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# Impact of Population Growth on $CO_2$ Emissions in Export-Driven Global Transport: A 30-Country Analysis (2011-2020)

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**Abstract:** This study explores the complex relationship between population growth and CO2 emissions in an export-driven activity that focuses on the global transportation sector. It addresses a gap in the existing literature by how demographic trends may influence the environmental impact of international trade. By using a robust dataset of 30 countries from 2011-2020. Advanced methods including CIPS, CADF Kao Test, Pedroni Test, and GMM tests applied to check the relationship between trade activities, population growth, and CO2 emissions. Results show that an export activity can highly influence in rising CO2 emissions due to an increased energy consumption which is associated with the production and transportation of goods. Further, population growth has strengthened by increasing the demand for transportation services which leads to a higher emission of CO2. Furthermore, it underscores the importance of including demographic factors in formulating or devising sustainable transportation policies. Policymakers, urban planners, and stakeholders can develop more effective strategies to reduce the carbon footprint of transportation and promote environmental sustainability by understanding the moderating role of population growth. Finally, it provides valuable insights into the complex connection between trade, population growth, and environmental impact that contribute to the broader discussion on sustainable development and climate change mitigation.
**Keywords:** Population Growth; CO2 Emissions; Global Transportation Sector; International Trade; Sustainable Development.[1]

## 1. Introduction

The worldwide transportation area plays an essential part in working with economic activities and global exchange (De Silva et al., 2016). Throughout many years, developments in the transportation framework and coordinated actions have prompted a huge development in the development of services and products across borders. Furthermore, this development has been associated with a surge in carbon dioxide (CO2) outflows, fundamentally because of the burning of non-renewable energy sources in vehicles and transportation-related effects (Grossman & Krueger, 1991). According to the World Trade Organization, trade hugely affects GHG emissions, which go past outflows from formation and worldwide transportation. It influences where creation is occurring and, if the carbon power of creation isn't equivalent all over, this likewise influences the degree of emissions. Significantly, trade likewise plays a basic role in diffusing green innovation and can help nations change to bring down carbon-intensive economic activities. Consequently, trade diversely affects fossil fuel byproducts. Diminishing the discharges related to trade is conceivable with the assistance of technological advancement and worldwide environmental cooperation.

People depend on petroleum derivatives immensely as our primary source of energy, which has brought about a concerning rise in worldwide ozone-depleting substance levels. As uncertainties over environmental change and sustainability keep rising, there is a clutching need to figure out the natural consequences of transportation and recognize techniques to moderate its carbon effect. The worldwide transportation area remains a foundation of present-day progress, supporting economic practices, working with global exchange, and

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developing cultural connections (Shahbaz et al., 2017). Since the approach of industrialization, transportation networks have constantly extended and developed, driven by innovative developments and globalization. From the improvement of rail line frameworks in the nineteenth century to the cutting-edge multiplication of air travel and container delivery, transportation plays had an urgent impact in molding the shapes of the worldwide economy and empowering the trading of merchandise, administrations, and thoughts across huge distances however, this development and network have come at a critical environmental cost (Peters et al., 2012). The dependence on petroleum products, especially in road automobiles, planes, and marine vessels, has brought about a significant expansion in carbon dioxide (CO2) released from the transportation area (Knight & Schor, 2014). As per the International Energy Organization (Heil & Selden, 2001) (IEA, 2020), transportation represents roughly one-fourth of absolute CO2 outflows universally, making it one of the biggest supporters of human-caused ozone-depleting substance discharges. The natural effects of transportation reach beyond CO2 releases alone. Different contaminations, like nitrogen oxides (NOx), particulate matter (PM), and sulfur dioxide (SO2), discharged by vehicles and transport foundations, add to air contamination, respiratory infections, and biological system debasement (Heil & Selden, 2001).

Lately, concerns over environmental change and ecological supportability have heightened, provoking calls for dreadful acts to alleviate the effects of transportation on the climate. State-run administrations, worldwide associations, and common society groups have progressively centered around carrying out measures and drives pointed toward decreasing transportation production and refining the treatment of cleaner and more feasible innovations (Jiborn et al., 2018). However, during these activities, there is a basic gap in how we might understand the perplexing communication between transportation activities, demographic trends, and environmental consequences. While past exploration has studied the effects of transportation-related issues, somewhat little consideration has been paid to addressing the situation of population factors, like population growth, on this relationship. Population growth has a significant effect on different parts of economic and social turn of events, including urbanization, utilization examples, and transportation interest (Hossain, 2012). However, its implications for transportation discharges are certainly not known. As the worldwide population keeps on growing, especially in city regions, understanding how section elements cooperate with transportation frameworks and releases turns out to be progressively significant for inventing successful methodologies to address environmental change and advance manageable turn of events.

Despite the growing interest in the environmental impacts of transportation, there remains a gap in our understanding of the complex interactions between goods and service transport, CO2 emissions, and demographic factors such as population growth. While previous research has examined the relationship between transportation and emissions, relatively little attention has been paid to the moderating role of population. Understanding how population growth influences the environmental footprint of transportation is crucial for devising effective policies and strategies to promote sustainable transportation systems and mitigate climate change.

This examination aims to explore the effect of merchandise and administration transport on CO2 outflows, explicitly focusing on the moderating role of population growth. The targets incorporate looking at the connection between transportation exercises, CO2 discharges, and demographic factors; recognizing the components through which population growth directs the connection among transport and CO2 discharges; evaluating the results of population growth on the environmental sustainability of transportation frameworks; and giving proof-based suggestions to policymakers, urban planners, and transportation partners to advance manageable transportation practices with regards to population development and natural difficulties.
This study will address the following question.

