Interrelationships among Trade Openness, Foreign Direct Investment and Environmental Pollution: A study on Selected Developing Countries of the World

Sujata Deb Roy
Ph. D. Scholar, Department of Economics, Vidyasagar University, Midnapore, India
E-Mail: sujatadebroy@gmail.com

Joydeb Sasmal
Retired Professor of Economics
Department of Economics, Vidyasagar University, Midnapore, India,
E-Mail: joydebsasmal@yahoo.co.in

Ramesh Chandra Das
(Corresponding author)
Professor of Economics
Department of Economics, Vidyasagar University, Midnapore, India
E-Mail: ramesh051073@gmail.com

Abstract

In the recent years, environmental quality is degrading over time due to adoption of several economic policies across the world, especially in developing countries. Rising magnitudes of trade openness (TRO) and international capital flow in terms of foreign direct investment (FDI) are the major ones out of them. The growth impacts of these policies are well known to many countries. Besides, there are rising pollution levels in terms of different pollutants as the by-product of these liberalization policies. Under the backdrop, the present study examines the relationship among FDI, trade openness and CO2 emission in 26 developing nations with upper- as well as lower-middle income levels. The study finds long-run stable relationship among the three in four countries, namely Argentina, Jordan, Russia and Thailand. The estimated vector error correction model shows that the long-run causality runs from FDI and TRO to CO2 in Argentina, Jordan and Russia. The Block Erogeneity test results for the countries having no such long run relationships show a set of mixed outcomes. The different short-run causal relations are per capita FDI to per capita CO2, per capita TRO to per capita CO2, combined per capita FDI and TRO to per capita CO2, per capita CO2 to per capita FDI etc.

***Keywords**: FDI, Trade Openness, CO2, Cointegration, Causality, developing countries*

1. Introduction

With the internal resource constraints and population pressure international trade has been a panacea to growth and development of many countries in the world. The world output has increased tremendously in the last several decades leading to increase in the per capita output and aggregate employment as well. Besides all these good effects, there has been increasing magnitudes of environmental degradation which has led to several natural disasters. Though the worlds so called developed countries of the west were mainly responsible for those ill effects due to their early participations in international trade activities, the emerging economies of the world are now occupying the major trade share and thereby becoming the significant contributor to the natural disasters. The developed economies are offering foreign direct investments to the emerging economies which are mainly dirty in nature. The emerging economies, having their prime focus upon growth of income, have accepted these dirty capital flows as the important input of production. The emerging/developing countries are thus treated as the pollution havens. Hence, there must be an interrelationship among trade volume, foreign capital flow and environmental degradation in the emerging economies. The present study intervenes in this area.

In the present era, environmental quality is depredating over time as the result of adoption of several developmental economic policies across the world. The bundle of globalisation, liberalisation, capital outflow and inflow are the remarkable part of any emerging economy in the new era. The economy is impacted by trade openness and foreign direct investment (FDI) in both positive as well as negative ways. FDI is a crucial component of trade liberalisation. Due to the transfer of dirty industries from advanced countries to LDCs without care of environmental standards as a result of liberalisation, the environmental degradation is on the rise. On the other hand, trade liberalisation increases employment opportunities, raising living standards in LDCs. In addition, a rise in FDI involves the transfer of knowledge and technology from developed to LDCs. Therefore, liberalisation has both positive and negative effects on the economy.

Today, environmental unsanitariness is seen as one of the most significant problems facing policymakers in emerging nations. Growing levels of economic activity and competition to world market over time made the pollution issue worse in developing economies. Therefore, reducing pollution is one of the top concerns for policymakers in emerging nations. Examining how trade openness and FDI affects environment by creating pollution is one of important implications to the present study. The primary goal of this study is thus to examine the effects of trade openness and FDI on environmental degradation. For this, it study employed appropriate time series econometric tools with a theoretical underpinning by taking the time period of 1992 to 2018 for 26 nations with upper-middle as well as lower-middle income level.

Literature Review

The main way that human activities have disrupted the energy balance of the earth during the past century is by burning fossil fuels, which boosts the amount of CO2 in the atmosphere and steadily raises global temperature. Greenhouse Gas (GHG) is the primary cause of global warming, and human activities have made this gas completely visible. According to current estimates, global carbon dioxide emissions from cement and fossil fuels rose by 1.0% in 2022, setting a new high of 36.6 billion tonnes of CO2 (Staff, C. B., 2022).

The present study reviews works on the interrelationship of trade related variables such as trade openness, foreign capital flow, GDP etc with environmental pollution, mainly the CO2 emission, in countries and groups over the years.

Greater trade openness, according to Damania et al. (2003), results in harsher (weaker) environmental restrictions in areas where government corruption is a problem (low). According to an empirical study by Fredriksson et al. (2003) that takes environmental policy as endogenous, stronger state environmental rules have a detrimental impact on the inflow of FDI in a variety of business sectors. In a political economy model with imperfect product market competition created by Cole et al. (2006), local and international businesses collaborate to persuade the local government for a favourable pollution tax. Environmental policy is found to be impacted by FDI, although the impact is dependent on how corruptible the local government is. According to Managi and Kumar (2009) and Zhang et al. (2017a, b) trade openness has a positive impact on CO2 emissions. The findings indicated that trade ignores environmental rules and regulations, which causes environmental degradations, in order to keep manufacturing costs low. This allows businesses to produce more items. By using the ARDL methodology, Ozturk and Acaravci (2013) discovered a positive association between world trade and CO2 per person in Turkey. AKIN (2014) focused on the major variables influencing the CO2 emissions of the 85 countries between 1991 and 2011 using annual balanced data. The findings indicate that growing energy demand and output result in higher CO2 emissions. Trade openness increases carbon dioxide emissions with an elasticity of 0.53, and there is a Granger causal relationship between trade openness and carbon dioxide emissions over the long run for newly industrialised nations as has been observed by Cetin, Seker and Cavlak's (2015). In a highly related work, Deb Roy and Sasmal (2020) examine the effects of trade liberalization on environment in the developing countries using a three-sector general equilibrium model including informal manufacturing sector which is considered as the polluting sector which supplies intermediate products to the formal manufacturing sector. Capital inflow, as a part of liberalization policy, results in expansion of both the formal manufacturing sector and the polluting informal sector and as a result, overall pollution increases. While a tariff cut leads to reduction in pollution. Le et al. (2016) examined how CO2 emissions alter with income level when taking into account various countries. The study's findings suggested that, in contrast to low- and middle-income countries, trade openness within high-income economies has less of an impact on CO2 emissions. Shahbaz et al. (2017) found that trade openness significantly affects the environment for global low-, middle-, and high-income panels as well as it have a positive impact on the CO2 emissions at both the middle income and global levels. Balsalobre-Lorente et al. (2018) found that trade openness and the connections between the use of renewable electricity and economic growth had a favourable impact on CO2 emissions. Kılıçarslan and Dumrul (2017) investigated how foreign direct investment had an environmental impact on the basis of the data from the years 1974 to 2013 in Turkey and the findings suggested that foreign direct investment had a long-term positive effect on carbon dioxide emissions and confirms the Pollution Haven hypothesis' existence. The relationship between economic growth, energy use, trade openness, population density, and carbon dioxide (CO2) emissions in Bangladesh from 1975 to 2013 is examined by Oh and Bhuyan (2018) through Autoregressive Distributed Lag (ARDL) bounds testing approach to Cointegration for establishing the existence of a long-run relationship. The findings show that both in the short- and long-term, energy consumption have a statistically significant positive impact on CO2 emissions. Yu et al. (2019) examined the EKC hypothesis on a panel of CIS (Commonwealth of Independent) countries between 2000 and 2013 by experimentally examining the relationship between trade openness, economic growth, and environmental pollution in order to quantify the direct, indirect, and overall effects of trade. Their findings confirm the presence of the inverted U-shaped relationship between per capita income and carbon dioxide emissions and back up the EKC theory. Panel data of 64 countries along the Belt and Road from 2001 to 2019 were utilised by Chen et al. (2021) to assess the impact of trade openness and CO2 emissions on environmental issues. Three channels were used to explain the impact: the technical channel (energy intensity), which shows a positive influence, the economic channel (GDP) and the energy-substitution channel (consumption of renewable energy) indicates a negative mediator impact on CO2 emission.

