Investigating the foreign trade-emission nexus in RCEP

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Abstract: Foreign trade is usually considered a culprit for rising emissions. In this article, the authors attempt to understand whether the creation of the regional comprehensive economic partnership (RCEP) will lead to more emissions from the region. To meet this objective, the study analyses the relationship between foreign trade and carbon emissions of the 15 RCEP constituents, using macroeconomic data for the period 1991–2016. The long-term causal relationship between foreign trade and emissions was tested using the ARDL bounds test. The results indicate a long-run causal relationship between the two variables. A fully-modified OLS regression model confirms that the three variables considered – foreign trade, economic growth, and energy consumption – have a significant, positive impact on emissions on RCEP member countries. The analysis of individual countries also confirms the cointegration between foreign trade and carbon emissions. ECMs further show the correction happens from foreign trade to carbon emissions.

Keywords: trade agreement; RCEP; emissions; foreign trade.

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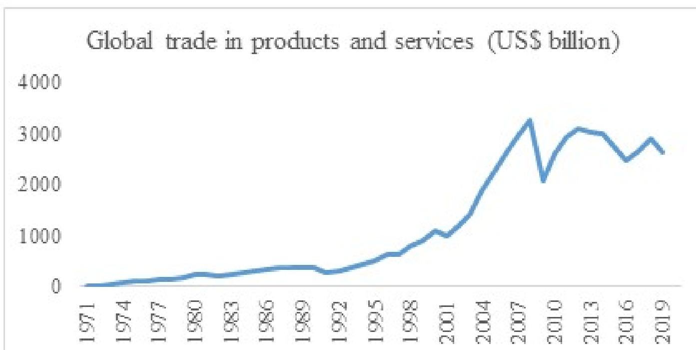
1 Introduction

Foreign trade and its impact on global warming have been a major concern for academics, politicians, industrialists, and conservationists. Post general agreement on tariffs and trade (GATT), free trade agreements (FTAs) have mushroomed across regions. Domestic economic growth through access to global markets is the primary motivation for these regional trade agreements (RTAs). While the western economies formed the North American Free Trade Agreement (NAFTA) and European Union (EU), the developing economies in Asia came together to form ASEAN and SAARC trade blocs. These regional agreements have increased foreign trade since the 1970s (refer to Figure 1). The growing trade brought in production and growth for the developing FTA member countries. Traditional trade theories – theories of absolute and comparative advantage – support the premise that foreign trade would lead to higher economic growth.

Figure 1 Global trade ($ billion) (see online version for colours)



Source: World Bank

Foreign trade led to increased production, particularly in developing economies. These opportunities brought economic growth and employment to these countries. However, the economic growth driven by foreign trade also brought in concerns regarding its long-run impact on carbon emissions. This concern is justified as energy production in poor countries is still dependent on carbon-intensive fossil fuels, primarily coal. Some empirical studies also indicate that trade openness has exposed developing countries to higher emissions (Shahbaz et al., 2017). Findings from empirical studies indicate that the relationship between trade and emissions is specific to the regions covered.

Regional comprehensive economic partnership (RCEP), an FTA initiated by Indonesia in 2011, came into force on January 1, 2022. It is the largest trade bloc with the participating countries representing one-third of the global gross domestic product (GDP) and almost half of the world population (RCEP, 2022). RCEP participants include members of ASEAN (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam) and their FTA partners (Australia, China, Japan, New Zealand, and South Korea). These countries together accounted for more than 30% of the global GDP in 2020. Similar to the earlier RTAs, RCEP targets to reduce transit costs of goods, services, and factors of production through reducing import tariffs, unified rules, and streamlined supply chains. The free trade zone is expected to boost the industrial output of China, the world's largest emitter of carbon (Wardani and Cooray, 2019). This raises concerns as almost three-fourths of the energy used in China is generated through fossil fuels. Due to its high emission intensity and fossil fuel use, China reported a 170% increase in its emissions during the last decade (EIA, 2020; Liu et al., 2016).

Though there is a growing literature on the relationship between foreign trade, economic growth, and carbon emissions, there is no available research specifically covering RCEP member countries. RCEP is an important trade group as the economies are primary drivers of growth in the Asia-Pacific region. In addition to maintaining economic growth, these countries are also required to shift towards cleaner growth trajectories (UNFCCC, 2015b).

