Tariffs, Tensions, Transition and Environmental Sustainability: An Analysis of Trade Fragmentation and its Global Impact within the OECD Economies

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ABSTRACT
Trade fragmentation within global trading systems refers to the increasing complexity and division of trade links between various countries, often associated with the rise of regional trade agreements that create distinct trading blocs. This paper examines the impact of trade openness on the economic growth of 31 selected nations within the Organisation for Economic Cooperation and Development (OECD) between 1990 and 2024. The paper utilised the Pooled Ordinary Least Squares (OLS) regression. The findings indicate that trade openness has a positive influence on economic growth. Furthermore, CO_2 emissions and political stability have a positive influence on economic growth within the nations. This paper, therefore, recommends strengthening trade relations, boosting energy transitions, and utilising clean energy sources as a means of increasing trade while also mitigating environmental degradation.

Introduction

Trade fragmentation within global trading systems refers to the increasing complexity and division of trade links between various countries, often associated with the rise of regional trade agreements that create distinct trading blocs [1]. Trade fragmentation reduces geopolitical risks but typically increases trade concentration, resulting in substantial macroeconomic consequences. It is essential to recognise that international trade plays a crucial role in the global economy, facilitating the exchange of capital, goods, and services across borders. However, globalisation, tariffs, and trade agreements have reshaped how countries intersect economically [2].

While evidence suggests that trade conflicts, trade restrictions and tensions between countries can have unintended consequences, such as tariff hikes on imported goods, which can result in trade fragmentation, the incorporative initiative of sustainability has become a significant procurement at the forefront of trade agreements [3,4]. Many trading parties have undergone significant transitions to enhance their international competitiveness and environmental sustainability within the global trading landscape, leaving many behind in the process [5]. It is therefore crucial to investigate trade fragmentation and its global impact, taking into account the roles of tariffs, tensions, and environmental sustainability. This paper examines the impact of trade openness on the economic growth of 31 selected nations within the Organisation for Economic Cooperation and Development (OECD).

While the United States of America has proposed imposing 25% tariff on imports from some of its trading partners within the OECD (Canada and Mexico) and 10% tariff on imports from China in the 1st quarter of 2025, the OECD nations accounted for 52.6% and 57.7% of the global exports and imports, respectively in the year 2023 [6] . Scholars believe that the recent tariffs imposed by the USA could trigger or worsen trade wars; however, evidence suggests that an increase in tariffs may, in many cases, deter foreign entities that create new job opportunities for local economies [7,8]. Nevertheless, despite rising tariffs, tensions, and international trade agreements, the GDP growth within OECD economies is projected to increase from 1.4% in 2025 to 1.5% in 2026 [9].

It is important to note that within international trade, trade openness (exports plus imports) positively influences economic growth and economic growth results in an increase in carbon dioxide emissions [10,11]. These aspects of international trade have prompted the World Trade Organisation (WTO) committee for trade and environment to bring sustainable development and environmental considerations into the organisation's domain [12]. However, notwithstanding the increased trade fragmentation within the OECD, the nations have not maintained their commitment to achieving the United Nations' Sustainable Development Goals (SDGs), which include reducing carbon emissions and promoting energy transition [13].

The nations are considered the highest complexity in the world; their hydrocarbons and primary energy consumption significantly contribute to global warming [14]. Moreover, the OECD countries remain high emitters, despite reducing their share of global energy-related emissions from 50% in 1990 to 35% today. Scholars have suggested that there is a direct link between trade openness and CO2 emissions within these nations, which is mediated by income growth, exerting an opposing adverse effect on the relationshi [15]. As a counter-effect of high emissions, the energy transition has been widely recognised as crucial for achieving sustainable development; hence, the OECD economies have achieved 57.46% of the world's clean energy sources [16,17]

Figure 1 below illustrates the relationship between trade openness, GDP, and CO_2 emissions in OECD countries from 1990 to 2024.
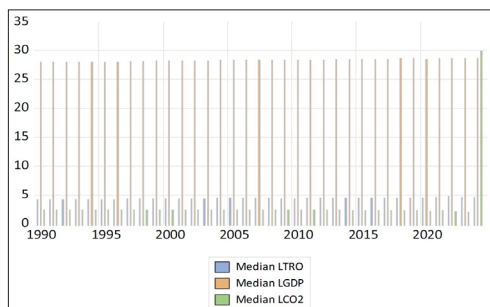

Figure 1: Link Between Trade Openness, GDP and CO_2 Emissions

Source: Author's Drawing, Data from EViews 13

From Figure 1 above, it can be concluded that as trade openness increases, GDP also increases drastically, while CO2 emissions decrease. This substantiates the fact that the OECD economies have achieved 57.46% of the world's clean energy sources. However, it can be noted from Figure 1 that CO2 emissions rise enormously above GDP and trade openness in the year 2024; hence, Hamroni, Hasni, and Jebli (2025) argue that the OECD economies remain the world's largest emitters. Figure 2 below depicts the selected 31 OECD countries.