For East Asian countries, a rise in per capita GDP in both the present and prior periods, an increase in FDI in both those periods, and an increase in trade openness in the latter period will all result in an increase in carbon dioxide emissions in the short run, whereas, in the long run, CO2 emissions are not much impacted by per capita GDP, FDI, or trade openness (Wang & Huang 2022). Karedla et al. (2021) used the autoregressive distributive lag (ARDL) bounds test approach and examined the association among CO2 emissions, trade, manufacturing, and GDP per capita in India. Using an annual time series of data from the World Development Indicators between 1971 and 2016, results show that CO2 emissions and other variables have a long-term link. Manufacturing industry and GDP, which have long-term significant effects on CO_2 emission, on the other hand, trade openness dramatically reduces CO_2 emissions (due to cleaner and efficient technological practises). Galvan et al. (2022) evaluated the long-term impacts of economic growth, trade, foreign direct investment (FDI), and gross domestic product (GDP) on carbon dioxide (CO_2) emissions in middle-income nations (Singapore, the US, and South Korea) and an upper-middle-income country (China).

Research Gaps

The review of the extant literature so far, we have made covers the studies related to the issues of trade in goods and capital flows, particularly FDI and environmental pollution in the high-income countries and groups of the world. But, the progress of the world's emerging economies from the low- and middle-income countries has also implications with the environmental pollution. The importance of the informal or unorganized sectors and the issue of occupational hazards become pertinent when we go for considering the cases of the emerging economies; the existing studies did not focus upon these aspects.

Research Questions

The present study has aimed for capturing the countries from the low- and middle-income countries to analyse whether their rising volume of international trade do have any such environmental implications or not. It has tried to analyse the impact of trade upon environmental pollution through the channels of the informal sectors which are mainly polluting in nature. The study is expected to reduce the gap in the existing literature on the relationships of trade and environmental pollution during the post globalization era.

Objective of the Study

The aim of the study is to examine the long-run and short-run relationship among foreign direct investment, trade openness and carbon dioxide in per capita terms for 26 selected upper-middle as well as lower-middle income countries.

Variable Description and the Data Source

The present study is based on three variable model, namely, per capita Carbon Dioxide (PCO2; as the proxy for environmental pollution), Trade Openness (TRO) and the per capita Foreign Direct Investment (PFDI). TRO is calculated by the sum of export and import as a ratio to GDP. Their respective time series data (1992 to 2018) for 26 nations with upper-middle as well as lower-middle income level are collected from the 'World Bank Open Data'.

2. Theoretical Framework

The main theoretical pillar of the present study is the work of Deb Roy and Sasmal (2020) which examines the impacts of trade liberalization upon environmental pollution in the developing economies incorporating informal sector as the polluter and which maintains intermediate input supply relations to the formal manufacturing sector. The brief sketch of the theoretical underpinning is presented here whose empirical verification has been the prime focus of the study.

Let us consider a small economy with three sectors- Agricultural sector (A), the formal manufacturing sector (M) and an informal polluting sector (Z). There are two factors of production, labour (L) and capital (K). Suppose a_{ij} is the quantity of i^{th} input required for production of one unit of output of the j^{th} sector, i = L, K; j = A, M, Z. The competitive equilibrium price conditions are given by the following three equations:

1. $1 = a_{LA}W + a_{KA}r$
2. $(1+t)P_M^* = a_{LM}\overline{W} + a_{KM}r + a_{ZM}P_Z$
3. $P_Z = a_{LZ}W + a_{KZ}r$

Where, W= wage rate, r = rate of return on capital, t = ad valorem tariff rate, P_M^*= world price of M sector, $\overline{W}$ = exogenously given wage rate of the workers of that sector, P_Z = price of non-traded intermediate product produced by sector Z.

Full-employment conditions are:

4. $K = a_{KA}X_A + a_{KM}X_M + a_{KZ}X_Z$
5. $Lh = a_{LA}X_A + a_{LM}X_M + a_{LZ}X_Z$
6. $X_Z = a_{ZM}X_M$

Where Lh is nutritionally efficient labour. The nutritional efficiency function is a decreasing function of the level of pollution which is given by

7. h = h(Q); where, $\frac{\partial h}{\partial Q} < 0$

Total pollution in the economy is:

8. $Q = \alpha_A X_A + \alpha_M X_M + \Omega_C + \alpha_Z X_Z$

Where,Q= total actual pollution in the economy, Ω_C= pollution generated from the combined wastes of the agriculture and manufacturing sector as a result of consumption, α_A, α_M and α_Z are shares of pollution in the production of A, M and Z sectors respectively. It can be written as:

9. $Q = \Omega + \alpha_Z X_Z$

Where, Ω= maximum allowable level of pollution in the economy, and $\Omega = \alpha_A X_A + \alpha_M X_M + \Omega_C$.

It is simple for them to make polluting products under the veil of the formal manufacturing sector because the government cannot regulate the informal sector. The labour-intensive farm sector, on the other hand, will experience a decline in order to free up labour for the rise of the formal and informal manufacturing sectors. Thus, equation 4 and 5 can be written as:

10. $K = a_{KA}X_A + a_{KM}X_M + a_{KZ}a_{ZM}X_M$
11. $Lh = a_{LA}X_A + a_{LM}X_M + a_{LZ}a_{ZM}X_M$

Solving these two equations after differentiation, we get

12. $\frac{dX_A}{\partial K} = \frac{(a_{LM} + a_{LZ}a_{ZM})}{|A|}$
13. $\frac{dX_M}{\partial K} = \frac{-a_{LA}}{|A|}$

Where, $|A|$ = $[a_{KA}\ (a_{LM} +\ a_{LZ}a_{ZM})]$ - $[a_{LA}\ (a_{KM} +\ a_{KZ}a_{ZM})]$.

Thus, an increase in foreign capital inflow leads to the increase in both the economy's degree of environmental pollution as well as the growth of the informal manufacturing sector, which produces pollution. Following similar calculations, trade liberalisation in the form of a decrease in the tariff rate for goods produced by the import-competing formal manufacturing sector reduces the size of the polluting informal sector as well as the amount of environmental pollution in the economy.