In this context, this study examines the nexus between foreign trade and carbon emissions in RCEP. The analysis is based on the macroeconomic data of 15 RCEP members during 1991-2016, as the majority of the developing countries liberalised their trade policies during the 1990s. The period chosen for the study was limited due to the unavailability of country-level carbon emissions data in the World Bank (WB) database. In addition to external trade and emissions, income levels (GDP per capita) and energy use (per capita energy consumption) were included as control variables. The consolidated dataset was a panel covering 15 cross-sections and 26 time periods. Panel unit-root test was used to check data stationarity. As the primary objective of the study was to understand the foreign trade-carbon emissions nexus, cointegration using the auto-regressive distributed lag (ARDL) bounds test was checked. The direction of correction was confirmed using an error correction model (ECM) and Granger causality. The long-run relationship between the exogenous and emissions was modelled using a panel fully modified ordinary least squared (FMOLS) regression model. In addition to the aggregate RCEP, the study also estimates the country-level cointegration equation. The paper also discusses the implications of the findings.

The article extends the growing literature connecting foreign trade, economic growth, and carbon emissions. With countries getting more conscious about the environmental impacts of their policies, carbon emissions become a critical criterion while formulating foreign trade agreements. The findings of this article provide evidence for strategically controlling the production mix, especially in developing countries. The article is organised into five sections – the next section covers relevant theories and literature followed by research methodology in Section 3, findings in Section 4, a discussion of results in Section 5, and the conclusion in Section 6.

2 Theoretical framework and literature review

2.1 Theoretical framework

Based on comparative cost advantage, Ricardo argued that trade of goods with lower opportunity cost can be advantageous to both trading partners (Ricardo, 1817). The theory was proposed during the industrial revolution and hence the long-term effect of carbon emissions on global warming was excluded. Considering the absence of such externalities, Ricardo concluded that both trading parties stood to gain if they focused on producing goods advantageous to them. However, later economists showed that there is no surety of net trade gains once the externalities are included (Harris, 2004). Growing scientific evidence of global warming and its links to carbon emissions have forced policymakers to penalise polluters. The penalty has taken varied forms such as tariffs, permits, and carbon credits. However, these penalties are in prominence primarily in developed countries and the poorer countries are yet to implement such regulations. With rising penalties in western countries, polluting industries are shifting their production to developing countries. Western countries are looking to import these high-carbon products manufactured in developing countries, rather than producing them in-house. Academicians have highlighted how foreign trade is used to export pollution from wealthier to poorer nations, rather than finding a solution for the emissions problem (Rothman, 1998). This creates pollution havens in less developed countries with lax environmental laws. Modern economists have used this pollution haven hypothesis to explain the direction of bilateral foreign trade (Copeland, 2008). The pollution haven hypothesis is considered an extension of Ricardo's comparative advantage theory with developing countries having a comparative advantage due to their lenient environmental laws. This is particularly true for products with high pollution intensity. However, with UNFCCC setting and tracking national emissions targets (UNFCCC, 2015a), even developing countries feel the need to tighten their environmental regulations. Policymakers in these countries are increasingly becoming aware of their export mix and are grappling with balancing economic growth and emissions.

The pioneering work to assess the impact of trade openness on the environment was conducted by Harris (2004). According to the researcher, the impact on the environment can be separated into three independent parameters – scale, composition, and technique. Trade openness increases economic activity as production within the country to cater to the new markets increase. This increase in the scale of production leads to higher energy consumption and emissions. Harris argued that trade openness could also bring in a change in the composition of products manufactured within the country. Post liberalisation, if the country allocates its resources to manufacturing products with lower emissions, then trade openness could lead to a drop in emissions. However, if the production of polluting industries picks up post-liberalisation, this would lead to higher country-specific emissions. The impact of a change in the composition will depend on national trade strategies and hence, will be difficult to predict. Another impact of trade is exposure to advanced, cleaner technologies. Harris explained the impact of 'technique' transfer on emissions of producing countries using two approaches. In the first case, producers have increased access to clean technologies through foreign exposure. Over time, the cost of these technologies in the domestic market starts decreasing making them affordable to producers. It is also possible that access to a larger market motivates local producers to invest in building new sustainable products.

