Ping, 2018; Okenna & Adesanya, 2020; Shahbaz, Shafiullah, Papavassiliou, & Hammoudeh, 2017). However, the negative characteristics of international trade cannot be avoided, and these issues have already been debated in a wide range of literature. Since the economic activities undertaken to drive economic development unavoidably hinder the environmental quality (Nemat, 1994), the impact of trade openness on environmental quality has become one of the most debated topics in recent years because environmental quality is seen as one of the indicators to assess economic development (Chuzhi & Xianjin, 2008). The huge increase in the world merchandise trade is driving growth in production and the establishment of infrastructure, manufacturing, and industrial entities.

This necessitates the simultaneous establishment of an efficient transportation network, which results in negative consequences regarding the quality of the environment, especially the release of carbon dioxide (He & Wang, 2012).

However, some scholars do not agree with the findings of an adverse impact of trade on environmental quality; based on empirical evidence and the application of the Kuznets theory, they believe that good economic performance, including trade, is positively associated with good environmental performance (Al-Tuwaijri, Christensen, & Hughes Ii, 2004). For instance, several studies have already discussed that environmental quality initially reduces because of industrial and transport activities and then starts to improve after a threshold level, while per capita income improves in developed and emerging economies (Goodness & Edoja, 2017; Peters & Hertwich, 2007). Nevertheless, timely updated studies regarding the relationship between emissions and trade are needed by taking developing and small economies into account.

From a wide range of literature surveyed with regard to addressing the association between CO_2 emissions and export, it is evident that there was little research conducted, except the study by Athula (2011), which was carried out a long time ago. Since there is no recent study in the literature, the findings of this study may offer a valuable contribution.

1.1. CO_2 Emissions and Export in Sri Lanka

Sri Lanka opened its borders to facilitate international trade in 1977. It concentrated on export-oriented industrialization and promoted trade with various policy implications to promote its significant productions, such as textiles and clothing, tourism, telecommunication, shipping refined petroleum, construction, tea processing, rubber, and spices (Sriyani, 1991). However, next to the oil industry, the apparel industry is responsible for around 10% of the world's carbon emissions, which is the primary foreign revenue source in the industrial sector of Sri Lanka (Muthukumarana, Karunathilake, Punchihewa, Manthilake, & Hewage, 2018). Meanwhile, according to the Ministry of Power and Energy's 2012 report on Sri Lanka, the transport sector is a significant contributor to greenhouse gas (GHG) emissions and accounts for a 48% share of all fossil fuel combustion. Therefore, unavoidably, all measures taken to promote international trade, and the progress of the supporting services, likely discharge significant CO_2 emissions into the environment in Sri Lanka.

The trends of CO_2 emissions (metric tons per capita) and export volume as a percentage of GDP in millions, as shown in Figure 1, are growing in Sri Lanka. Since Sri Lanka cannot also be an exceptional country escaping from the negative consequences of trade openness and inadequate empirical investigations in the literature in this area (Athula, 2011), it is vital to investigate the association between the performance of trade and emissions to add new knowledge to the existing literature.

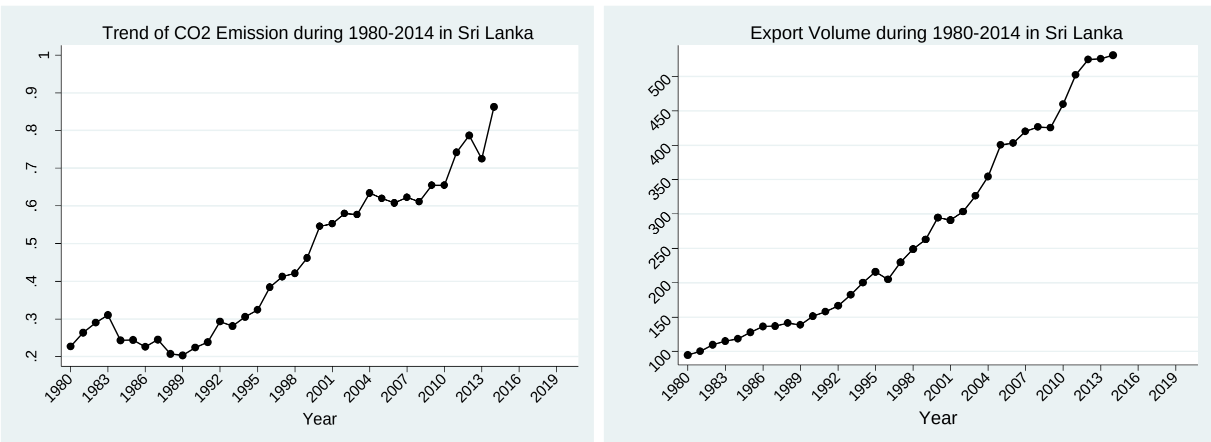

Figure 1. The trends of CO_2 emissions and export volume in Sri Lanka (1980–2014).