3. Empirical Methodology

Given the nature of problem and quantum of data this study forms an econometric perspective starting with the stationary tests of the series. For this, the study conducted unit root test in line with the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) techniques. The ADF test model, which can be estimated and the null hypothesis H_0: $\delta = 0$ (non-stationary series) can be tested by using a τ-statistic. The equation is-

$$\Delta(PCO2)_t = a + \delta(PCO2)_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta(PCO2)_{t-i} + u_t \ldots\ldots \text{(i)}$$

Where PCO2 is the per capita CO2 emission. The error term is assumed to be serially independent and to have a constant variance when performing the ADF test. The ADF test approach was generalized by Phillips and Perron, allowing for less stringent distributional assumptions to be made. Here, the AR(1) procedure serves as the regression test-

$$\boldsymbol{\Delta(PCO2)_t = a + \delta(PCO2)_{t-1} + u_t} \ldots\ldots \text{(ii)}$$

Similarly, we can test the stationarity of all the series, such that PFDI (per capita FDI) and TRO (trade openness) under study.

The long-run relationships are then studied using Johansen's ML cointegration test method. The final equation is shown as follows-

$$\boldsymbol{\Delta Z_t = c} + \mu \boldsymbol{Z_{t-1}} + \sum_{\boldsymbol{i=1}}^{\boldsymbol{p-1}} \mu_{\boldsymbol{i}} \boldsymbol{\Delta Z_{t-i}} + \Omega_{\boldsymbol{t}} \ldots\ldots\ldots \text{(iii)}$$

Where, ΔZ_t= the k*1 matrix, i.e., $[\Delta(PCO2)_t, \Delta(PFDI)_t, \Delta(PTRO)_t]'$, c = intercept matrix of k*1 vector, $\mu = -(I - \sum_{i=1}^{m} A_i)$, $\mu_i = -\sum_{j=i+1}^{m} A_i$, A and I are coefficient and identity matrix respectively. 'm' is the lag length, Ω_t = k*1 vector of residual term. The Trace test statistic, (λ_{trace}) is-

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{k} \ln(1 - \hat{\lambda}_i) \ldots\ldots\ldots\ldots\ldots \text{(iv)}$$

Where, $\hat{\lambda}_i$ is Eigenvalue obtained from the estimated μ matrix and T = the number of usable observations. The alternative hypothesis, H1, of k cointegrating relations will be evaluated against the null hypothesis, H0, of at most 'r' cointegrating vectors, until the null hypothesis, H0: r = k, is attained. The presence of at most r cointegrating is implied by the rejection of the null.

Of certainly, disequilibrium could exist in the short term. The Vector Error Correction Mechanism (VECM)'s purpose is to demonstrate the rate of transition from the short-run disequilibrium state to the long-term equilibrium state. Since there are three variables in the current investigation, the VECM is defined as

$$\Delta(PCO2)_t = a_1 + \sum_{i=1}^{p} b_i \Delta(PCO2)_{t-i} + \sum_{i=1}^{p} c_i \Delta(PFDI)_{t-i} + \sum_{i=1}^{p} d_i \Delta(PTRO)_{t-i} + \lambda_1 \hat{\varepsilon}_{t-1} + \varepsilon_{1t} \quad \text{.... (v)}$$

$$\Delta(PFDI)_t = a_2 + \sum_{i=1}^{p} g_i \Delta(PCO2)_{t-i} + \sum_{i=1}^{p} h_i \Delta(PFDI)_{t-i} + \sum_{i=1}^{p} q_i \Delta(PTRO)_{t-i} + \lambda_2 \hat{\varepsilon}_{t-1} + \varepsilon_{2t} \quad \text{........ (vi)}$$

$$\Delta(PTRO)_t = a_3 + \sum_{i=1}^{p} l_i \Delta(PCO2)_{t-i} + \sum_{i=1}^{p} r_i \Delta(PFDI)_{t-i} + \sum_{i=1}^{p} s_i \Delta(PTRO)_{t-i} + \lambda_3 \hat{\varepsilon}_{t-1} + \varepsilon_{3t} \quad \text{....... (vii)}$$

The error correction term (ECT) is denoted by $\hat{\varepsilon}_{t-1}$ and the error correction coefficient λ, which measures how much of the disequilibrium is being rectified. When λ is non-zero (positive or negative), there is disequilibrium in the short run. Long-term equilibrium will only return, though, if and only if it is negative.

Finally, VAR Granger Causality Wald test and Block Exogeneity test is applied to investigate the short-run causality among the variables.

4. Results and Discussion

Unit Root Test Result

Before moving on to the cointegration and causality test, unit root tests are completed. Unit root test is used to determine whether the variables are stationary. In order to accomplish this, ADF and PP tests were used in this study. The results of the ADF and PP tests for PCO2, PFDI and TRO for countries are shown in Table 1.

Table 1. *Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test result*

Country	Indicators	ADF test (Prob) (Intercept)	PP test (Prob) (Intercept)	Stationarity
Argentina	PCO2	-4.2936 (0.0026)	-4.2962 (0.0026)	Stat at 1st diff
	PFDI	-7.3348 (0.0000)	-8.4493 (0.0000)	Stat at 1st diff
	TRO	-5.2121 (0.0003)	-5.2118 (0.0003)	Stat at 1st diff
Bangladesh	PCO2	-4.8890 (0.0009)	-33.014 (0.0001)	Stat at 2nd diff
	PFDI	-3.0088 (0.0521)	-18.358 (0.0001)	Stat at 2nd diff
	TRO	-8.2030 (0.0000)	-22.645 (0.0001)	Stat at 2nd diff
Bolivia	PCO2	-3.5994 (0.0161)	-3.5513 (0.0148)	Stat at 1st diff
	PFDI	-5.6022 (0.0001)	-5.5971 (0.0001)	Stat at 1st diff
	TRO	-4.2930 (0.0026)	-4.2891 (0.0027)	Stat at 1st diff
Brazil	PCO2	-3.7431 (0.0096)	-3.7270 (0.0099)	Stat at 1st diff
	PFDI	-5.5107 (0.0001)	-5.5837 (0.0001)	Stat at 1st diff
	TRO	-4.7236 (0.0009)	-4.7239 (0.0009)	Stat at 1st diff
Bulgaria	PCO2	-5.5163 (0.0002)	-9.1089 (0.0000)	Stat at 1st diff
	PFDI	-4.3192 (0.0026)	-3.0501 (0.0438)	Stat at 1st diff
	TRO	-6.3339 (0.0000)	-15.477 (0.0000)	Stat at 1st diff
China	PCO2	-5.7981 (0.0001)	-5.7981 (0.0001)	Stat at 2nd diff