RQ1: How does population growth impact CO2 emissions from global transport?
RQ2: What's the role of population growth in moderating transportation's CO2 emissions?
RQ3: How can grasping population growth's effect on transport emissions guide sustainable policy and planning?
This exploration is critical considering multiple factors. Firstly, by looking into the intricate collaborations between transportation, populace elements, and natural sustainability, the evaluation adds to driving hypothetical comprehension of these basic issues. By revealing the nuanced manners by which population growth impacts the environmental impact of transportation, the examination fills a pivotal role in existing

literature. It gives significant insight into future research endeavors. Moreover, the findings have practical implications for policymakers, urban planners, and transportation stakeholders looking to address the difficulties of environmental change and advance practicable turns of events.
The practical implication of this study reaches out to different areas and stakeholders. Firstly, policymakers can use the findings to create designated transportation and natural approaches, considering demographic trends. Urban planners and infrastructure developers can integrate this insight of knowledge into their techniques, expecting to limit the environmental effect of transportation in quickly developing urban areas. Organizations in the transportation and strategy areas can streamline tasks and diminish their carbon impression by adopting better advancements and productive operations practices informed by the research. Community engagement and collaborator-coordinated effort are fundamental for fruitful execution, worked with by discourse upheld by this study's insight. Eventually, the study adds to the more extensive objective of accomplishing long-term environmental sustainability, featuring the significance of comprehensive methodologies in transportation planning and environmental management. Through purposeful undertakings, collaborators can make progress toward an additional, sustainable, and adaptable future.

The following chapters of this study are sequenced in the following order: Section 1 covers the introduction part i.e. background of the study, problem statement, objective, and significance of the study following possible practical implications of the study. Section 2 focuses on thoroughly reviewing existing literature to support the study that establishes the theoretical context of the research. Sections 3 and 4 describe research techniques, including data gathering, data analysis, and discussion. The following sections present and evaluate the data before ending with Section 4 which is the implications part, limitations, and future research directions, and then the reference section. The study's thorough examination aims to add to the expanding conversation to investigate the impact of goods and service transport on CO2 emissions, specifically focusing on the moderating role of population growth.

## 1.1 Literature review

One of the greatest threats to the environment is the rising global temperature. inciting humanities in this modern era. At the core of this emergency lies the heightening concentration of carbon dioxide (CO2) and other greenhouse gases in the atmosphere of the Earth emerging as the primary agent (Majumder et al., 2022). The wave in in recent years, carbon dioxide emissions have been closely linked to the global economy's dependence on non-sustainable power sources, a pattern that has ignited significant natural worry across the globe (Luo et al., 2017). as the population expands and the economic activities continue unabated, the environmental pressures increase, driven by the push for industrialization and economic growth, which is especially evident in developing countries. (Md. H. Rahman & Majumder, 2022). As a result, the negative effects of the effects of human activity, like the widespread use of fossil fuels, extend beyond just the present climate yet additionally represent a critical gamble for our group of people yet to come (Polcyn et al., 2023). It has become increasingly difficult to keep up with the rapid rate of climate change caused by global warming important to look at these issues from a political and economic point of view to create effective methodologies for moderation and transformation (Zhang et al., 2023).

In response to the urgent need for action, international agreement like the Kyoto protocol, signed in Japan in 1997, have been established to address the issues of greenhouse gas emission. Hence transition from non-renewable to renewable energy sources emerges as a key strategy in this effort as its offers' a pathway to reduce carbon dioxide emission and mitigate the adverse impact of climate change (Zafar et al., 2019). Consequently, reducing CO2 emission emerges as a pivotal measure to combat global warming and foster sustainable economic development on a global scale (Wang et al., 2020).

## 1.2 Exports of Goods and Services and CO2 Emissions

Exports of goods and services are important for economic growth, but they also have important natural consequences, i.e. in terms of emissions. When examining trade dynamics of some Asian countries the difference between exports and imports indicates the different levels of CO2 emissions particularly in some countries (Raihan et al., 2023). This difference is significant because it shows that distinct trade activities have different environmental impacts. Through extensive research on intricate relations b/w exports and emissions, researchers have shed light on various tools due to which exports can contribute to environmental degradation. The increased energy consumption associated with export-oriented industries is one crucial link linking products to an increased emission. Higher export levels often coincide with an increased energy use, which eventually leads to higher CO2 emissions (Leitão & Lorente, 2020). Because of their energy-concentrated nature, these ventures leave a huge carbon impression. Besides, the consuming of oil subordinates delivers a ton of carbon dioxide (CO2) into the environment, which further powers the issue in numerous product driven economies. One more stressful part of good-driven development is the consumption of normal assets, which can possibly compound fossil fuel byproducts. As demonstrated by Konuk et al. (2021), the advancement of item organized ventures routinely achieves an extension in the extraction and usage of ordinary resources like minerals and non-non-renewable energy sources. This accelerates asset exhaustion and increases fossil fuel byproducts through mining and drilling. At the point when petroleum derivatives extricated for trade are scorched, carbon dioxide (CO2) is delivered into the air, which adds to environmental change and degradation. In this manner, pursuing exchange driven improvement could unfavorably influence overall climate and ordinary organic frameworks. The negative effects that products have on the environment are not limited to specific areas, as the results of research that was carried out in several different countries and at various times indicate.