2. LITERATURE REVIEW

Growing empirical literature has already opened up a discussion about the association, impact, and causes between trade openness and emissions (Wang & Zhang, 2021). Some scholars argue that international trade growth degrades environmental quality, whereas some findings try to prove that economic development may solve the environmental issue as per capita income passes the threshold level. Nasir and Rehman (2011) have also endorsed a positive effect of trade openness on carbon emissions in the long run for Pakistan, whereas Salah-Uddin, Bidisha, and Ozturk (2016) considered the long-run association between carbon emissions, energy consumption, trade openness, and economic growth in Sri Lanka between 1971 and 2006. They confirmed the existence of a long-run causal relationship between economic growth and carbon emissions. Rahman, Saidi, and Mbarek (2020) investigated the impact of population density, CO_2 emissions, and trade openness on the economic growth of five South Asian countries from 1990 to 2017. The results of the cointegration tests show the existence of a long-run equilibrium link between the variables, and causality test results show bidirectional causality between trade openness and CO_2 emissions. Nasir and Rehman (2011), Farhani and Ozturk (2015), and Shahbaz, Nasreen, Ahmed, and Hammoudehe (2016) also found a positive association between trade openness and carbon emissions in the long run, indicating that an increase in trade openness causes an increase in environmental pollution. Wen, Mahmood, and Zakaria (2020) examined the impact of trade openness on pollution in China through wavelet coherence analysis and causality tests using annual time series data from 1982 to 2016. They revealed that trade openness increased exports by increasing the scale of industries, which, in turn, has increased pollution in the country. Further, researchers confirmed that trade openness causes carbon emissions in the short, medium, and long runs by applying the spectral domain causality test. Cheon, Nataliia, Yoo, and Hwang (2019) investigated the consequences of trade openness on the environment using the Kuznets curve hypothesis, a two-equation model, instrumental variable techniques, and GLS analysis for CIS countries from 2000–2013. The findings show that trade openness directly increases CO_2 emissions and indirectly decreases per capita income. Ertugrul, Cetin, Seker, and Dogan (2016) evaluated the relationship between carbon dioxide (CO_2) emissions, trade openness, real income, and energy consumption in the top ten CO_2 emitting countries (China, India, South Korea, Brazil, Mexico, Indonesia, South Africa, Turkey, Thailand and Malaysia) from 1971–2011. The findings showed the existence of a long-run relationship in Thailand, Turkey, India, Brazil, China, Indonesia, and Korea. The level of carbon emissions is determined by real income, energy consumption, and trade openness. The existence of causal relations among the variables in Turkey, India, China, and Korea validated the EKC hypothesis.

Variations from the above findings are observed in some studies as they do not reveal a long-run relationship between carbon emissions and trade openness. Athula (2011) studied the relationship between carbon emissions and trade openness for Sri Lanka from 1960 to 2006 and found the existence of a short-run relationship but not a long-run equilibrium relationship or long-term causality between trade openness and carbon emissions. Similarly, Sin-Yu and Iyke (2019) examined the effects of trade openness on carbon dioxide emissions for a sample of 17 Central and Eastern European (CEE) countries over the period from 1994 to 2014 by using a composite trade share measure of trade openness. The study concluded that high trade openness is associated with low carbon emission in the long run, and high openness is associated with high emissions in the short run.

Zhang, Liu, and Bae (2017) investigated the existence of a hypothetical environmental Kuznets curve (EKC) in terms of how trade openness affects CO_2 emissions together with real GDP and total primary energy consumption on a sample of ten newly industrialized countries (NICs-10) from 1971 to 2013. The findings confirm that the existence of a hypothetical EKC indicates that trade openness negatively and significantly affects emissions, while real GDP and energy have positive effects on emissions. Zhang et al. (2017) also suggested, based on their findings, that expansion of trade openness not only reduces CO_2 emissions but also enhances growth. Similarly, Wang and Zhang (2021) investigated the heterogeneous effects of trade openness on carbon emissions using data from 182 countries from 1990 to 2015. They found that trade openness decreased carbon emissions in high-income and uppermiddle-income countries but has no significant impact on the carbon emissions of lower-middle-income countries. Further, they confirmed that the heterogeneous effects of trade openness on carbon emissions indicate that trade openness positively impacts the decoupling of economic growth from carbon emissions in rich countries but negatively impacts developing countries. Shahbaz et al. (2016) investigated the relationship between trade openness and CO_2 emissions by incorporating economic growth as an additional and potential determinant of this relationship for three groups of 105 high-, middle-, and low-income countries from 1980–2014. They employed panel cointegration tests and found that trade openness delays environmental quality in various countries. The causality findings concluded that there is a feedback effect between trade openness and carbon emissions at global level and the middle-income countries, but trade openness Granger causes CO_2 emissions for the high-income and low-income countries.