	PFDI	-2.8148 (0.0075)	-15.512 (0.0000)	Stat at 2nd diff
	TRO	-6.7263 (0.0000)	-8.8656 (0.0000)	Stat at 2nd diff
Congo	PCO2	-5.0240 (0.0005)	-5.0240 (0.0005)	Stat at 1st diff
	PFDI	-3.6177 (0.0149)	-11.310 (0.0000)	Stat at 1st diff
	TRO	-4.6087 (0.0015)	-7.4713 (0.0000)	Stat at 1st diff
Costa Rica	PCO2	-5.3683 (0.0002)	-6.2064 (0.0000)	Stat at 1st diff
	PFDI	-4.8225 (0.0007)	-5.3990 (0.0002)	Stat at 1st diff
	TRO	-3.2667 (0.0282)	-4.0024 (0.0052)	Stat at 1st diff
Fiji	PCO2	-4.7445 (0.0009)	-4.7382 (0.0009)	Stat at 1st diff
	PFDI	-7.6969 (0.0000)	-7.4220 (0.0000)	Stat at 1st diff
	TRO	-6.9624 (0.0000)	-6.9847 (0.0000)	Stat at 1st diff
India	PCO2	-4.0451 (0.0047)	-4.0836 (0.0043)	Stat at 1st diff
	PFDI	-5.3951 (0.0002)	-5.3964 (0.0002)	Stat at 1st diff
	TRO	-5.6184 (0.0001)	-5.6213 (0.0001)	Stat at 1st diff
Indonesia	PCO2	-4.4131 (0.0021)	-6.6784 (0.0000)	Stat at 1st diff
	PFDI	-6.1324 (0.0000)	-6.3148 (0.0000)	Stat at 1st diff
	TRO	-8.1213 (0.0000)	-6.8987 (0.0000)	Stat at 1st diff
Jordan	PCO2	-5.7121 (0.0001)	-5.6728 (0.0001)	Stat at 1st diff
	PFDI	-4.6185 (0.0012)	-4.6185 (0.0012)	Stat at 1st diff
	TRO	-3.7908 (0.0086)	-3.6618 (0.0115)	Stat at 1st diff
Kenya	PCO2	-4.3418 (0.0024)	-4.3381 (0.0024)	Stat at 1st diff
	PFDI	-5.0430 (0.0005)	-5.1236 (0.0004)	Stat at 1st diff
	TRO	-3.4697 (0.0186)	-7.4457 (0.0000)	Stat at 1st diff
Malaysia	PCO2	-5.7772 (0.0001)	-5.9398 (0.0000)	Stat at 1st diff
	PFDI	-6.7757 (0.0000)	-9.8883 (0.0000)	Stat at 1st diff
	TRO	-3.8002 (0.0090)	-4.0156 (0.0051)	Stat at 1st diff
Mauritius	PCO2	-4.1635 (0.0036)	-4.1764 (0.0035)	Stat at 1st diff
	PFDI	-8.3853 (0.0000)	-9.3613 (0.0000)	Stat at 1st diff
	TRO	-4.5602 (0.0022)	-7.0074 (0.0000)	Stat at 1st diff
Mexico	PCO2	-5.7751 (0.0001)	-5.7927 (0.0001)	Stat at 1st diff
	PFDI	-8.3576 (0.0000)	-21.300 (0.0001)	Stat at 1st diff
	TRO	-4.9234 (0.0006)	-4.9238 (0.0006)	Stat at 1st diff
Panama	PCO2	-5.7400 (0.0001)	-5.7976 (0.0001)	Stat at 1st diff
	PFDI	-6.3604 (0.0000)	-9.5564 (0.0000)	Stat at 1st diff
	TRO	-4.3248 (0.0024)	-4.3248 (0.0024)	Stat at 1st diff
Paraguay	PCO2	-3.2169 (0.0309)	-3.2168 (0.0309)	Stat at 1st diff
	PFDI	-11.025 (0.0000)	-11.314 (0.0000)	Stat at 1st diff
	TRO	-4.0172 (0.0049)	-4.1121 (0.0039)	Stat at 1st diff
Philippines	PCO2	-4.8576 (0.0008)	-7.8215 (0.0000)	Stat at 2nd diff
	PFDI	-5.6903 (0.0001)	-20.411 (0.0001)	Stat at 2nd diff
	TRO	-10.316 (0.0000)	-10.450 (0.0000)	Stat at 2nddiff
Romania	PCO2	-4.4086 (0.0021)	-3.7269 (0.0099)	Stat at 1st diff
	PFDI	-5.6245 (0.0001)	-5.5853 (0.0001)	Stat at 1st diff

	TRO	-4.2924 (0.0026)	-4.2385 (0.0030)	Stat at 1st diff
Russia	PCO2	-3.6133 (0.0129)	-3.7517 (0.0094)	Stat at 1st diff
	PFDI	-5.2953 (0.0002)	-5.4551 (0.0002)	Stat at 1st diff
	TRO	-3.3624 (0.0225)	-3.3395 (0.0237)	Stat at 1st diff
South Africa	PCO2	-5.3856 (0.0002)	-5.3867 (0.0002)	Stat at 1st diff
	PFDI	-5.5160 (0.0002)	-15.807 (0.0000)	Stat at 1st diff
	TRO	-4.9162 (0.0008)	-8.8123 (0.0000)	Stat at 1st diff
Sri Lanka	PCO2	-5.4710 (0.0002)	-5.6134 (0.0001)	Stat at 1st diff
	PFDI	-4.6450 (0.0012)	-4.4073 (0.0020)	Stat at 1st diff
	TRO	-4.5467 (0.0015)	-4.9339 (0.0006)	Stat at 1st diff
Thailand	PCO2	-4.0071 (0.0052)	-4.0071 (0.0052)	Stat at 1st diff
	PFDI	-6.2607 (0.0000)	-23.827 (0.0001)	Stat at 1st diff
	TRO	-5.6803 (0.0001)	-5.7422 (0.0001)	Stat at 1st diff
Turkey	PCO2	-5.6574 (0.0001)	-6.0751 (0.0000)	Stat at 1st diff
	PFDI	-4.0787 (0.0044)	-4.0463 (0.0047)	Stat at 1st diff
	TRO	-4.3637 (0.0024)	-4.8875 (0.0006)	Stat at 1st diff
Vietnam	PCO2	-3.8338 (0.0078)	-3.6454 (0.0120)	Stat at 1st diff
	PFDI	-3.9798 (0.0055)	-3.9582 (0.0058)	Stat at 1st diff
	TRO	-4.5210 (0.0015)	-4.5025 (0.0016)	Stat at 1st diff

Source: Authors' calculations

All the variables, PCO2, PFDI and TRO have unit root in level. The series are not stationary in the level value for all the countries. Table 1 shows that these variables have no unit root (stationary series) in the first as well as second differences. The countries having stationary in the first difference are Argentina, Bolivia, Brazil, Bulgaria, Congo, Costa Rica, Fiji, India, Indonesia, Jordan, Kenya, Malaysia, Mauritius, Mexico, Panama, Paraguay, Romania, Russia, South Africa, Sri Lanka, Thailand, Turkey and Vietnam. The study proceeds the Johansen's cointegration test to examine the long-run relationship among these variables for these nations. In contrast, the table shows that the variables are stationary in the second difference for Bangladesh, China and Philippines. Thus, the study skips to conduct cointegration test for these three nations.

Cointegration Test Result

In this section, the study exhibits the long-run relationship among the variables across countries under study. For this, Johansen cointegration test is applied, where the results are presented in Table-2.