Khan et al. (2019) contended that export growth has prompted expanded carbon emissions in a huge range of nations throughout the course of recent many years. Between 1990 and 2011, data from 189 countries were analyzed, and they found a worrying pattern of rising emissions caused by export-oriented economic policies. Besides, Johnsson et al. (2019) recognized a bidirectional causality among exports and carbon emissions in various nations, recommending a complicated transaction between economic activity and ecological degradation. Regardless of these alarming pattern, a couple of researchers have proposed elective perspectives on the association among commodities and fossil fuel byproducts. Chang et al. (2018) found a correlation between lower carbon emissions and higher exports of manufactured goods in a sample of industrialized and developing nations. Their examination, which ran from 1981 to 2012, stirred up the acknowledged insight by setting that some commodity-situated businesses could adopt more environmentally friendly methods and reduce their impact on the environment. However, these findings should be interpreted with caution due to the possibility that they may not apply to all export sectors or regions. Through a variety of channels, imports, in addition to exports, also play a significant role in shaping environmental outcomes. One essential concern is the natural effect of transportation exercises related to imported goods. Imported goods often require extensive transportation networks to reach global markets, (Sadorsky, 2012). These transportation exercises consume a lot of fuel, adding to fossil fuel byproducts and worsening ecological debasement. Additionally, the longer distances involved in transportation because of supply chain globalization have increased the carbon footprint of imported goods.

Moreover, the energy force of imported items can likewise impact carbon emission levels. It has been found that specific imported goods, like coolers, climate control systems, and cars, are energy-concentrated and can contribute essentially to general energy utilization and emanations. This is especially pertinent with regards to non-industrial nations, where the reception of energy-concentrated innovations and ways of life is on the ascent. As these countries keep on bringing in such goods to fulfill developing consumer need, their ecological impression is probably going to extend, fueling worldwide environmental change. Another important aspect of the environmental impact of imports is how free trade agreements affect economic growth and consumption patterns. Al Mamun et al., (2014) argued that different countries may experience increased energy consumption and carbon emissions because of higher import levels. Countries that sign free trade agreements can gain access to a broader range of goods and services, which in turn can increase consumer demand and economic activity. Emissions and energy use may rise as a result. By pointing out that both imports and exports significantly contribute to emissions based on consumption, Liddle (2018) also emphasized the interconnectedness of global trade and environmental degradation.

### 1.3 Population Growth and CO2 Emissions

Different assessments have reviewed the versatile relationship between population size and growth and carbon emission in various countries, uncovering knowledge into the perplexing association between human socio economics and natural effects (Esquivias et al., 2022). It has been noted that the growth of the population affects the quality of the environment by increasing the demand for energy, a scarce resource. Population growth

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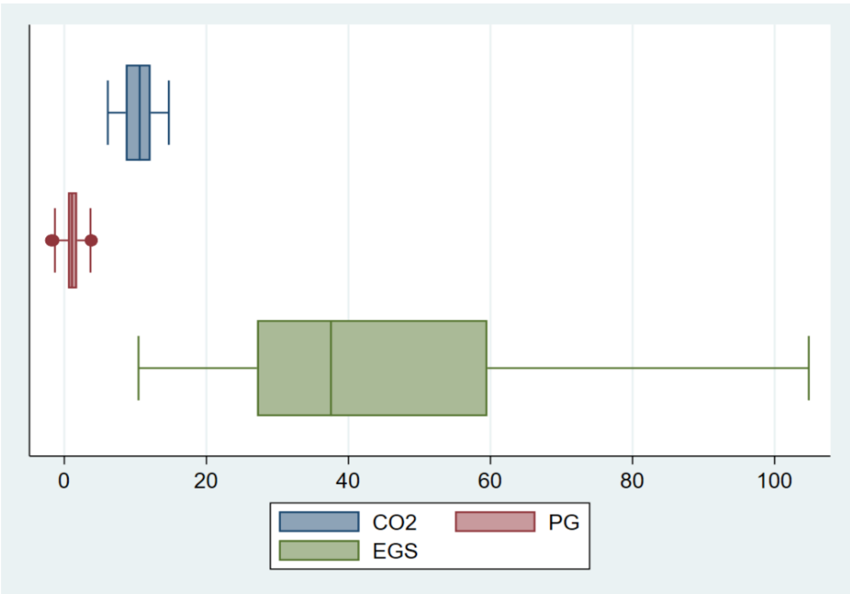
minimize the ecological quality by rising energy demand for industry, transport, and power areas (Ohlan, 2015). Al Mamun et al. (2014) also looked at the relationship between population and carbon emissions and other macroeconomic indicators. The study found that increasing population over time makes pollution of the environment worse. M. M. Rahman (2017) investigated how population growth and other factors related to the environment affect environmental quality, came up with similar findings. In 11 Asian nations, the findings indicate that population growth worsens environmental quality. The period from 1990 to 2019 is the focal point of this review and they found, using panel quantile regression, a convincing determination: districts with a higher population density ordinarily display activities that sabotage ecological supportability. While assessing the consequences for the climate, this tracking down features the meaning of considering the size of the whole population as well as its distribution and density (Esquivias et al., 2022). Shao et al. (2021) looked at data for a group of nations known as the N11 from 1980 to 2018. Their investigation revealed a clear link between the components of the population and CO2 emissions. As computations obtained from long-term data examination, they found that utilization-based CO2 emanations expanded by 0.197% for each 1% expansion in population. This suggests that, especially when seen through utilization patterns, population growth can essentially impact on carbon emissions.