The effect of growth on emissions has also been explained using the environmental Kuznets curve (EKC) hypothesis (Grossman and Krueger, 1991). According to the EKC hypothesis, the relationship between economic growth and the emissions of a country takes an inverted U-shape. With the increased production in developing countries post-liberalisation boosting economic growth, EKC predicts the emissions to keep increasing until it starts dropping beyond a growth point. The drop has been explained using the increasing demand for better living conditions from citizens with higher disposable incomes.

The theoretical relationship between trade liberalisation and emissions can be explained using the paths shown in Table 1.

Table 1 Transmission channels connecting trade to emissions

Component	*Transmission process*	*Impact on emissions*
Scale	Liberalisation → increase in production → more energy use → higher emissions	Increase
Composition	Liberalisation → change in product composition → more/less energy use → higher/lower emissions	Increase or decrease depending on the product composition
Technique	Liberalisation → transfer of cleaner technologies → less energy use → lower emissions	Decrease
	Liberalisation → increase in production → increase in income → demand for cleaner production → lower emissions	

Source: Authors' analysis

As is evident from Table 1, scale and technique have opposing impacts on carbon emissions, while the impact of changing composition post-liberalisation depends on production strategy. The extent of the impact will depend on the comparative strength of each of these parameters. We can conclude that the overall impact is country-specific and hence, cannot be generalised. Having said that, countries rarely change their production strategies, and hence, the existing link between foreign trade and emissions can be used to predict the effect of future trade agreements on emissions.

2.2 Recent literature

The nexus between trade, economic growth, and carbon emissions have raised much interest among academicians (Ang, 2007; Cole and Elliott, 2003; Duan et al., 2021; Shen et al., 2022; Soytas et al., 2007). The empirical studies connecting these factors are vast and growing. There is a consensus among academicians that economic growth has a significant impact on a country's carbon emissions. Many researchers have empirically validated the EKC hypothesis (Ang, 2007; Managi and Jena, 2008). Studies have shown that higher economic growth need not necessarily translate to a reduction in emissions, even in the long run. Empirical studies have shown that an increase in income can lead to steadily rising emissions (Holtz-Eakin and Selden, 1995). Some researchers have also reported no significant relationship between economic growth and emissions (Richmond and Kaufmann, 2006). The majority of the studies agree that economic growth requires higher energy consumption which leads to higher carbon emissions (Alshehry and Belloumi, 2015; Ghosh, 2010; Kraft and Kraft, 1978; Stern, 1993).

Region-specific studies on the nexus between economic growth, economic growth, and emissions have shown mixed reports (Zhang and Cheng, 2009). A study conducted on countries in the Middle East and North Africa (MENA) reported a causal relationship between the variables (Omri, 2013). Recent literature has extended the variables to include trade openness (Halicioglu, 2009). The study conducted by Shahbaz et.al. modelling the trade and emissions of 105 countries across income groups (Shahbaz et al., 2017) concluded a reversed U-shaped relationship across all groups. However, Sohag et al. (2017) concluded that foreign trade led to a drop in emissions only in high-income countries. The study covering 82 countries reported mixed results for low – and middle-income groups. Other researchers studying trade and emissions have also reported a difference in results based on the regions covered. For instance, Managi and Jena (2018) reported with empirical evidence that trade helped reduce emissions of technologically advanced countries while increasing it in non-advanced countries. A few studies have also shown a reduction in emissions from developing countries with increasing trade (Jayanthakumaran et al., 2012).

Considering the contradicting results linking trade and emissions in literature, we can conclude that the direction and extent of the link between foreign trade and emissions are region-specific. The lack of literature on factors impacting the emissions of RCEP countries motivated the researchers to develop an empirical model linking foreign trade and the emissions of RCEP members.

3 Research methodology

3.1 Data and variables

After setting the research objectives, we look at the data and variables used for analysis. As the objective is to understand the statistical link between foreign trade and carbon emissions in RCEP member countries, the research utilises total trade (sum of exports and imports in US$ at current prices) and CO2 emissions (represented in kt tons) to represent foreign trade and environmental damage. CO2 emissions are the principal GHG emission and hence, the inclusion of the variable to represent environmental damage is justified. Following the literature, control variables representing per capita income and energy consumption are introduced in the model. GDP per capita (in US$ at current prices) is used to represent per capita income. Energy consumption per capita represented in kg of oil equivalent is used for energy consumption. Considering the wide dispersion across cross-sections, all variables are log-transformed for modelling. All the required data is obtained from WB database.