Table 2. *Johansen Cointegration Test Result*

Country	Hypothesized No of CE(s)	Trace Statistics (Prob)	Remarks
Argentina	None	31.507 (0.03)	The variables are cointegrated and there are 2 cointegrating equations at 0.05 level
	At most 1	13.361 (0.10)	
	At most 2	4.9300 (0.02)	
Bolivia	None	23.494 (0.22)	The variables are not cointegrated at 0.05
	At most 1	9.8920 (0.28)	
	At most 2	1.2315 (0.26)	
Brazil	None	20.279 (0.40)	The variables are not cointegrated at 0.05

	At most 1	4.4197 (0.86)	
	At most 2	1.1356 (0.28)	
Bulgaria	None	20.818 (0.36)	The variables are not cointegrated at 0.05
	At most 1	10.438 (0.24)	
	At most 2	2.4513 (0.11)	
Congo	None	29.724 (0.05)	The variables are not cointegrated at 0.05
	At most 1	5.0795 (0.80)	
	At most 2	0.6925 (0.40)	
Costa Rica	None	21.026 (0.35)	The variables are not cointegrated at 0.05
	At most 1	7.9388 (0.47)	
	At most 2	0.1595 (0.68)	
Fiji	None	37.486 (0.00)	The variables are not cointegrated at 0.05
	At most 1	7.6432 (0.50)	
	At most 2	0.8490 (0.35)	
India	None	28.278 (0.07)	The variables are not cointegrated at 0.05
	At most 1	11.072 (0.20)	
	At most 2	0.0311 (0.85)	
Indonesia	None	21.408 (0.33)	The variables are not cointegrated at 0.05
	At most 1	5.5322 (0.20)	
	At most 2	0.2974 (0.85)	
Jordan	None	29.203 (0.05)	The variables are cointegrated and there are 2 cointegrating equations at 0.05 level
	At most 1	14.406 (0.07)	
	At most 2	3.5593 (0.05)	
Kenya	None	29.715 (0.05)	The variables are not cointegrated at 0.05
	At most 1	12.239 (0.14)	
	At most 2	0.6050 (0.43)	
Malaysia	None	38.456 (0.00)	The variables are not cointegrated at 0.05
	At most 1	13.599 (0.09)	
	At most 2	2.9047 (0.08)	
Mauritius	None	20.330 (0.40)	The variables are not cointegrated at 0.05
	At most 1	6.7648 (0.60)	
	At most 2	1.4557 (0.22)	
Mexico	None	27.822 (0.08)	The variables are not cointegrated at 0.05
	At most 1	10.812 (0.22)	
	At most 2	0.1178 (0.73)	
Panama	None	24.798 (0.16)	The variables are not cointegrated at 0.05
	At most 1	9.7799 (0.29)	
	At most 2	2.8213 (0.09))	
Paraguay	None	34.795 (0.01)	The variables are not cointegrated at 0.05
	At most 1	8.3307 (0.43)	
	At most 2	0.6397 (0.42)	
Romania	None	32.674 (0.02)	The variables are not cointegrated at 0.05
	At most 1	13.079 (0.11)	
	At most 2	2.9907 (0.08)	
Russia	None	32.608 (0.02)	The variables are cointegrated and there are 2 cointegrating equations at 0.05 level
	At most 1	14.280 (0.07)	

	At most 2	4.4580 (0.03)	
South Africa	None	22.541 (0.26)	The variables are not cointegrated at 0.05
	At most 1	7.6556 (0.50)	
	At most 2	2.9171 (0.08)	
Sri Lanka	None	36.156 (0.00)	The variables are not cointegrated at 0.05
	At most 1	7.2521 (0.54)	
	At most 2	1.9298 (0.16)	
Thailand	None	36.107 (0.00)	The variables are cointegrated and there are two cointegrating equations at 0.05 level
	At most 1	13.344 (0.10)	
	At most 2	3.3875 (0.05)	
Turkey	None	28.772 (0.06)	The variables are not cointegrated at 0.05
	At most 1	9.5237 (0.31)	
	At most 2	0.0323 (0.85)	
Vietnam	None	43.603 (0.00)	The variables are not cointegrated at 0.05
	At most 1	7.7164 (0.49)	
	At most 2	0.9742 (0.32)	

Source: Authors' calculations

In Table 2, the Johansen's cointegration test is significant at 0.05 level for Argentina, Jordan, Russia and Thailand. The rejection of null hypothesis of no cointegration implies that there exist a long-run association among PFDI, TRO and PCO2 in these nations. The test is insignificant, i.e., cannot reject the null hypothesis of no cointegration at 0.05 level of significant in Bolivia, Brazil, Bulgaria, Congo, Costa Rica, Fiji, India, Indonesia, Kenya, Malaysia, Mauritius, Mexico, Panama, Paraguay, Romania, South Africa, Sri Lanka, Turkey and Vietnam. The study cannot find any long-run relationship among these variables in these nations.

Vector Error Correction Model (VECM) Estimation

The study estimates the VECM to identify short-run dynamics of variables and the correction of disturbances over time. The disturbance correcting mechanism and the converging to the stable relationship among the variables are identified the Error Correction Term (ECT). The estimated ECT and their respective provability values are presented in Table-3.

Table 3. *Estimated ECT of Vector Error Correction Model*

Country	Dependent Variable	Independent Variable	ECT	Prob	Remarks
Argentina	PCO2	PFDI, TRO	-0.1464	0.0079	PFDI, TRO → PCO2
	PFDI	PCO2, TRO	-93.815	0.0624	PCO2, TRO→ PFDI
	TRO	PCO2, PFDI	-0.0251	0.0845	No LR causality
Jordan	PCO2	PFDI, TRO	-0.0569	0.0034	PFDI, TRO → PCO2
	PFDI	PCO2, TRO	-21.590	0.1226	No LR causality
	TRO	PCO2, PFDI	-0.0098	0.5147	No LR causality
Russia	PCO2	PFDI, TRO	-0.4582	0.0070	PFDI, TRO → PCO2
	PFDI	PCO2, TRO	69.410	0.1943	No LR causality
	TRO	PCO2, PFDI	-0.0047	0.7541	No LR causality
Thailand	PCO2	PFDI, TRO	0.0223	0.5342	No LR causality
	PFDI	PCO2, TRO	51.533	0.0001	No LR causality

	TRO	PCO2, PFDI	-0.0221	0.2867	No LR causality

Source: Authors' calculations

From the above table, we find some mixed result regarding the coefficient of Error Correction Term (ECT). When PCO2 is dependent, the coefficient value of ECT is negative and significant in case of Argentina, Jordan and Russia. The negative and significant coefficient of ECT implies that the short-term disequilibrium among variables is corrected over time and the long-run stable relation is restored. This also implies the long-run causality running from PFDI and TRO to PCO2. So, both foreign direct investment and trade openness leads to sustain increase in carbon emissions in Argentina, Jordan and Russia. In contrast, when PFDI is dependent variable, the coefficient of the ECT is negative and significant in Argentina, where the long-term causal relationship is running from PCO2 and TRO to PFDI. Taking TRO as dependent variable, the coefficients of ECT are negative but insignificant in Argentina, Jordan, Russia and Thailand. PCO2 as well as PFDI does not influence TRO in these nations.