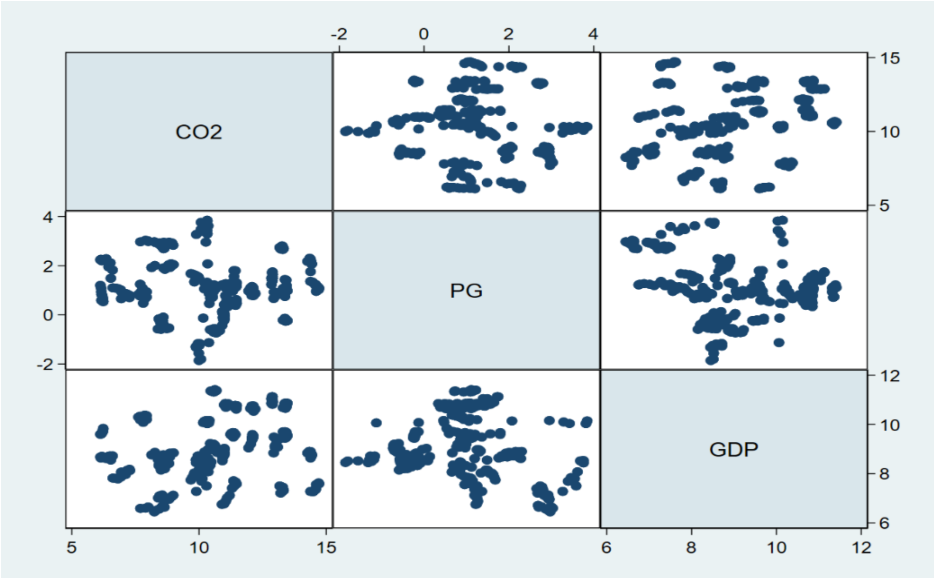
Figure 1 depicts boxplots for CO2, PG, and EGS. The CO2 boxplot is compact, suggesting minimal variability in its data distribution. The range between the quartiles and whiskers is narrow, indicating consistent CO2 levels across the dataset. This stability could signify that CO2 levels are less sensitive to fluctuations in the explanatory variables (PG and EGS). PG exhibits a narrow distribution with two visible outliers. The concentration of data points near zero suggests that PG values are clustered in a specific range. However, the outliers might influence CO2 variability. These outliers need further examination to determine whether they significantly impact CO2 levels. EGS has a wide variability, as evident from its larger interquartile range and long whiskers. This indicates a diverse spread in EGS values. The variability in EGS could provide a more substantial explanation for variations in CO2 levels compared to PG.




(Source: Author's Derivation)

**Figure 1**: CO2, ESG and PG (2011-2020)

The graph highlights that EGS might have a broader influence on CO2 due to its greater variability. PG, on the other hand, shows limited variability but may still contribute to CO2 fluctuations through outlier effects. Analyzing these relationships using statistical methods could clarify the strength and significance of the explanatory variables on CO2.




(Source: Author's Derivation)

**Figure 2:** CO2, PG and GDP (2011-2020)

Figure 2 explains the relationship between CO2 emissions, population growth and GDP over the period from 2011 to 2020. We can observe that there is a positive relationship between these variables. A study by Anser (2019) in Pakistan over the period of 41 years and the results showed that population growth can significantly raise CO2 emissions in the country. (Ahmed et al., 2017) also presented alike outcomes whereby population growth can increase CO2 emissions in the South Asian countries. Bekhet & Othman (2017) explored the relationship among financial development urbanization, economic growth, energy consumption, and CO2 emissions in Malaysia and found that urbanization can have a significant impact on CO2 emissions. The relationship between population growth and CO2 emissions from 1980 to 2016 is examined by utilizing the CCEMG technique, they found a huge positive relationship between these two factors. As a result, efforts to reduce climate change must consider the dynamics of population growth (Namahoro et al., 2021). This implies that as the region's population grows, so will its carbon emissions. Amin et al. (2022) used a powerful ARDL way to deal with and inspect the connection between population development and natural contamination from 1980 to 2016. Their discoveries repeated those of past examinations, recommending that population development adds to an expansion in fossil fuel byproducts. This demonstrates how crucial it is to address population dynamics alongside environmental policies to implement policies that lead to sustainable development on a global scale. Usman et al. (2022) analyzed the effect of population on environmental footprints in twelve high level nations. Their study used the CS-ARL approach, which showed that there was a negative correlation between population size and ecological footprint. This suggests that ecological footprints per person may decrease. This nuanced point of view features the need to think about the absolute population development and size as well as the per capita utilization designs while evaluating ecological effects. In addition, Voumik et al. (2023) conducted a panel study in the BRICS economies from 1972 to 2021 to investigate the connection between population growth and environmental degradation. Even though the size of the population harmed CO2 emissions, the statistical significance of this relationship was not established. This highlights the need for additional research to clarify the complex relationship between population dynamics and environmental outcomes.

### 1.4 Research Gap

Despite the broad exploration of the natural effects of transportation and the connection between population dynamics and CO2 emissions, there exists a critical gap in grasping the understanding between these variables. Even though previous research has examined the effects of transportation on CO2 emissions and the influence of population growth on environmental sustainability separately, there is a dearth of research that specifically examines how population dynamics moderate the relationship between transportation activities and CO2 emissions. Considering export-oriented industries and the energy-intensive nature of transportation networks, existing literature has highlighted the significant contribution of transportation to CO2 emissions. Moreover,

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studies have exhibited a positive relationship between population size and ecological degradation and the impact that population growth has on CO2 emissions. However, the specific mechanisms by which transportation's environmental impact is affected by population dynamics are still poorly understood. Understanding the moderation role of population growth in the connection between transportation activities and the CO2 outflows is essential for devising effective methodologies and strategies to advance supportable transportation structures and moderate ecological change. The proposed study aims to fill this research gap and provide valuable insights into the intricate interactions that exist among demographic trends, transportation structure, and environmental sustainability.