From the above literature, the association between trade openness and CO_2 emissions is diverse and inconclusive. The findings vary based on the time period, method of data analysis, and categories of the countries, which are based on per capita income and possible technology factors. Since there is no study incorporating recent trends of trade and emissions in the case of Sri Lanka, this study investigates the association between trade and emissions by incorporating recent data.

3. METHODOLOGY

3.1. Data and Variables

The time series data covers the period from 1980 to 2014 for five variables-carbon dioxide emission (CO_2), trade openness, energy consumption, foreign direction investment (FDI) and economic growth—and were extracted from the World Bank Development Indicators (WDI) database. Table 1 contains a summary of the statistics of the variables.

Table 1. Summary of the variables' statistics.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
CO_2 Emissions	34	0.445	0.198	0.203	0.862
Export	34	29.463	5.703	19.553	39.037
Electric Power Consumption	34	269.35	142.16	94.773	531.091
Gross Domestic Product per capita	34	1146.35	1029.49	267.669	3819.25
Foreign Direct Investment	34	0.270	0.299	0.02	0.96

3.2. Empirical Model and Method

The econometric model specification employed in the study is as follows:

$$lnCO_{2t} = \beta_0 + \beta_1 lnEX_t + \beta_2 lnEC_t + \beta_3 lnFDI_t + \beta_4 lnGDP_t + \epsilon \quad (1)$$

Where $lnCO_2$ is the logarithm of carbon dioxide emissions per capita in metric tons; *lnEX* is the logarithm of export as a percentage of GDP, which serves as a proxy variable for trade openness; *lnEC* is the logarithm of electric power consumption in kilowatts per capita; *lnFDI* is the logarithm of foreign direct investment inflow in billions of US dollars; and *lnGDP* is the logarithm of GDP per capita in US dollars. ϵ is the error term and t is time.

3.3. Unit Root Analysis

First, the stationary properties of the variables were tested by performing the augmented Dickey–Fuller (ADF) unit root test because most time series data contain unit root problems that can lead to spurious results. Thus, the stationary properties at their level and integrated orders need to be carefully investigated to move to the next level of data analysis with the appropriate method.

Table 2 shows the results of the unit root analysis. According to the results, the null hypothesis cannot be rejected, and all variables are non-stationary at their level and become stationary at the first difference *I(1)*. The AIC, SBIC, and HQIC suggest the lag length to be (0). In the second step, the analysis employs Johansen's maximum likelihood estimator of the parameters of the cointegrating vector error correction model (VECM) to analyze the existing dynamic long-run relationship among the variables.

Table 2. ADF test results.

Variable	Test Statistic at Level	Test Statistic at First Difference	Order of Integration
lnCO₂	-0.071 (0.9523)	-5.887 (0.0000)	I(1) ***
lnEX	-0.490 (0.8940)	-4.474 (0.0002)	I(1) ***
lnEC	-0.774 (0.8266)	-6.021 (0.0000)	I(1) ***
lnGDP	1.662 (0.9979)	-4.807 (0.0001)	I(1) ***
lnFDI	-1.670 (0.4464)	-7.721 (0.0000)	I(1) ***

Note: *** indicates the level of significance at 1%; p-values are in parentheses.

4. EMPIRICAL FINDINGS

Table 3 sets out the results of Johansen's cointegration analysis. In the results, the value of the trace statistics at r = 0 of 77.5439 exceeds the critical value of 68.52, which recommends that the null hypothesis of no cointegration cannot be rejected. However, for the trace statistics at r = 1, the critical value of 42.5871 exceeds the trace statistic of 42.58, which concludes that the null hypothesis is rejected, suggesting that there is cointegration among the variables with the detection of a long-run association.

Table 3. Johansen test for cointegration.

Maximum Rank (r)	Parameters	LL	Eigen value	Trace statistic	5% critical value
0	55	138.284	0.0	77.543	68.52
1	64	155.763	0.676	42.587*	47.21
2	71	164.868	0.444	24.376	29.68
3	76	171.500	0.348	11.112	15.41
4	79	175.465	0.225	3.182	3.76
5	80	177.056	0.097	0.0	0.0

Note: * $p < 0.1$.