Granger causality test result in VAR(1) model

In spite of having long-run relation, there exists causal relationship among the variables in the short-run. Therefore, the test is done to show the short-run causal relation among the variables.

Table 4. *Wald Test Result*

Country	Dependent variable	Independent variable	Chi square value	Prob	Remarks
Argentina	ΔPCO2	ΔPFDI, ΔTRO	4.9080	0.0859	No SR causality
	ΔPFDI	ΔPCO2, ΔTRO	1.3176	0.5175	No SR causality
	ΔTRO	ΔPCO2, ΔPFDI	2.1709	0.3377	No SR causality
Jordan	ΔPCO2	ΔPFDI, ΔTRO	10.232	0.0060	PFDI, TRO→PCO2
	ΔPFDI	ΔPCO2, ΔTRO	4.9137	0.0857	No SR causality
	ΔTRO	ΔPCO2, ΔPFDI	0.6673	0.7163	No SR causality
Russia	ΔPCO2	ΔPFDI, ΔTRO	2.0750	0.3543	No SR causality
	ΔPFDI	ΔPCO2, ΔTRO	0.7452	0.6889	No SR causality
	ΔTRO	ΔPCO2, ΔPFDI	15.424	0.0004	PCO2, PFDI→TRO
Thailand	ΔPCO2	ΔPFDI, ΔTRO	0.4618	0.7938	No SR causality
	ΔPFDI	ΔPCO2, ΔTRO	4.2008	0.1224	No SR causality
	ΔTRO	ΔPCO2, ΔPFDI	1.4622	0.4814	No SR causality

Source: Authors' calculations

The conclusion drawn from the causality test in VAR model, which is that both PFDI and TRO in one period lead to PCO2 emissions in the next period in Jordan. Thus, the combined causality runs from foreign direct investment and trade openness to carbon emissions in Jordan. In contrast of this, both PCO2 and PFDI jointly causses trade openness in Russia. Finally, the result shows that there is no causal relation among these variables in Argentina and Thailand.

Similarly, the individual as well as joint short-run causal relation is shown in the following Table-5.

Table 5. *Block Exogeneity Test Result*

Country	Dependent Variable	Independent Variable	Chisquare value	Prob	Remarks
Bangladesh	ΔΔPCO2	ΔΔPFDI	2.6095	0.2712	No SR causality
		ΔΔTRO	0.2549	0.8803	No SR causality
		Over all	4.0783	0.3955	No SR causality
	ΔΔPFDI	ΔΔPCO2	15.797	0.0004	PCO2→PFDI
		ΔΔTRO	8.9100	0.0116	TRO→PFDI
		Over all	20.979	0.0003	PCO2,TRO→PFDI
	ΔΔTRO	ΔΔPCO2	10.065	0.0065	PCO2→TRO
		ΔΔPFDI	12.974	0.0015	PFDI→TRO
		Over all	17.691	0.0014	PCO2,PFDI→TRO
Bolivia	ΔPCO2	ΔPFDI	1.6249	0.2024	No SR causality
		ΔTRO	0.4538	0.5005	No SR causality
		Over all	1.6815	0.4314	No SR causality
	ΔPFDI	ΔPCO2	0.0514	0.8205	No SR causality
		ΔTRO	1.1551	0.2825	No SR causality
		Over all	1.1590	0.5602	No SR causality
	ΔTRO	ΔPCO2	0.0434	0.8349	No SR causality
		ΔPFDI	0.2634	0.6078	No SR causality
		Over all	0.4112	0.8141	No SR causality
Brazil	ΔPCO2	ΔPFDI	7.9684	0.0467	PFDI→PCO2
		ΔTRO	5.1853	0.1587	No SR causality
		Over all	13.010	0.0429	PFDI,TRO→PCO2
	ΔPFDI	ΔPCO2	2.2493	0.5223	No SR causality
		ΔTRO	9.0276	0.0289	TRO→PFDI
		Over all	17.052	0.0091	PCO2,TRO→PFDI
	ΔTRO	ΔPCO2	1.0657	0.7854	No SR causality
		ΔPFDI	2.2157	0.5288	No SR causality
		Over all	3.7596	0.7092	No SR causality
Bulgaria	ΔPCO2	ΔPFDI	0.4735	0.4914	No SR causality
		ΔTRO	5.6674	0.0173	TRO→PCO2
		Over all	6.3071	0.0427	PFDI,TRO→PCO2
	ΔPFDI	ΔPCO2	0.0451	0.8317	No SR causality
		ΔTRO	0.9627	0.3265	No SR causality
		Over all	0.9630	0.6178	No SR causality
	ΔTRO	ΔPCO2	3.6478	0.0561	PCO2→TRO
		ΔPFDI	3.4835	0.0620	PFDI→TRO
		Over all	12.235	0.0022	PCO2,PFDI→TRO
China	ΔΔPCO2	ΔΔPFDI	5.0024	0.0820	NoSRcausality
		ΔΔTRO	5.5753	0.0616	TRO→PCO2
		Over all	10.681	0.0304	PFDI,TRO→PCO2
	ΔΔPFDI	ΔΔPCO2	9.9733	0.0068	PCO2→PFDI
		ΔΔTRO	1.6298	0.4427	No SR causality
		Over all	10.241	0.0366	PCO2, TRO→PFDI
	ΔΔTRO	ΔΔPCO2	2.8735	0.2377	No SR causality

		ΔΔPFDI	2.8644	0.2388	No SR causality
		Over all	4.6924	0.3203	No SR causality
Congo	ΔPCO2	ΔPFDI	0.6851	0.7100	No SR causality
		ΔTRO	0.8776	0.6448	No SR causality
		Over all	1.2523	0.8694	No SR causality
	ΔPFDI	ΔPCO2	1.1498	0.5628	No SR causality
		ΔTRO	26.842	0.0000	TRO→PFDI
		Over all	29.077	0.0000	TRO, PCO2→PFDI
	ΔTRO	ΔPCO2	1.3726	0.5034	No SR causality
		ΔPFDI	6.4491	0.0398	PFDI→TRO
		Over all	6.8363	0.1448	No SR causality
Costa Rica	ΔPCO2	ΔPFDI	1.0149	0.3137	No SR causality
		ΔTRO	0.0619	0.8035	No SR causality
		Over all	1.4961	0.4733	No SR causality
	ΔPFDI	ΔPCO2	8.9865	0.0027	PCO2→PFDI
		ΔTRO	0.4282	0.5129	No SR causality
		Over all	9.0245	0.0110	PCO2, TRO→PFDI
	ΔTRO	ΔPCO2	14.486	0.0001	PCO2→TRO
		ΔPFDI	1.3479	0.2456	No SR causality
		Over all	16.341	0.0003	PCO2, PFDI→TRO
Fiji	ΔPCO2	ΔPFDI	0.4494	0.5026	No SR causality
		ΔTRO	2.9974	0.0834	No SR causality
		Over all	3.0972	0.2125	No SR causality
	ΔPFDI	ΔPCO2	3.1329	0.0767	No SR causality
		ΔTRO	0.0593	0.8076	No SR causality
		Over all	4.3964	0.1110	No SR causality
	ΔTRO	ΔPCO2	0.5861	0.4439	No SR causality
		ΔPFDI	6.1458	0.0132	PFDI→TRO
		Over all	6.2875	0.0431	PFDI, PCO2→TRO
India	ΔPCO2	ΔPFDI	20.572	0.0001	PFDI→PCO2
		ΔTRO	11.835	0.0080	TRO→PCO2
		Over all	22.677	0.0009	PFDI,TRO→PCO2
	ΔPFDI	ΔPCO2	5.3351	0.1488	No SR causality
		ΔTRO	11.729	0.0084	TRO→PFDI
		Over all	21.143	0.0017	PCO2, TRO→PFDI
	ΔTRO	ΔPCO2	0.2960	0.9608	No SR causality
		ΔPFDI	0.5882	0.8991	No SR causality
		Over all	0.7765	0.9927	No SR causality
Indonesia	ΔPCO2	ΔPFDI	2.9350	0.0867	No SR causality
		ΔTRO	1.2580	0.2620	No SR causality
		Over all	9.3059	0.0095	PFDI,TRO→PCO2
	ΔPFDI	ΔPCO2	2.1465	0.1429	No SR causality
		ΔTRO	1.2714	0.2595	No SR causality
		Over all	3.2846	0.1935	No SR causality
	ΔTRO	ΔPCO2	0.9127	0.3394	No SR causality
		ΔPFDI	4.6658	0.0308	PFDI→TRO
		Over all	6.4013	0.0407	PCO2, PFDI→TRO