The compilation of the macroeconomic variables across 15 RCEP member countries over the period 1991–2016 yielded the panel data for analysis. The majority of the Asia-Pacific economies liberalised their trade policies during the 1990s. The time period is restricted due to the unavailability of CO2 emissions data in the WB database for periods beyond 2016. A detailed description of the variables considered for this study is available in Table 2.

Table 2 Variables used for analysis

Variable	*Units*	*Definition*
CO2	Kiloton (kt)	Carbon dioxide emissions. It is expressed as the equivalent weight of elemental carbon
FTrade	US$ billion	Foreign trade is the sum of imports and exports expressed in current prices
PerCapitaGDP	US$	Gross domestic product divided by midyear population
PerCapitaEnergy	Kg of oil equivalent	Use of primary energy. Sum of indigenous production and stock changes minus exports and that used for international transport

Source: WB Database

3.2 Methodology

Considering the time-series nature of the data used for analysis, the first step was to determine stationarity using a panel unit root test, Levin-Lin-Chu test (Levin et al., 2002). If the four variables – CO2, FTrade, PerCapitaGDP, and PerCapitaEnergy – are stationary at level or at first difference, the cointegration of the variables can be checked through an ARDL model. If the variables are cointegrated, only then we can build a long-term regressive relationship. The optimum lag for the ARDL model is obtained before building the ARDL model.

3.3 Modelling

The ARDL model can be written as:

$$\begin{aligned}\Delta \ln CO_{2t} = {} & \rho 0 + \sum \rho 1i^{*}\Delta \ln FTrade_{t-i} + \sum \rho 2i^{*}\Delta \ln PerCapitaGDP_{t-i} \\ & + \sum \rho 3i^{*}\Delta \ln PerCapitaEnergy_{t-i} + \sum \rho 4i^{*}\Delta \ln CO_{2t-i} \\ & + \rho 5i^{*}\ln FTrade_{t-i} + \rho 6i^{*}\ln PerCapitaGDP_{t-i} \\ & + \rho 7i^{*}\ln PerCapitaEnergy_{t-i} + \rho 8i^{*}\ln CO_{2t-i} + \Phi_t\end{aligned} \tag{1}$$

After building the ARDL model, we check the autocorrelation of the residuals using Durbin-Watson statistics. Wald Test is conducted on the coefficients of lnFTrade, lnPerCapitaGDP, and lnPerCapitaEnergy, i.e., ρ_5, ρ_6, ρ_7, and ρ_8. The F-test statistic of the Wald Test is checked against the Pesaran table to confirm cointegration using bounds testing (Pesaran et al., 2001).

ECM to confirm the cointegration and direction of error correction can be expressed as:

$$\begin{aligned}\Delta \ln CO_{2t} = {} & \lambda_0 + \sum \lambda 1i^{*}\Delta \ln FTrade_{t-i} + \sum \lambda 2i^{*}\Delta \ln PerCapitaGDP_{t-i} \\ & + \sum \lambda 3i^{*}\Delta \ln PerCapitaEnergy + \theta^{*}ECT + \mu_t\end{aligned} \tag{2}$$

To understand the effect on carbon emissions, we represent carbon emissions as a function of trade, income levels, and energy use, i.e.

$$CO_{2it} = f\left(FTrade_{it}, PerCapitaGDP_{it}, PerCapitaEnergy_{it}\right) \tag{3}$$

To obtain the optimal estimates of cointegrating regression, a panel fully-modified OLS (FMOLS) model was developed. FMOLS model can be expressed as:

$$\ln CO2 = \lambda 0 + \lambda 1 * \ln FTrade + \lambda 2 * \ln PerCapitaEnergy + \lambda 3 * \ln PerCapitaGDP \tag{4}$$

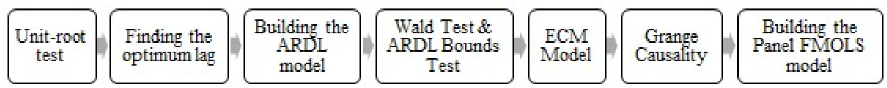
where $\ln CO_2$, lnFTrade, lnPerCapitaGDP, and lnPerCapitaEnergy are the natural logs of CO_2 emissions, foreign trade, per capita GDP, and per capita energy consumption, respectively.