The elasticity values of the respective variables are depicted in Table 4. The results are transferred to Equation 1, reversing the sign as per Johansen's technique as follows:

$$lnCO_{2t} = 0.075 + 1.228lnEX_t + 0.997lnEC_t - 0.218lnFDI_t + 1.212lnGDP_t$$

Table 4. Normalized cointegration coefficients.

Variable	Coefficient	Std. Err.	T-Value	P-Value
lnCO₂	1	-	-	-
lnEX	-1.228	0.337	-3.64	0.000
lnEC	-0.997	0.649	-1.53	0.125
lnFDI	0.218	0.050	4.33	0.000
lnGDP	-1.212	0.362	-3.35	0.001
cons	0.075	-	-	-

All variables, except electricity consumption, are statistically significant at the 1% level. As our prime concern is to investigate the relationship between emissions and trade, the results conclude that there is a significant long-run positive association between emissions and trade in Sri Lanka. Every 1% increase in export in Sri Lanka is positively associated with emissions by 1.23%.

Table 5 describes the results of Johansen's error correction model, which implies the adjustment parameters in the error correction model, which is the speed of adjustment towards long-run equilibrium.

Table 5. Error correction model.

Variable	D_dlnco2	D_dlnec	D_dlnex	D_dlngdp	D_dlnfdi
Coefficient	-0.777***	0.103	0.158	0.192	-4.908***
Standard Error	0.228	0.128	0.178	0.174	2.066
T-Value	-3.41	0.81	0.89	1.10	-2.38

Note: *** indicates significance at the 10% level.

4.1. Diagnostic and Stability Test for Cointegration

Diagnostic tests are undertaken to check the feasible modeling errors. The outcomes of the Lagrange multiplier test confirm that the model residues have no serial correlations. The normality test also concludes that the model residues have a normal distribution by kurtosis, Jarque–Bera, and skewness, as shown in Table 6. The Eigenvalue stability also confirmed the stability of the model, as shown in Figure 2. The Eigenvalues confirm that none of the residual Eigenvalues in the matrix seems near to the unit circle. Thus, the results of this study are not inspired by inconsistencies and survive multiple specifications, permitting the detection of the association with great accuracy.

Table 6. Diagnostic test results.

Diagnostic Test	P-value
LM (2) Lagrange multiplier test for autocorrelation at lag order	0.481
Normality Test	
Skewness	0.413
Kurtosis	0.194
Jarque–Bera	0.260

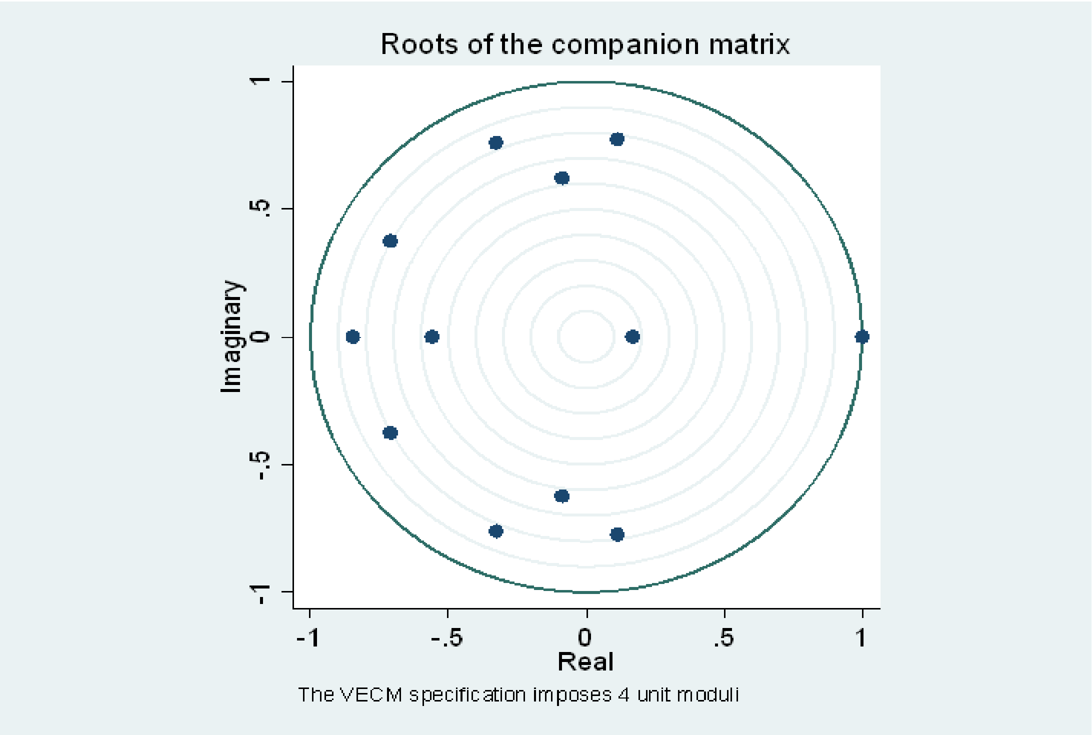

Figure 2. Stability test for cointegration among the variables.