Kenya	ΔPCO2	ΔPFDI	12.842	0.0003	PFDI→PCO2
		ΔTRO	0.5055	0.4771	NoSRcausality
		Over all	13.890	0.0010	PFDI,TRO→PCO2
	ΔPFDI	ΔPCO2	2.2762	0.1314	NoSRcausality
		ΔTRO	2.7355	0.0981	NoSRcausality
		Over all	3.2581	0.1961	NoSRcausality
	ΔTRO	ΔPCO2	0.7055	0.4009	NoSRcausality
		ΔPFDI	0.0550	0.8145	NoSRcausality
		Over all	1.1050	0.5755	NoSRcausality
Malaysia	ΔPCO2	ΔPFDI	0.8024	0.3704	NoSRcausality
		ΔTRO	0.4036	0.5252	NoSRcausality
		Over all	1.3828	0.5009	NoSRcausality
	ΔPFDI	ΔPCO2	0.0597	0.8069	NoSRcausality
		ΔTRO	0.2255	0.6348	NoSRcausality
		Over all	0.2795	0.8696	NoSRcausality
	ΔTRO	ΔPCO2	1.5150	0.2184	NoSRcausality
		ΔPFDI	1.2045	0.2724	NoSRcausality
		Over all	2.0587	0.3572	NoSRcausality
Mauritius	ΔPCO2	ΔPFDI	0.7564	0.3844	NoSRcausality
		ΔTRO	0.6293	0.4276	NoSRcausality
		Over all	1.0302	0.5974	NoSRcausality
	ΔPFDI	ΔPCO2	0.1024	0.749	NoSRcausality
		ΔTRO	4.4620	0.0347	TRO→PFDI
		Over all	4.4626	0.1074	NoSRcausality
	ΔTRO	ΔPCO2	0.4853	0.4860	NoSRcausality
		ΔPFDI	5.8279	0.0158	PFDI→TRO
		Over all	8.7799	0.0124	PCO2, PFDI→TRO
Mexico	ΔPCO2	ΔPFDI	0.5886	0.7450	NoSRcausality
		ΔTRO	0.5132	0.7737	NoSRcausality
		Over all	1.1381	0.8882	NoSRcausality
	ΔPFDI	ΔPCO2	0.0987	0.9518	NoSRcausality
		ΔTRO	0.0314	0.9844	NoSRcausality
		Over all	0.1196	0.9983	NoSRcausality
	ΔTRO	ΔPCO2	0.2030	0.9035	NoSRcausality
		ΔPFDI	7.9045	0.0192	PFDI→TRO
		Over all	9.0493	0.0599	PCO2, PFDI→TRO
Panama	ΔPCO2	ΔPFDI	0.0908	0.7632	NoSRcausality
		ΔTRO	0.1271	0.7214	NoSRcausality
		Over all	0.2512	0.8820	NoSRcausality
	ΔPFDI	ΔPCO2	16.680	0.0000	PCO2→PFDI
		ΔTRO	8.1204	0.0044	TRO→PFDI
		Over all	19.198	0.0001	PCO2, TRO→PFDI
	ΔTRO	ΔPCO2	0.0011	0.9733	NoSRcausality
		ΔPFDI	0.0139	0.9059	NoSRcausality
		Over all	0.0144	0.9928	NoSRcausality
Paraguay	ΔPCO2	ΔPFDI	0.8168	0.3661	NoSRcausality
		ΔTRO	4.6883	0.0304	TRO→PCO2

		Over all	4.9243	0.0853	NoSRcausality
	ΔPFDI	ΔPCO2	0.0340	0.8537	NoSRcausality
		ΔTRO	2.5739	0.1086	NoSRcausality
		Over all	2.5900	0.2739	NoSRcausality
	ΔTRO	ΔPCO2	0.0020	0.9643	NoSRcausality
		ΔPFDI	11.996	0.0005	PFDI→TRO
		Over all	12.007	0.0025	PCO2, PFDI→TRO
Philippines	ΔΔPCO2	ΔΔPFDI	0.0109	0.9945	NoSRcausality
		ΔΔTRO	3.4231	0.1806	NoSRcausality
		Over all	3.9745	0.4095	NoSRcausality
	ΔΔPFDI	ΔΔPCO2	0.4407	0.8022	NoSRcausality
		ΔΔTRO	0.5264	0.7686	NoSRcausality
		Over all	1.3820	0.8473	NoSRcausality
	ΔΔTRO	ΔΔPCO2	1.8232	0.4019	NoSRcausality
		ΔΔPFDI	1.2018	0.5483	NoSRcausality
		Over all	2.2655	0.6871	NoSRcausality
Romania	ΔPCO2	ΔPFDI	1.2221	0.2689	NoSRcausality
		ΔTRO	11.467	0.0007	TRO→PCO2
		Over all	11.527	0.0031	PFDI, TRO→PCO2
	ΔPFDI	ΔPCO2	0.0102	0.9193	NoSRcausality
		ΔTRO	0.1130	0.7367	NoSRcausality
		Over all	0.1603	0.923	NoSRcausality
	ΔTRO	ΔPCO2	2.9116	0.0879	NoSRcausality
		ΔPFDI	1.3172	0.2511	NoSRcausality
		Over all	6.1005	0.0473	PCO2, PFDI→TRO
SouthAfrica	ΔPCO2	ΔPFDI	0.9116	0.8226	NoSRcausality
		ΔTRO	5.3850	0.1457	NoSRcausality
		Over all	7.4058	0.2849	NoSRcausality
	ΔPFDI	ΔPCO2	10.181	0.0171	NoSRcausality
		ΔTRO	12.166	0.0068	TRO→PFDI
		Over all	22.884	0.0008	PCO2, TRO→PFDI
	ΔTRO	ΔPCO2	7.4835	0.058	PCO2→TRO
		ΔPFDI	13.241	0.0041	PFDI→TRO
		Over all	28.840	0.0001	PCO2, PFDI→TRO
SriLanka	ΔPCO2	ΔPFDI	3.0860	0.079	NoSRcausality
		ΔTRO	17.243	0.0000	TRO→PCO2
		Over all	39.566	0.0000	PFDI, TRO→PCO2
	ΔPFDI	ΔPCO2	4.7221	0.0298	PCO2→PFDI
		ΔTRO	0.3254	0.5683	NoSRcausality
		Over all	4.7236	0.0942	NoSRcausality
	ΔTRO	ΔPCO2	3.3379	0.0677	NoSRcausality
		ΔPFDI	8.0040	0.0047	PFDI→TRO
		Over all	8.6518	0.0132	NoSRcausality
Thailand	ΔPCO2	ΔPFDI	1.2340	0.2666	NoSRcausality
		ΔTRO	4.9961	0.0254	TRO→PCO2
		Over all	5.0592	0.0797	NoSRcausality
	ΔPFDI	ΔPCO2	1.2112	0.2711	NoSRcausality