This is in line with the econometric models exploring the relationship between trade, economic activity, energy use, and emissions (Dogan and Turkekul, 2016; Kasman and Duman, 2015). ε_{it} is the stochastic error term that is assumed to be normally distributed with constant variance, i.e., homoscedastic. The coefficients $\alpha 1$, α_2, and α_3 indicate the impact of the variable on carbon emissions with their sign and value showing the direction and extent of the impact, respectively. α_0 is the constant parameter. As most of the Asian economies included in RCEP are still in the developing stage, we expect α_1 to be positive, indicating a positive impact of foreign trade on carbon emissions.

Cross-sectional ECM equations of individual member countries are checked to verify cointegration. The causality is confirmed using the Granger Causality test.

The step-wise methodology involved is summarised in Figure 2.

Figure 2 Step-wise methodology



Source: Authors' analysis

The findings of the analysis are discussed in the following section.

4 Findings

To gain an understanding of the variables before analysis, we built a descriptive statistics table (Table 3). The table shows the wide disparity between the parameters across the RCEP members. This justifies the log transformation of the variables before analysis.

Next, Levin-Lin-Chu test is used to check the stationarity of variables. Results of the unit root test (Table 4) indicate the stationarity of all the variables at level or first difference. As all the variables are stationary at level or first difference, data meets the requirement for constructing an ARDL model.

Table 3 Descriptive statistics

Variable	*Mean*	*Median*	*Maximum*	*Minimum*	*Std. dev.*
CO2 (kt)	625,007	127,183	10,291,927	1,540	1,585,074
FTrade (US$ bn)	385	153	4,700	0.03	641
PerCapitaGDP (US$)	14,099	5,739	68,150	137	16,033
PerCapitaEnergy (kg of oil equivalent)	2,811	2,164	9,838	251	2,331
lnCO_2	11.63	11.75	16.15	7.34	1.96
lnFTrade	25.38	25.76	29.18	17.31	2.17
lnPerCapitaGDP	8.52	8.65	11.13	4.92	1.70
lnPerCapitaEnergy	7.45	7.68	9.19	5.53	1.11

Source: World Bank database

ARDL models are sensitive to the lag of variables used. To find the optimum lag, different information criteria are used (Table 5). Based on the principle of parsimony, we proceed to build an ARDL model with a lag length of two, based on SC.

Now we proceed to construct ARDL with lag 2. Lag 2 can be used to revise the ARDL model as:

$$\begin{aligned}\Delta lnCO_{2t} = {} & \rho 0 + \rho 11{*}\Delta lnFTrade_{t-1} + \rho 12{*}\Delta lnFTrade_{t-2} \\ & + \rho 22{*}\Delta lnPerCapitaGDP_{t-1} + \rho 22{*}\Delta lnPerCapitaGDP_{t-2} \\ & + \rho 31{*}\Delta lnPerCapitaEnergy_{t-1} + \rho 32{*}\Delta lnPerCapitaEnergy_{t-2} \\ & + \rho 41{*}\,\Delta lnCO_{2t-1} + \rho 42{*}\Delta lnCO_{2t-2} + \rho 5{*}lnCO_{2t-1} \\ & + \rho 6{*}lnFTrade_{t-1} + \rho 7{*}lnPerCapitaGDP_{t-1} \\ & + \rho 8{*}lnPerCapitaEnergy_{t-1} + \Phi_t \end{aligned} \tag{5}$$

The ARDL model based on (5) is given in Table 6. The Durbin-Watson statistic (1.9489) shows that there is low autocorrelation. To check for cointegration, we conduct the Wald test on long-run variable coefficients, namely, $lnCO_{2t-1}$, lnFTradet-1, $lnPerCapitaGDP_{t-1}$, and $lnPerCapitaEnergy_{t-1}$.