5. DISCUSSION AND CONCLUSION

The objective of this study was to investigate the existence of a long-run relationship between trade openness and CO_2 emissions in Sri Lanka from 1980–2014. First, the stationary properties of the variables were tested by employing the augmented Dickey–Fuller (ADF) unit root technique. Based on the time series properties of the variables, the cointegrating vector error correction model (VECM) was employed to test the existence of a long-run relationship. The study found a long-term relationship between export, proxied trade openness, and carbon dioxide emissions in Sri Lanka. Diagnostic tests also confirmed the association with great accuracy among the variables. The results derived from the study are not consistent with the findings of Athula (2011) who found no long-run relationship between trade and emissions, but aligned with the findings of Salah-Uddin et al. (2016). The rationale may well be due to the variation in the time period covered and the performance of trade in Sri Lanka because the trend of CO_2 emissions per capita in Sri Lanka started to increase rapidly during the 1990s and has been continuing with a steady upward trend, which was flatter in movement until 1992.

The reason behind the increase in CO_2 emissions and export in Sri Lanka's case is conceivably historical. Sri Lanka introduced a trade liberalization policy in 1977 as the first country in South Asia to open for trade and subsequently experiencing export progress. This trade liberalization was embedded in production, transport network, and consumption along the supply chain. It triggered industrialization in the country with a historical experience in industrial growth and export orientation (Athukorala, 2006). Industrialization and trade expansion have an apparent direct influence on the environment by the development of transport networks, significant energy consumption, and degradation of natural resources. Since the industrial sector usually demands more electricity, countries such as Sri Lanka experienced an intense rise in electricity usage from 1998 through 2004 (Ram, Anandarajah, & Liyanage, 2009) while also operating coal-fired power plants. Salah-Uddin et al. (2016) found that fossil fuel consumption, massive destruction of natural resources resulting from fast industrialization, and increasing integration to the outside of the world with the export of goods and services were reported in the case of Sri Lanka. The author also supported the findings of a rise in the trade-to-GDP ratio, which contributed to the high demand for energy and carbon emissions in Sri Lanka. Trade liberalization will likely develop pollution-intensive activities if the country has no effective environmental-related policies. So far, Sri Lanka has not been well prepared to be more environmentally integrated in terms of trade with more incentives for environmental standards. This may result from the high performance of trade with low environmental pollution.

At this juncture, sound policies are required to have a sustainable external sector in the country. Specific policies are needed and that can be derived among renowned policy instruments to mitigate CO_2 emissions, including carbon taxes, cap-and-trade systems, energy efficiency standards, emission standards, incentives for renewable energy sources, feebates, and regulatory guidelines. However, the challenges lie in balancing production emission levels as it may travel in opposite directions regarding the objectives, and deep emission cuts will affect export-oriented industries in countries like Sri Lanka. However, some effective policies have already been suggested by some scholars based on their empirical works. Peters and Hertwich (2007) suggested a policy approach to adjust emission inventories for trade, whereas (Gao, Gao, Yin, & Zhang, 2021) proposed a low-carbon transformation of foreign trade strategies and implementation of close environmental supervision while expanding international trade. Nabernegg, Bednar-Friedl, Muñoz, Titz, and Vogel (2019) discussed consumption-based and production-based policy designs, which can be implemented in trade-based activities. In this line, Lin and Sun (2010) found that production-based emissions in China are greater than consumption-based emissions and are required to have policies in the area of energy price reforms and the introduction of renewable energy. Chen, Wang, and Zhong (2019) also supported renewable energy consumption as one of the best solutions to reduce trade-based emissions.

However, the carefully designed policies should be comprehensive, cost-effective, and transparent. Policymakers for Sri Lanka have to drive more specific policy instruments because the emissions resulting from trade is determined by several factors, such as the size of the economy, sectoral composition in trade, the level of participation in the global value chain, the modes of transportation used in imports and exports, the energy used in production systems, and the intention to mitigate pollution.

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