## 2. Research Methodology

In this research, we aim to explore how trade indicators influence climate change. Trade is the independent variable under scrutiny, while climate change is the dependent variable. Health, specifically population growth, is also considered a moderate variable for this study. Exports of goods and services include the total amount of goods and various services traded with other countries. It includes merchandise amount, transportation costs, travel expenses, royalties and license fees, and an array of services like financial, information, business, personal, and government services. Carbon dioxide emissions stem from burning fossil fuels and cement manufacturing. These emissions include carbon dioxide generated using solid, liquid, gas fuels, and flaring activities.

The annual population growth rate, defined by a given year "t," is the exponential growth rate of the population from the preceding year "t-1" to the year "t," indicating a percentage. The population calculation is based on the de facto definition, which identifies all residents regardless of their legal citizenship. Investment in transport projects involving private involvement involves commitments made to infrastructure projects in the transport sector that have achieved financial closure and provide directly or indirectly to public needs.

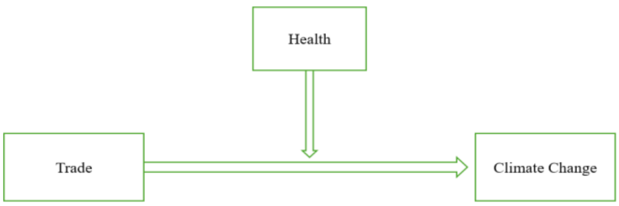
**Table 1** Variable Description

| Variable | Symbol | Proxy | Measurement | Sources |
|---|---|---|---|---|
| **Trade** | EGS | Exports of Goods and Service | % of GDP | WDI |
| **Climate Change** | $CO_2$ | $CO_2$ Emission | kt | WDI |
| **Health** | PG | Population Growth | annual % | WDI |
| **Infrastructure** | ATW | Investment in transport | Current US $ | WDI |
| **Economy and Growth** | GDP | Gross Domestic Product | Per Capita | WDI |

Sample Selection, Data Collection, and Limitations

The data for this study has been obtained from the World Bank indicators and a sample of 30 countries around the world has been taken for the period of 10 years from 2011 to 2020.

### 2.1 Theoretical Model of the Study



## 3. Research Hypothesis

### 3.1 Trade has a positive impact on Climate Change.

Trade activities, portrayed by the trading of goods and services across borders, frequently include moving goods over significant distances, resulting in significant carbon emissions from transportation-related activities. Additionally, trade-oriented industries might emphasize cost-effectiveness over environmental sustainability, which would increase the use of fossil fuels and the production of more greenhouse gases, i.e. emissions of CO2. Besides, the effect of trade on climate change extends beyond emissions to include deforestation, habitat destruction, and pollution related to the creation and transportation of traded goods. Enterprises like agriculture, forestry, and manufacturing may engage in practices that degrade natural ecosystems and contribute to global warming.

This hypothesis suggests that the negative effects of trade on climate change can significantly exacerbate environmental degradation because of the interconnected relationship between trade dynamics and climate change. The concept is based on a belief that increasing trade activities, particularly in regions with high carbon emissions and environmental footprints, can add to the development of climate change.

### 3.2 Health moderates the relationship between trade and climate change

Trade and climate change are hugely influenced by interaction due to population growth. In rapidly developing populations, natural resources and ecosystems are under increased pressure, which leads to greater deforestation, habitat destruction, and pollution related to trade. Trade has a huge effect on climate change due to quick population growth. In the same way, trade may be less beneficial if there is no way to manage or slow down the population's growth. Small populations are considerably less inclined to consume large amounts of assets or create waste that contributes to climate change and fossil fuel byproducts from a trade program. The complicated connection between trade and climate or environmental change is affected by population growth, which acts as the critical moderation effect in mitigating ecological outcomes of trade activities and alleviating the effects of climate change on a worldwide scale. The relationship between climate change and trade is largely influenced by population growth. As the population growth decreases, there is an increased demand for services and goods, prompting increased trade activities. This expanded trade can contribute to environmental change through various channels, including elevated fossil fuel byproducts from transportation or trade activities.

## 4. Empirical Study of Model

**For H1**

$$CO2it = \beta 0 + \beta 1 \cdot EGSit + \mu i + \epsilon it \text{........................ (Eq. 1)}$$

The concept is that trade has a direct impact on climate change. When trade increases, it speeds up climate change. To test this, we'll use a statistical model where we look at how changes in trade relate to changes in climate.

In equation (1), CO2it represents the carbon dioxide emissions in a country i at time t. TDSit represents a trade dependence score in country i at time t. β0 is the intercept, β1 is the coefficient representing the effect of trade dependence on carbon dioxide emissions, μi is the country-specific effect, and ϵit is the error term.

**For H2**

$$CO2it = \beta 0 + \beta 1 \cdot EGSit + \beta 2 \cdot PGit + \beta 3 \cdot (EGSit \times PGit) + \mu i + \epsilon it \text{............ (Eq. 2)}$$

In equation (2), CO2it represents the carbon dioxide emissions in a country i at time t. TDSit represents the trade dependence score in country i at time t. PGit represents the population growth rate in country i at time t. β0 is an intercept, β1, β2, and β3 are coefficients representing the effects of trade dependence, population growth, and the interaction between trade dependence and population growth on carbon dioxide emissions respectively. μi is the country-specific effect, and ϵit is the error term. The concept is that the effect of trade on climate change depends on the health factor. This means that the connection between trade and climate change can change based on whether the population is growing or shrinking.