Table 4 Results of the stationarity test

Panels/series	*At level*↓		*At first difference*↓	
	Intercept	*Intercept and trend*	*Intercept*	*Intercept and trend*
$lnCO_2$	–3.0549**	0.1946	–12.2742**	–10.4947**
	(0.0011)	(0.5771)	(0.0000)	(0.0000)
lnFTrade	–3.9427**	2.0280	–12.4657**	–9.5054**
	(0.0000)	(0.9787)	(0.0000)	(0.0000)
lnPerCapitaGDP	–0.7072	0.4586	–10.4041**	–9.2044**
	(0.2397)	(0.6767)	(0.0000)	(0.0000)
lnPerCapitaEnergy	–2.7266**	–2.2702**	–9.3796**	–7.1951**
	(0.0032)	(0.0116)	(0.0000)	(0.0000)

Note: ↓Levin-Lin-Chu statistic with the p-value in bracket; **$p < 0.05$.

Source: Authors' analysis

Table 5 Choosing optimum lag for the ARDL model

Lag	*AIC*	*SC*	*HQ*
0	11.76	11.82	11.78
1	–4.04	–3.77	–3.93
2	–4.53	–4.05*	–4.34
3	–4.68	–3.99	–4.40
4	–4.78*	–3.88	–4.42*

Notes: *Indicates lag order selected by the criterion
AIC: Akaike information criterion; SC: Schwarz information criterion;
HQ: Hannan-Quinn information criterion

Source: Author's analysis

The Wald test results are given in Table 7. The null hypothesis equates the coefficient ρ_5, ρ_6, ρ_7, and ρ_8 to zero. Comparing the results of the Wald test with the Pesaran table, the F-statistic of 7.7361 is higher than the upper bound at both 5% and 1% levels of significance. Hence, we can conclude that the variables are cointegrated indicating a long-term association between emissions, trade, growth, and energy use.

Table 6 ARDL Model coefficients

Dependent variable: $\Delta lnCO_{2t}$	
Variable	*Coefficient (p-value)*
$\Delta lnFTrade_{t-1}$	0.0234 (0.1216)
$\Delta lnFTrade_{t-2}$	0.0062 (0.6785)
$\Delta lnPerCapitaGDP_{t-1}$	0.0869* (0.0938)
$\Delta lnPerCapitaGDP_{t-2}$	0.0153 (0.7699)
$\Delta lnPerCapitaEnergy_{t-1}$	0.0296 (0.7565)
$\Delta lnPerCapitaEnergy_{t-2}$	0.1959** (0.0440)
$\Delta lnCO_{2t-1}$	–0.0815 (0.1842)
$\Delta lnCO_{2t-2}$	–0.2848** (0.0000)
$lnCO_{2t-1}$	–0.0129** (0.0178)
$lnFTrade_{t-1}$	0.0128** (0.0240)
$lnPerCapitaGDP_{t-1}$	–0.0148 (0.2354)
$lnPerCapitaEnergy_{t-1}$	–0.0103 (0.5549)
Constant	0.0639 (0.5189)
R-squared	0.1718
Adjusted R-squared	0.1369
F-statistic (p-value)	4.9269 (0.000)
Durbin-Watson statistic	1.9489

Note: **$p < 0.05$, *$p < 0.1$.

Source: Authors' analysis

Table 7 Wald test result and Pesaran table

Null hypothesis: $\rho_5 = \rho_6 = \rho_7 = \rho_8 = 0$			
Test statistic	Value (p-value)		
F-statistic	7.7361*** (0.0000)		
Lower and upper bounds from Pesaran table			
5% level		*1% level*	
Lower bound	*Upper bound*	*Lower bound*	*Upper bound*
4.01	5.07	5.17	6.36

Note: ***$p < 0.01$.

Source: Author's analysis and Pesaran table

To confirm cointegration and to check the direction of error correction, we proceed to build an ECM. The ECM can be represented as:

$$\begin{aligned}\Delta lnCO_{2t} = \lambda_0 &+ \sum \lambda 1i^*\Delta lnFTrade_{t-i} + \sum \lambda 2i^*\Delta lnPerCapitaGDP_{t-i} \\ &+ \sum \lambda 3i^*\Delta lnPerCapitaEnergy_{t-i} + \sum \lambda 4i^*\Delta lnCO_{2t-i} \\ &+ \theta^*ECT + \mu_t\end{aligned} \quad (6)$$

ECT stands for error correction term. For error correction to happen from independent variables to carbon emissions, the coefficient of ECT, θ, should be negative and significant. The coefficient of ECM, using the optimum lag of 2, is given in Table 8. The coefficient of ECT in Table 8 is negative and significant confirming that error correction is happening from the independent variables to carbon emissions.