		ΔTRO	18.424	0.0000	TRO→PFDI
		Over all	20.429	0.0000	PCO2, TRO→PFDI
	ΔTRO	ΔPCO2	2.3797	0.1229	NoSRcausality
		ΔPFDI	6.7738	0.0093	PFDI→TRO
		Over all	8.0948	0.0175	PCO2, PFDI→TRO
Turkey	ΔPCO2	ΔPFDI	0.7754	0.3785	NoSRcausality
		ΔTRO	4.2076	0.0402	TRO→PCO2
		Over all	7.1337	0.0282	PFDI, TRO→PCO2
	ΔPFDI	ΔPCO2	9.3330	0.0023	PCO2→PFDI
		ΔTRO	0.6071	0.4359	NoSRcausality
		Over all	9.3428	0.0094	PCO2, TRO→PFDI
	ΔTRO	ΔPCO2	6.6573	0.0099	PCO2→TRO
		ΔPFDI	0.0393	0.8428	NoSRcausality
		Over all	6.6869	0.0353	PCO2, PFDI→TRO
Vietnam	ΔPCO2	ΔPFDI	11.017	0.0264	PFDI→PCO2
		ΔTRO	6.5689	0.1605	NoSRcausality
		Over all	35.464	0.0000	PFDI, TRO→PCO2
	ΔPFDI	ΔPCO2	0.1474	0.9974	NoSRcausality
		ΔTRO	7.3962	0.1164	NoSRcausality
		Over all	10.560	0.2279	NoSRcausality
	ΔTRO	ΔPCO2	145.98	0.0000	PCO2→TRO
		ΔPFDI	301.80	0.0000	PFDI→TRO
		Over all	335.80	0.0000	PCO2, PFDI→TRO

Source: Authors' calculations

In Table-5, the study relates three alternative equations, such that (i) per capita carbon emission (PCO2) equation, (ii) per capita foreign direct investment (PFDI) equation and (iii) per capita trade openness (TRO) equation.

On the basis of our results, it can be said that in the short-run, PFDI individually affects PCO2 in Brazil, India and in Kenya. Similarly, the individual effect of TRO on PCO2 is found in Bulgaria, China, India, Paraguay, Romania, Sri Lanka, Thailand and Turkey. The joint causal relation, that is running from both PFDI and TRO to PCO2 exists in Brazil, Bulgaria, India, Indonesia, Kenya, Romania, Sri Lanka, Turkey and in Vietnam.

Regarding the second equation, the result shows that there is individual short-run causal relation running from PCO2 to PFDI exists in Bangladesh, China, Costa Rica, Panama, Sri Lanka and Turkey. The causality running from TRO to PFDI found in Bangladesh, Brazil, Congo, India, Mauritius, Panama, South Africa and Thailand. The overall short-tun causality, i.e., causality running from both PCO2 and TRO to PFDI found in Bangladesh, Brazil, China, Costa Rica, India, Panama, South Africa and in Turkey.

Lastly, in third equation, the result shows that there is unidirectional causality running from PCO2 to TRO in Bangladesh, Bulgaria, Costa Rica, South Africa, Turkey and Vietnam. Similarly, the individual unidirectional causality from PFDI to TRO presence in Bangladesh, Bulgaria, Congo, Fiji, Indonesia, Mauritius, Mexico, Paraguay, South Africa, Sri Lanka, Thailand and in Vietnam. Finally, the overall, i.e., both PCO2 and PFDI simultaneously causes TRO in Bangladesh, Bulgaria, Costa Rica, Fiji, Indonesia, Mauritius, Mexico, Paraguay, Romania, South Africa, Thailand, Turkey and in Vietnam.

5. Conclusion

The sustained reduction of environmental quality is a crucial issue in the recent years. The increase of trade and foreign direct investment are the elements among the major cause of environmental degradation in the developing nations. Focussing on 26 nations with upper-middle as well as lower-middle income level, the Johansen cointegration test result shows that there is long-run relationship among per capita FDI (PFDI), per capita trade openness (TRO) and per capita CO2 (PCO2) in four countries, namely Argentina, Jordan, Russia and Thailand. The estimated vector error correction model shows that the long-run causality that is running from PFDI, TRO to PCO2 in Argentina, Jordan and Russia. According to the Wald test result of VAR model, short-run causality from PFDI, TRO to PCO2 is found in Jordan.

Similarly, the Block Exogeneity test result shows the alternative short-run causal relation in different countries. For example, PFDI individually affects PCO2 in Brazil, India and in Kenya. TRO causes PCO2 in Bulgaria, China, India, Paraguay, Romania, Sri Lanka, Thailand and Turkey. Both PFDI and TRO jointly causes PCO2 exists in Brazil, Bulgaria, India, Indonesia, Kenya, Romania, Sri Lanka, Turkey and in Vietnam.

In contrast, PCO2 causes PFDI in Bangladesh, China, Costa Rica, Panama, Sri Lanka and Turkey. TRO causes PFDI in Bangladesh, Brazil, Congo, India, Mauritius, Panama, South Africa and Thailand. Both PCO2 and TRO causes PFDI in Bangladesh, Brazil, China, Costa Rica, India, Panama, South Africa and in Turkey.

Lastly, PCO2 causes TRO in Bangladesh, Bulgaria, Costa Rica, South Africa, Turkey and Vietnam. PFDI causes TRO in Bangladesh, Bulgaria, Congo, Fiji, Indonesia, Mauritius, Mexico, Paraguay, South Africa, Sri Lanka, Thailand and in Vietnam. And both PCO2 and PFDI simultaneously causes TRO in Bangladesh, Bulgaria, Costa Rica, Fiji, Indonesia, Mauritius, Mexico, Paraguay, Romania, South Africa, Thailand, Turkey and in Vietnam.

Though the study has obtained some relevant results required for policy formulations, there could be better results if it could make two different panels of the countries depending upon their magnitudes of trade or geographical/spatial dimensions. The study preserves it as its future research agenda.

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