### 4.1 Analysis Tools and Techniques

Stata is a well-known instrument among researchers, financial experts, and social scientists for investigating data. It provides a great many measurable techniques, like various sorts of modeling, investigating data over the long run, and regression analysis. Microsoft Excel is a spreadsheet sheet that is used to organize and analyze data. It is useful for simple tasks because it has fundamental functionalities like finding midpoints, medians,

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and standard deviations. It uses various statistical tools and techniques to check the relationship between trade, climate change, and health. Moderation analysis is also used to find the relationship between trade and climate change. Regression analysis is then used to calculate the direct effect of trade on climate change while checking the moderate role of health. The analysis consists of two main components that is to determine factors that influence climate change and examine how health affects the relationship between trade and climate change. This approach is used to provide insights into a complex relationship among variables through rigorous statistical analysis.

## 5. Data Analysis

**Table 2:** Data analysis

| Variable | N | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **Code** | 300 | 15.5 | 8.67 | 1 | 30 |
| **Year** | 300 | 2015.5 | 2.877 | 2011 | 2020 |
| **$CO_2$** | 300 | 10.571 | 2.251 | 6.123 | 14.715 |
| **EGS** | 300 | 43.249 | 22.054 | 10.443 | 104.805 |
| **PG** | 300 | 1.119 | 1.163 | -1.854 | 3.845 |
| **ATW** | 300 | 10.78 | 2.295 | 2.303 | 14.285 |
| **GDP** | 300 | 9.026 | 1.275 | 6.449 | 11.413 |

The dataset gives a descriptive statistic for five variables across 300 observations, providing insights into the central tendencies, dispersion, and ranges. The "CO2" variable has an average value of 10.571, with a standard deviation of 2.251 which indicates some variation and values ranging from 6.123 to 14.715. The "EGS" shows a high level of variability with a mean of 43.249 and a standard deviation of 22.054 that covers a wide range from 10.443 to 104.805. For the "PG" variable, the mean is 1.119 and the standard deviation is 1.163, which suggests moderate variability and a range of values from -1.854 to 3.845, which indicates both negative and positive values. The "ATW" variable has an average of 10.78 with a standard deviation of 2.295 and values from 2.303 to 14.285, indicating a moderate spread around the mean. And "GDP" variable shows a mean of 9.026 with a relatively low standard deviation of 1.275 with values ranging from 6.449 to 11.413, showing less variability around the mean.

**Table 3:** Matrix of Correlations

| Variables | VIF | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|---|
| **(1) $CO_2$** | - | 1.000 | | | | |
| **(2) EGS** | 1.38 | -0.095 | 1.000 | | | |
| **(3) PG** | 1.23 | -0.012 | -0.149 | 1.000 | | |
| **(4) ATW** | 1.47 | 0.698 | 0.069 | 0.158 | 1.000 | |
| **(5) GDP** | 2.01 | 0.200 | 0.493 | -0.287 | 0.450 | 1.000 |

The table provides an analysis of the variance inflation factors (VIF) and the correlation matrix for five variables: CO2, EGS, PG, ATW, and GDP. The VIF values indicate the degree of multicollinearity present in the regression model. With VIF values for EGS at 1.38, PG at 1.23, ATW at 1.47, and GDP at 2.01, multicollinearity is low across these variables, as all values are well below the threshold of concern (commonly a VIF of 5-10). The correlation matrix reveals the relationships between these variables, with correlation coefficients ranging from -1 to 1. A coefficient close to 1 or -1 signifies a strong positive or negative correlation, respectively, while values near 0 indicate weak or no correlation. Specifically, CO2 shows a weak negative correlation with EGS (-0.095) and PG (-0.012), but a strong positive correlation with ATW (0.698), and a weak positive correlation with GDP (0.200). EGS is weakly negatively correlated with PG (-0.149) and weakly positively correlated with ATW (0.069), while having a moderate positive correlation with GDP (0.493). PG has a weak positive correlation with ATW (0.158) and a weak to moderate negative correlation with GDP (-0.287). Lastly, ATW and GDP are moderately positively correlated (0.450).

**Table 4:** Linear Regression

| $CO_2$ | Coef. | St. Err. | t-value | p-value | [95% Conf | Interval] | Sig |
|---|---|---|---|---|---|---|---|
| **EGS** | -.009 | .005 | -1.99 | .047 | -.019 | 0 | ** |
| **PG** | -.401 | .084 | -4.76 | 0 | -.567 | -.235 | *** |
| **ATW** | .803 | .047 | 17.21 | 0 | .712 | .895 | *** |
| **GDP** | -.322 | .098 | -3.28 | .001 | -.515 | -.129 | *** |
| **Constant** | 5.67 | .706 | 8.03 | 0 | 4.28 | 7.059 | *** |

| | | | |
|---|---|---|---|
| **Mean dependent var** | 10.571 | SD dependent var | 2.251 |
| **R-squared** | 0.547 | Number of obs | 300 |
| **F-test** | 88.928 | Prob > F | 0.000 |
| **Akaike crit. (AIC)** | 1109.836 | Bayesian crit. (BIC) | 1128.354 |
| ****** p<.01, ** p<.05, * p<.1*** | | | |

The linear regression results provide an analysis of the relationships between the dependent variable CO2 and the independent variables EGS, PG, ATW, and GDP. The table summarizes the coefficients, standard errors, t-values, p-values, and 95% confidence intervals for each predictor. EGS has a coefficient of -0.009 with a standard error of 0.005. The t-value is -1.99, and the p-value is 0.047, which is significant at the 0.05 level. This shows a small but significant negative relation between an EGS and CO2 where a one-unit increase in EGS is associated with the 0.009 decrease in CO2. PG has a coefficient of -0.401 with a standard error of 0.084. The t-value is -4.76, and the p-value is 0.000, which is significant at a 0.01 level. This tells a substantial negative relationship between PG and CO2, and the one-unit increase in PG leads to the 0.401 decreases in CO2 emission. ATW has a coefficient of 0.803 with a standard error of 0.047. The t-value is 17.21, and the p-value is 0.000, indicating significance at the 0.01 level. This strong positive relationship suggests that a one-unit increase in ATW is associated with a 0.803 increase in CO2. GDP presents a coefficient of -0.322 with a standard error of 0.098. The t-value is -3.28, and the p-value is 0.001, which is significant at the 0.01 level. This indicates a negative relationship between GDP and CO2, where a one-unit increase in GDP results in a 0.322 decrease in CO2. The constant term is 5.67 with a standard error of 0.706, a t-value of 8.03, and a p-value of 0.000, which is highly significant. This represents the expected value of CO2 when all predictors are zero.