Figure 2 illustrates the flags of the countries this paper focuses on. These include Australia, Austria, Belgium, Canada, Chile, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Israel, Italy, Japan, South Korea, Luxembourg,

Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Türkiye (Turkey), United Kingdom and the United States respectively.
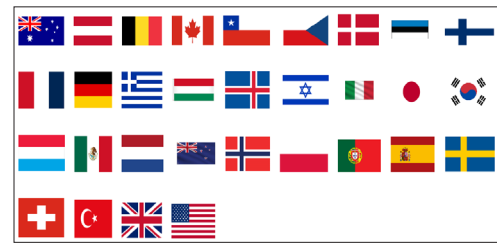

Figure 2: 31 Selected OECD Countries

Source: Author's Compilation. Flags from Google

That said, it is particularly significant to note that there is a phenomenon that better explains how nations interact within the global economy. It is the relationship between political stability and international trade. Political stability fosters an environment that attracts both foreign and domestic investments, facilitating trade and promoting continuous economic growth [18]. Evidence suggests a positive correlation between political stability and various economic factors, such as trade openness and GDP, and an adverse correlation between political stability and CO_2 emissions. However, research has noted that limited studies examine the interplay between trade openness, GDP, CO_2 emissions and political stability within the OECD countries. This paper, therefore, aims to broaden our understanding of the link, as mentioned earlier, noting the role of political stability in international trade and trade fragmentation.

Literature Review
Theoretical Literature
This section presents the theories applied in this paper. At the core of the discussion is Adam Smith's international trade theory (16th and 18th centuries), which describes a situation where a nation achieves a trade surplus by exporting more goods than it imports, thereby avoiding a trade deficit. Other theories include Simon's environmental Kuznets curve (EKC) (1990s) and the theory of optimum tariffs (1830s and 1840s). An empirical review is also conducted in the paper

Adam Smith's International Trade Theory (Mercantilism)
Mercantilism was first coined by Adam Smith and dominated the economic policy in Europe during the 16th and 18th centuries. The mercantilist system was based on the belief that global wealth was finite, and it urged governments to regulate trade to boost wealth and increase national power. As such, during the specified period, European countries sought to increase their share of global wealth by boosting exports and reducing imports through protective tariffs [19]. However, it has been argued that mercantilism stresses monopoly and regulation, leading to corruption and inefficiency. Furthermore, mercantilism leads to high tariffs on imports, which trigger retaliation, trade wars or even a rise in tension between countries. Within the context of this study, the theory suggests that nations impose high tariffs on imports to increase their global share or raise their economic growth. However, such an action usually leads to trade wars.

Simon's Environmental Kuznets Curve (EKC)

The environmental Kuznets curve (EKC) is derived from the Kuznets curve, which illustrates the inverted-U-shaped relationship between income inequality and economic growth [20]. The theory emphasises that at the initial stage of economic development, ecological degradation increases to a certain threshold level, beyond which economic growth improves environmental sustainability due to increased environmental awareness [21]. Nevertheless, scholars still criticise the theory due to its normative implications. These include the theory's assumption that ecological degradation is an inevitable outcome of economic growth and its resolution lies in reaching a certain income level rather than continuously implementing environmental regulation policies [22]. Within the context of this study, the theory suggests that trade openness and economic growth will initially lead to high emissions, up to a point where information spillovers result in reduced emissions.

Theory of Optimum Tariffs

The theory of optimum tariffs dates to the 1830s and 1840s, but its key elements were largely established in 1907. In 1940, the British economist Nicholas Kaldor opposed the notion that unrestricted free trade was optimally advantageous not only for the world as a whole but also for every individual country, asserting that tariffs only benefit the levying country, with the exception that the duty is not too large [23]. Within international trade, this theory posits that tariffs generate revenue only in the country that imposes them; hence, tariff hikes result in retaliation or the withdrawal of investments by foreign companies.