Table 8 ECM

Dependent variable: $\Delta lnCO_2$	
Variable	Coefficient (p-value)
ECT	*–0.0942*** (0.0489)*
$\Delta lnCO_2(-1)$	–0.1601** (0.0047)
ΔlnPerCapitalEnergy	0. 8631** (0.0030)
ΔlnPerCapitalEnergy(–1)	–0.0017 (0.9944)
ΔlnPerCapitalGDP	–0.0265 (0.8519)
ΔlnPerCapitalGDP(–1)	0.0285 (0.6707)
ΔlnFTrade	–0.0424 (0.6165)
ΔlnFTrade(–1)	0.0964* (0.0694)
Constant	0.0031 (0.9449)

Note: **$p < 0.05$; *$p < 0.10$.

Source: Author's analysis

Table 9 Short-run ECT of cross-sectional ECMs

Country	*ECT (p-value)*
Australia	0.1136 (0.0001)
Brunei	–0.1471 (0.0097)
Cambodia	–0.0349 (0.0014)
China	0.0267 (0.0013)
Indonesia	–0.3776 (0.0001)
Japan	0.0498 (0.0002)
Malaysia	–0.2118 (0.0001)
Myanmar	0.1663 (0.0002)
New Zealand	0.1302 (0.0019)
Philippines	–0.1440 (0.0019)
Singapore	–0.2996 (0.0008)
South Korea	–0.0987 (0.0000)
Thailand	–0.3538 (0.0001)
Vietnam	–0.1377 (0.0000)

Note: **$p < 0.05$.

Source: Source: Authors' analysis

The cross-sectional ECM is checked to confirm whether the variables are cointegrated in individual countries. The cointegration will depend only on the sign (-ve) and significance of the ECT. Table 9 lists the short-run ECT of cross-sectional ECMs. As is evident from the table all the member countries, except Australia, China, Japan, Myanmar, and New Zealand, have a long-run association between trade, emissions, growth, and energy use. Detailed analytical studies are required to understand country-specific dynamics which is not within the scope of this article.

Granger causality is used to confirm the direction of influence. The results (Table 10) show two-way causality, i.e., foreign trade impacting carbon emissions and vice versa.

Table 10 Results of Granger Causality

Null hypothesis	*F-statistic*	*p-value*
FTrade does not Granger Cause CO_2	15.5326	0.0000
CO2 does not Granger Cause FTrade	29.6235	0.0000
lnFTrade does not Granger Cause lnCO_2	3.8108	0.0231
lnCO2 does not Granger Cause lnFTrade	4.1928	0.0159

Source: Authors' analysis

Table 11 FMOLS results

Dependent variable: lnCO_2	
Variable	Coefficient (p-value)
lnFTrade	0.0931** (0.0174)
lnPerCapitaEnergy	0.7972** (0.0000)
lnPerCapitaGDP	0.1492** (0.0043)

Note: **$p < 0.05$.

Source: Authors' analysis

Having established a long-run relationship between the variables, we can now proceed to construct the panel FMOLS model. The results of the FMOLS, given in Table 11, show all variables have a significant, positive impact on lnCO_2.

The results are discussed in the following section.

5 Discussion

The stationarity test results (Table 4) show that the condition for ARDL, i.e., stationarity at level or first difference, is satisfied. The ARDL bounds test using the Pesaran table shown in Table 8 confirms cointegration, indicating a long-run relationship between emissions, trade, GDP, and energy consumption. The long-run relationship between the variables studied is established through panel FMOLS analysis (Table 11). The empirical results show that an increase in foreign trade, per capita GDP, and per capita energy consumption, significantly increased carbon emissions in RCEP countries. Every US$1 billion increase in foreign trade keeping the other variables constant leads to an additional 0.0931kt equivalent of emissions. This provides evidence that though the increasing foreign trade in RCEP is leading to economic growth, it is primarily driven by carbon-intensive production. Following the pollution haven hypothesis, the increase in carbon-intensive production could be because of the export of dirty industries from rich to poor countries. If the trend continues, the increasing trade post-RCEP would lead to higher emissions in the region. Though the findings are in line with the existing literature

(Managi and Jena, 2008), it raises concerns regarding the contribution towards global emissions.