**Table 5:** Testing for slope heterogeneity

| **H0: slope coefficients are homogenous** | |
|---|---|
| Delta | p-value |
| 6.266 | 0.000 |
| adj. 7.489 | 0.000 |
| Variables partially out: constant | |

The analysis conducted to test for slope heterogeneity, as outlined by Pesaran and Yamagata (2008) in the Journal of Econometrics, aims to assess whether the slope coefficients in a regression model exhibit uniformity across different groups or observations. The null hypothesis posits that these coefficients are homogeneous, while the alternative hypothesis suggests heterogeneity. The results of the test reveal a Delta statistic of 6.266 with a corresponding p-value of 0.000, indicating strong evidence against the null hypothesis. Additionally, an adjusted Delta statistic of 7.489 is reported, also yielding a p-value of 0.000. These highly significant p-values lead to the rejection of the null hypothesis, signifying significant heterogeneity in the slope coefficients. Consequently, it is inferred that the relationship between the dependent variable and the independent variables varies substantially across different subsets or observations within the dataset. Particularly a constant term has an adjusted for in the analysis to set apart the variability in a slope coefficient. By these findings, it is authoritative to account for slope heterogeneity in an analysis, with potentially necessitating the utilization of

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models capable of a seizing fluctuating slope, such as random coefficients models or a those including interaction terms to reason for a difference observed observations.

**Table 6:** Cross Sectional Dependency

| Variables | Statistics | P-Value | Abs(Corr) |
|---|---|---|---|
| **$CO_2$** | 9357*** | 0.000 | 0.46 |
| **EGS** | 9.042*** | 0.000 | 0.44 |
| **PG** | 20.147*** | 0.000 | 0.55 |

The *** represent significant level.

The analysis aims to evaluate a cross-sectional dependency among variables CO2 emission, (CO2), exports of goods and services (EGS), and population growth (PG). Statistical tests show highly significant results, with p-values of 0.000 which indicates strong evidence of cross-sectional dependency. The absolute correlation coefficients, that is ranging range from 0.44 to 0.55 more highlight the associations between the variables. This indicates that changes in one variable are likely correlated with changes in the others within this dataset. Therefore, it is crucial for any further analyses involving CO2, EGS, and PG to take these inter-relationships into report to maintain accuracy and validity of a findings.

**Table 7:** Unit Root Tests

| **Variable** | **CIPS** | | **Variable** | **CADF** | |
|---|---|---|---|---|---|
| | Level | First Difference | | Level | First Difference |
| $CO_2$ | -2.344 | -2.675 | $CO_2$ | -2.344 | -2.675 |
| EGS | -2.168 | -3.108 | EGS | -1.845 | -3.108 |

The data presented offers insights from two-unit root tests, namely the Cross-sectional Implied Pesaran-Shin (CIPS) test and the Cross-sectional Augmented Dickey-Fuller (CADF) test, performed on the variables CO2 and EGS at both the level and first difference. In the CIPS test, at the level, the test statistics indicate values of -2.344 for CO2 and -2.168 for EGS, respectively. Following the first difference, these statistics shift to -2.675 for CO2 and -3.108 for EGS. Similarly, the CADF test produces identical results at the level, with CO2 and EGS displaying test statistics of -2.344 and -2.168, respectively. Upon differencing, the values for CO2 and EGS remain consistent with those of the CIPS test, at -2.675 and -3.108, respectively. These statistics serve to discern the presence of stationary behavior or the existence of a unit root, indicating non-stationarity in the time series data.

**Table 8:** Pedroni Test for Cointegration

Ho: No cointegration Number of panels = 30
Ha: All panels are cointegrated Number of periods = 9
Cointegrating vector: Panel specific
Panel means: Included Kernel: Bartlett
Time trend: Not included Lags: 2.00 (Newey-West)
AR parameter: Panel specific Augmented lags: 1

| | Statistic | p-value |
|---|---|---|
| Modified Phillips-Perron t | 3.3152 | 0.0005 |
| Phillips-Perron t | -2.2259 | 0.0130 |
| Augmented Dickey-Fuller t | -3.1828 | 0.0007 |

The Pedroni test for cointegration is utilized to examine whether a long-term relationship, or cointegration, exists among variables across multiple panels. With the null hypothesis (Ho) positing no cointegration and the alternative hypothesis (Ha) suggesting cointegration across all panels, the test assesses various statistics to make this determination. In this analysis, conducted across 30 panels over 9 periods, the cointegrating vector is specified as panel-specific, and panel means are included in the assessment. The Bartlett kernel is employed, and no time trend is included, with lag specifications of 2.00 (Newey-West) and augmented lags of 1. The test statistics reveal significant evidence against the null hypothesis, indicating the presence of cointegration. Specifically, the Modified Phillips-Perron t statistic yields a value of 3.3152 with a corresponding p-value of 0.0005, the Phillips-Perron t statistic shows -2.2259 with a p-value of 0.0130, and the Augmented Dickey-Fuller t statistic registers -3.1828 with a p-value of 0.0007. These results collectively suggest strong support for the alternative hypothesis, signifying that all panels are co-integrated.