Empirical Literature

Using historical datasets, examined the impact of trade openness on CO_2 emissions in 20 OECD countries over a 150-year period. Their study found that trade openness has a positive influence on CO_2 emissions. This finding is supported by Wang, Li and Li, who found that trade openness reduces carbon emissions within 122 countries, which supports the pollution haven hypothesis. Furthermore, Almulhim, Qamruzzaman, and Aljughaiman investigated the effect of green trade openness, natural resource rents, institutional quality and R&D investment on ecological sustainability in OECD nations between 2007 and 2022. Their study found that green trade openness, institutional quality, and R&D investment significantly curb CO_2 emissions within the nations. This finding is of paramount significance as it underscores the role of trade openness, specifically green trade openness, in mitigating carbon dioxide emissions.

Moreover, another study by Alkaya and Islamoglu examined the relationship between economic growth, CO_2 emissions, and trade openness within the OECD nations between 1990 and 2015 using simultaneous equation models. Their study reveals that trade openness does not affect CO_2 emissions, but rather that economic growth increases them. This finding is particularly significant as it supports the EKC, which states that economic growth usually raises ecological degradation in the initial stages of economic development. A study by Simbi, Yao and Zhang also revealed outcomes that underpin the EKC. Nevertheless, Alvi, Ahmad, Nawaz, Connell, Anser and Hassan argue that energy transition reduces greenhouse gas emissions (GHGs). Their argument aligns with the argument of this study; hence,

it is strongly emphasised that within OECD economies, energy transition has been the core of sustainable development.

Methodology
Model specification
The model specifications within this section analyse the correlation between Trade openness, GDP, CO2 emissions, and political stability in the OECD countries.

Pooled Ordinary Least Squares (OLS) regression

According to Wiredu, Nketiah, and Adjei and Nketiah, Adjei, Boamah, and Adu- Gyamfi, the pooled OLS method is often used to obtain consistent and unbiased estimates of parameters, even when constant time attributes are present. The study utilises the following ordinary econometric model:

$$y1 = \beta_0 + \beta_1 x_{it} + \beta_2 x_{it} + \ldots + \beta_n x_{it} + \mu_{it} \qquad (1)$$

This paper applied the impact of trade openness on the economic growth of 31 OECD economies by developing a simple economic model as shown below:

$$lnGDP_{it} = \alpha + \beta_1 lnTRO_{it} + \beta_2 lnCO_{2it} + \beta_3 lnPS_{it} + \mu_{it} \qquad (2)$$

Where: TRO is trade openness, GDP is economic growth, CO_2 is carbon dioxide emissions, and PS is political stability, all for natural logarithms. i and t represent countries and periods, respectively.

Fixed Effect (FE) Model

According to Oppong-Baah, Bo, Twi-Brempong, Amoah, Prempeh, and Addai, fixed effects investigate the correlation between outcome variables within a single entity. Furthermore, fixed effects omit the effect of predictors on the outcome variable. The equation below displays the FE models:

$$Y_{it} = \beta_1 X_{it} + a_i + \mu_{it} \qquad (3)$$

Where $a_i (i = 1, \ldots, n)$ is the unknown intercept for each entity (n entity-specific intercepts), Y_{it} is the dependent variable (DV) where $i = entity$ and $t = time$, X_{it} signifies one dependent variable (IV), β_1 is the coefficient for IV and μ_{it} is the error term

$$lnGDP_{it} = \alpha + \beta_1 lnTRO_{it} + \beta_2 lnCO_{2it} + \beta_3 lnPS_{it} + \mu_{it} \qquad (4)$$

Where: TRO is trade openness, GDP is economic growth, CO2 is carbon dioxide emissions, and PS is political stability, all for natural logarithms. i and t represent countries and periods, respectively.