Trade, and the ensuing economic growth, are expected to increase per capita income in the region. However, as per the model, every US$1 increase in income leads to a 0.1492kt equivalent growth in carbon emissions. This result is in agreement with the earlier studies covering developing countries (Omri, 2013). The positive link indicates that the region is still in the downward-slopping part of the EKC curve. As per the EKC hypothesis, the emissions are expected to keep increasing post-RCEP until the income levels reach a threshold point beyond which emissions will drop with increasing income.

The ECM and Granger causality confirm the relationship between foreign trade and carbon emissions. Granger causality results indicate a bi-directional relationship between trade and emissions. This finding agrees with the existing literature (Sun et al., 2019). The results provide further evidence of trade openness creating pollution havens by shifting polluting-intensive industries to countries with weak environmental regulations. Trade agreements further drive this, as it eases the transfer of production to the most cost-effective destination.

The FMOLS model shows that per capita energy consumption has a significant, positive impact on carbon emissions. According to the model, a one-unit increase in per capita energy consumption, keeping all other variables constant, leads to 0.7672kt equivalent of excess carbon emissions. Higher energy consumption, particularly in fossil-fuel-dependent member economies, would lead to more carbon emissions. Though this result is expected and is consistent with the existing literature (Zhang and Cheng, 2009), the positive relationship is again a concern for policymakers. Renewable and non-fossil energy industries are still evolving in the majority of the RCEP member countries. The results indicate that foreign trade has not led to the transfer of energy-efficient and clean energy technologies. For instance, China, the largest polluter among RCEP member countries, uses 22% of the global energy use of which more than 70% is fossil-fuel based.

Building on the models proposed by Harris (2004), we infer that the impact of scale and composition outweighs technique in the case of RCEP countries. The increasing production (scale) of carbon-intensive products (composition) is responsible for the increase in emissions. If foreign trade had focused on the transfer of cleaner technologies, it would have decreased emissions in the long run (Beghin et al., 1995). In addition to focusing on technology transfer, the member countries should also reassess their production composition. A gradual shift to environment-friendly products from high carbon-intensive ones would also reverse the relationship between trade and emissions. Another approach for policymakers would be the increased adoption of non-fossil sources of energy such as renewable energy, hydroelectric, and biomass. To boost the sector, the member countries should encourage foreign investment in clean energy.

The Paris agreement and the successive confederation of parties (COP) meetings have been pushing for targeted reduction of country-specific emissions. Now, it is essential for developed and developing nations to devise policy measures to ensure lower emissions. The results strongly support the need for a change in policies governing the environmental impacts of foreign trade among RCEP members. The first step in this process is to develop a national policy around environmental protection. Ecological laws need strengthening to facilitate the national agenda. This policy should encourage sustainable investments (clean energy, carbon sinks, etc.) while restricting polluting industries. The restrictions could be through a carbon tax or quotas which will reduce the competitiveness of polluting industries. Many researchers have also recommended carbon trading as an effective tool for restricting polluting industries in developing countries (Abbasi et al., 2017). The government should also include policies to incentivise non-fossil-based energy projects through building cheaper financing options, providing subsidies, and tax reliefs. This will reduce the reliance on fossil-fuel sources for driving economic growth. Trade should create long-term benefits for both trading partners. Hence, FTAs should provide a platform for their member countries to voice their environmental concerns (Prakash and Sethi, 2022).

6 Conclusions

RCEP, the largest trade bloc in history, would have significant impacts on the economic, social, and political landscape. This study focused on an important question of global concern, i.e., how would the formation of RCEP influence the region's emissions? The findings provided crucial insights into the relationship between foreign trade, economic growth, energy use, and emissions. The results indicate that despite leading to strong economic growth and rising income, foreign trade also increases per capita energy use leading to higher emissions from the region. This shows that the RCEP region has not evolved to be at the upward slope EKC curve where an increase in per capita income leads to lower emissions. For RCEP countries to move to this space, the focus should be on building national policies encouraging cleaner energy sources, production composition favouring low-carbon products and services, transfer of technology, and tighter regulations on polluting industries. The authors acknowledge that the findings are at an aggregate level. To devise national strategies, country-specific analysis of trade policies would be essential. Future research could focus on country-specific studies and increase the factors to include urbanisation, human capital, regulatory framework, and innovation intention.

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