Random Effects (RE) Model

Within the random effects model, the variation among entities is assumed to be random, and there is no correlation between the independent or predictor variables in the model. The random effects model is advantageous because it can include time-invariant variables, which the intercept would absorb (Oppong-Baah et al., 2020). The model can be expressed as follows:

$$Y_{it} = \beta_1 X_{it} + a_i + \mu_{it} + \varepsilon_{it} \qquad (5)$$

Where $a_i (i = 1, \ldots, n)$ is the unknown intercept for each (n entity-specific intercepts), Y_{it} is the dependent variable (IV), β_1 is the coefficient for that IV, μ_{it} is the Between-entity error and ε_{it} is the within-entity error.

$$lnGDP_{it} = \alpha + \beta_1 lnTRO_{it} + \beta_2 lnCO_{2it} + \beta_3 lnPS_{it} + \mu_{it} + \varepsilon_{it} \qquad (6)$$

Where: TRO is trade openness, GDP is economic growth, CO_2 is carbon dioxide emissions, and PS is political stability, all for natural logarithms. i and t represent countries and periods, respectively.

Data sources and Expected A Priori

Countries that were examined by this paper include Australia, Austria, Belgium, Canada, Chile, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Israel, Italy, Japan, South Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Türkiye (Turkey), United Kingdom and the United States. As such $N = 31$. The period from 1990 to 2024 was selected. Data was obtained from the World Bank. Trade openness is measured by the sum of exports and imports, which are proxied by the exports of goods and services (as a percentage of GDP) and imports of goods and services (as a percentage of GDP), respectively. Economic growth is proxied by GDP (constant LCU), CO_2 emissions are proxied by Carbon dioxide (CO_2) emissions excluding LULUCF per capita (t CO_2e/capita) and political stability is proxied by political stability and absence of violence/terrorism: percentile rank. The variables, symbols, expected outcomes and databases are shown in Table 1 below.

Table 1: Description of Data and Variables

Variable Name	Symbol	Expected Outcome	Database
Trade openness	TRO	Positive	World Bank
Economic growth	GDP	Positive	World Bank
Carbon emissions	CO_2	Positive	World Bank
Political stability	PS	Positive	World Bank

Estimation Techniques

This paper employed the LLC and IPS tests as part of the panel unit root tests. The fixed effects (FE) and the random effects (RE) methods were also employed in this paper.

Panel Cointegration and Unit Root Tests

To ascertain the order of integration, the paper conducted the Levin, Lin & Chu (2002) (LLC) and Im, Pesaran and Shin (IPS) tests. According to Barbieri, the LLC assumes homogeneous autoregressive coefficients between individuals, i.e., $p_i = p$ for all i, and test the null hypothesis $H_0: p_i = p = 0$ against the alternative $H1: p_i = p < 0$ for all i. When imposing a cross-equation restriction on the initial partial correlation coefficients under the null, the procedure yields an assessment of significantly higher power than performing a separate unit root test. The IPS test enables the detection of residual serial correlation and heterogeneity in group dynamics and error variances.

Table 2: Summary Statistics

Variables	Observations	Mean	Std. Dev.	Skewness	Kurtosis
LGDP	775	28.39427	2.387661	0.833253	3.902655
LTRO	775	4.628645	1.237207	2.563393	9.459783
LCO2	775	3.920288	6.752970	3.532177	13.57021
LPS	775	4.172005	0.511741	-2.270313	8.056558

To Note: Authors' drawings.
Source: Eviews 13. (*10%, **5% & ***1% significance level).

The method is the simplest way to estimate model parameters by combining cross- section and time series data. According to Fiveable, the pooled OLS method assumes that the correlation between the dependent and independent variables is constant across all periods and individual observations. Furthermore, the pooled OLS ignores the panel structure of the data and potential individual-specific effects, thus treating all the observations as independent. This paper employs this method to investigate the relationship between two phenomena: trade openness and economic growth. Additionally, this paper utilises fixed and random effects methods. According to Mustafa, the fixed effects method is pivotal in statistical analysis, enabling researchers to account for constant factors across different observations. The random effects method accounts for variations and variability between different entities. Furthermore, this paper employs the Hausman test to assess whether the random or fixed effects methods better fit the data set. According to Pedersen, within the Hausmann test, P-values < 0.05 indicate systematic variations in the coefficients of the estimates, necessitating the selection of the fixed effects method and vice versa.

Empirical Results

Table 3:Correlation Test

	LGDP	LTRO	LCO2	LPS
LGDP	1.0000000	-0.2636154	0.1241640	-0.0952150
LTRO	-0.2636154	1.0000000	-0.1087216	0.1421516
LCO2	0.1241640	-0.1087216	1.0000000	-0.2591655
LPS	0.0952150	0.1421516	-0.2591655	1.0000000

To Note: Authors' drawings.
Source: Eviews 13. (*10%, **5% & ***1% significance level).

Table 4: LLC and IPS Tests

Variable	Levin, Lin, and Chu		Im, Pesaran and Shin	
	Statistic	Prob.**	Statistic	Prob.**
LGDP	-7.75783	0.0000***	-21.9294	0.0000***
LTRO	-4.77285	0.0000***	-24.3082	0.0000***
LCO2	-23.1062	0.0000***	-22.9450	0.0000***
LPS	-5.58421	0.0000***	-5.99235	0.0000***

To Note: Authors' drawings.
Source: Eviews 13. (*10%, **5% & ***1% significance level).

Summary Statistics

Table 2 presents the statistical summary of the data. All variables have positive mean coefficients, indicating upward trends. The standard deviation indicates that the variables are closely centred on the average. The skewness of the variables is positive except for political stability (LPS). Additionally, the kurtosis, which is above 3, indicates that the variables are platykurtic, as evident in Table 2.

Correlation Test

Furthermore, Table 3 shows the correlation test results. Values range between 0.0952150 and 0.2636154. As such, it can be concluded that there is no multicollinearity in the variables. Qoko, Sibanda and Senzangakhona argue that within modern econometric analysis, no specific rules indicate a perfect correlation among variables. That said, Halmuratov, Madraximov, Zakirova, Xolmuratov, Djumabayeva, Yaqubova and Xolmurotov support the negative correlation between economic growth (GDP) and trade openness (TRO); hence, the results show a weak negative correlation between TRO and GDP with a magnitude of -0.2636154. A weak positive correlation exists between GDP and carbon dioxide emissions (CO2) with a magnitude of 0.1241640. Mebrek, Louail and Riache support this finding as their study also shows a positive link between GDP and CO2 emissions. Idrizi, Besimi and Çaushi also support the weak negative correlation between GDP and political stability (PS).

Table 5: Pooled Ordinary Least Squares (OLS) Regression Results

Variable	coefficient	Std. Error	t-statistic	Prob.
LTRO	0.387995	0.115386	3.362586	0.0008***
LCO2	0.203566	0.021525	9.457163	0.0000***
LPS	6.094365	0.132327	46.05539	0.0000***

To Note: Authors' drawings.
Source: Eviews 13. (*10%, **5% & ***1% significance level).

Panel Unit Root Tests

Table 4 portrays the outcomes of the LLC and IPS tests. For GDP, the outcomes suggest that the series is stationary at levels under the LLC, while under the IPS, the series is stationary at first differencing. These outcomes are similar to the outcomes of trade openness. Furthermore, carbon dioxide emissions are stationary at first differencing. Lastly, political stability is stationary at levels.

Pooled Ordinary Least Squares (OLS) Regression Results

Table 5 shows the results obtained from the OLS regression. A one-unit increase in trade openness results in a 0.387995-unit increase in GDP. The outcomes are statistically significant at 1%. This outcome aligns with the findings of Xuan, who found that trade openness has a significant contribution to GDP growth. Furthermore, an increase in CO2 emissions is associated with a rise in GDP. The finding is statistically significant at 1% level. Simbi, Yao, and Zhang support this finding, as their research results showed that the EKC was evident within 36 African

countries. This is demonstrated in their findings, which indicate that GDP initially increases CO2 emissions during the early stages of economic development. Additionally, there is a positive relationship between political stability and GDP. The finding is significant at 1% significance level. A study by Aldabagh, Abbas, Kadhim, and Kalenychenko also found a positive correlation between political stability and economic growth.

Table 6. Fixed Effects Results

Variable	coefficient	Std. Error	t-statistic	Prob.
LTRO	0.566733	0.043776	12.94628	0.0000***
LCO2	-0.089182	0.036662	-2.432587	0.0152**
LPS	-0.205638	0.039740	-5.174567	0.0000***

To Note: Authors' drawings.
Source: Eviews 13. (*10%, **5% & ***1% significance level).

Table 7: Random effects results

Variable	coefficient	Std. Error	t-statistic	Prob.
LTRO	0.564066	0.042926	13.14056	0.0000***
LCO2	-0.058975	0.031974	-1.844461	0.0655*
LPS	-0.210103	0.039680	-5.294981	0.0000***

To Note: Authors' drawings.
Source: Eviews 13. (*10%, **5% & ***1% significance level).

Fixed Effects Results

Table 6 shows the fixed effects outcomes. From the analysis, it can be noted that the findings from the fixed effects model are similar to those of the OLS regression, except for carbon dioxide emissions and political stability, which have a negative influence on GDP. That said, the positive correlation between trade openness and GDP implies that a unit increase in trade openness results in an increase in GDP by a magnitude of 0.566733. The outcomes are statistically significant at 1% significance level. In support of this finding, Talafha, Bashayreh, Abdelhadi and Alsamman argue that trade openness contributes significantly towards economic development. Furthermore, the t-statistic of 2.432587, which exceeds the threshold of 2, along with the corresponding probability of 0.0152, suggests that the negative relationship between CO2 emissions and GDP is statistically significant at a 5% significance level. These results align with Farooq, Faheem, Shah, and Hussain's findings, which prove the existence of the invented U-shaped EKC, asserting that GDP curbs CO2 emissions in 38 OECD economies. Finally, a unit increase in political stability leads to a decrease in GDP by -0.205638. The outcome is statistically significant at 1% significance level. This finding is closely related to a study by Aich, Tareque, Ahmed, and Rahman, which demonstrates that political stability does not have a long-term effect on financial inclusion, another indicator of economic growth.

Random Effects Results

The outcomes of the random effects model are shown in Table 7. The assessment outcomes are similar to those of the fixed effects model. As such, the t-statistic of 13.14056, which is greater than the critical value of 2, accompanied by a p-value of 0.0000, makes the finding statistically significant at 1% level; hence, a

unit increase in trade openness increases GDP. In support of this finding, Bunje, Abendin, and Wang found that trade openness had a statistically adverse effect on GDP per capita in 52 African nations. Being statistically significant at a 10% significance level, the negative correlation between carbon dioxide and GDP implies that CO_2 emissions reduce GDP by a magnitude of -0.058975. Mirziyoyeva and Salahodjaev also argue that an inverted U-shaped link between CO_2 and GDP in their study on Renewable energy, GDP and CO_2 emissions in high-globalised countries. Finally, a unit increase in political stability decreases GDP by -0.210103 units. Diken, Parlakkaya, Kara, and Kodalak concur with this finding, as they also found that political stability yields positive and significant results only in the long run.

Table 8: Hausman Test Results

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	12.355958	3	0.0063
Cross-section random effects test comparisons:			

Variable	Fixed	Random	Var (Diff.)	Prob.
LTRO	0.566733	0.564066	0.000074	0.7561
LCO2	-0.089182	-0.058975	0.000322	0.0922
LPS	-0.205638	-0.210103	0.000005	0.0417

To Note: Authors' Drawings.
Source: Eviews 13. (*10%, **5% & ***1% significance level).

Hausman Test Results
The results of the Hausman test are presented in Table 8. From the results, it can be noted that the Chi-Sq. Statistic > Prob. Furthermore, the probability of 0.0063 is less than 0.05, which necessitates selecting the fixed effects model as the most appropriate model.

Summary, Conclusions, and Policy Recommendations
This paper examines the impact of trade openness on the economic growth of 31 selected OECD economies, highlighting the role of political stability, and utilises pooled ordinary least squares (OLS) regression to shed light on trade fragmentation and its global impact. The paper summed up exports and imports, creating a new trade openness index. The empirical findings underscore the substantial impact of trade openness on promoting economic growth by facilitating trade and stimulating economic development within OECD countries. The paper also revealed that factors such as CO_2 emissions and political stability play a significant role in enhancing economic growth.

In light of these findings, the study recommends that countries within the OECD strengthen their trading relations, as the findings prove that these trading relations are beneficial within the economies of these nations. Furthermore, since it has been found that CO_2 emissions contribute to economic growth, they are a significant cause of ecological degradation. This paper strongly advocates that businesses, individuals, and societies within these countries adopt energy transition, renewable energy use, and green technological innovation to enhance their energy efficiency and utilisation of renewable energy sources. Additionally, the paper notes that tariffs can cause tensions, retaliation, or even trade wars between countries. As such, the paper strongly recommends that these countries impose tariffs on imported goods and services to generate revenue but should ensure that the duties are not too large. Lastly, the paper encourages these countries to strengthen their internal political affairs, as this research has proven that political stability raises economic growth [23-49].

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