**Table 9:** Kao Test for Cointegration

| | | |
|---|---|---|
| Ho: No cointegration | Number of panels = 30 | |
| Ha: All panels are cointegrated | Number of periods = 8 | |
| Cointegrating vector: Same | | |
| Panel means: Included | Kernel: Bartlett | |
| Time trend: Not included | Lags: 1.33 (Newey-West) | |
| AR parameter: Same | Augmented lags: 1 | |
| | Statistic | p-value |
| Modified Dickey-Fuller t | 0.0709 | 0.4718 |
| Dickey-Fuller t | -2.2034 | 0.0138 |
| Augmented Dickey-Fuller t | -1.8674 | 0.0309 |
| Unadjusted modified Dickey-Fuller t | -0.5179 | 0.3022 |
| Unadjusted Dickey-Fuller t | -2.6013 | 0.0046 |

The Kao test for cointegration is a robust tool used to assess whether a long-term relationship, or cointegration, exists among variables across multiple panels. In this analysis, the null hypothesis (Ho) posits no cointegration, contrasting with the alternative hypothesis (H1), which suggests that all panels are cointegrated. The examination incorporates various statistics to scrutinize this relationship. Applying the test to a dataset featuring 30 panels over 8 periods, the cointegrating vector is specified as the same across panels, and panel means are included in the assessment. The Bartlett kernel is utilized, and a time trend is omitted from the analysis. Lag specifications are set at 1.33 (Newey-West), with an augmented lag of 1. The test statistics yield insightful results: the Modified Dickey-Fuller t statistics register a value of 0.0709 with a corresponding p-value of 0.4718, indicating relatively weak evidence against the null hypothesis. In contrast, the Dickey-Fuller t and Unadjusted Dickey-Fuller t statistics present more compelling evidence against the null hypothesis, with p-values of 0.0138 and 0.0046, respectively, suggesting stronger indications of cointegration. The Augmented Dickey-Fuller t statistic also provides evidence against the null hypothesis, albeit less significantly, with a p-value of 0.0309.

**Table 10:** Regression results (GMM)

| **$CO_2$** | **Coef.** | **St.Err.** | **t-value** | **p-value** | **[95% Conf** | **Interval]** | **Sig** |
|---|---|---|---|---|---|---|---|
| **L** | .658 | .08 | 8.27 | 0.000 | .502 | .813 | *** |
| **EGS** | .005 | .001 | 4.65 | 0.000 | .003 | .007 | *** |

| | | | |
|---|---|---|---|
| **Mean dependent var** | 10.592 | SD dependent var | 2.237 |
| **Number of obs** | 240 | Chi-square | . |

****** p<.01, ** p<.05, * p<.1***

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| **VARIABLES** | $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ |
| | | | | | |
| **EGS** | -0.00966 | -0.00966 | -0.0101* | -0.0101* | 0.00512*** |
| | (0.00589) | (0.00589) | (0.00596) | (0.00596) | (0.00110) |

| | | | | | |
|---|---|---|---|---|---|
| **PG** | | | -0.0507 | -0.0507 | |
| | | | (0.113) | (0.113) | |
| **L.$CO_2$** | | | | | 0.658*** |
| | | | | | (0.0796) |
| **Constant** | 10.99*** | 10.99*** | 11.06*** | 11.06*** | |
| | (0.286) | (0.286) | (0.330) | (0.330) | |
| **Observations** | 300 | 300 | 300 | 300 | 240 |
| **R-squared** | 0.009 | 0.009 | 0.010 | 0.010 | |
| **Number of Code** | | | | | 30 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The regression analyses conducted using the Generalized Method of Moments (GMM) and the Autoregressive Generalized Method of Moments (AGM) techniques yield insightful findings regarding the relationships between the dependent variable CO2 and the independent variables EGS and PG. In the GMM regression, a coefficient for a lagged CO2 variable (L.CO2) is estimated at 0.658 with a standard error of a 0.08 which indicates a highly significant positive relationship with CO2 levels. Likewise, coefficient for an EGS is 0.005 with standard error of 0.001 which also indicates a statistically significant positive association between an EGS and CO2. The AGM regression provides a more detailed examination of these relationships by including additional variables. In a different model specification, the coefficient for an EGS varies from -0.00966 to 0.00512, that is all statistically significant and reinforces the positive relationship between EGS and CO2. In contrast a coefficient for PG, which could influence CO2 levels, does not show statistical significance in some models which suggests that it may have a less substantial role in predicting CO2 levels. And the inclusion of a lagged CO2 variable (L.CO2) in some models shows it has a strong positive effect on current CO2 levels that is highly significant coefficients. The constant term represents a baseline CO2 level when all the independent variables are at zero and remain highly significant across all the models.

### 5.1 Summary of the Result

In summary, an extensive examination of a dataset provides useful insights into an intricate dynamic that is influencing CO2 emissions. Descriptive statistics provide a fundamental understanding of variables characteristics which highlight the variability and inter-connections. Subsequent analyses which include correlation matrices, variance inflation factor assessments, and linear regression models reveal substantial relations between a CO2 emission and a key predictor. The findings underscore the importance of considering multiple determinants when addressing CO2 emissions which emphasize the impactful roles played by various variables. Slope heterogeneity and cointegration suggests complex dynamics among these relationships and careful consideration in a policy formulation and strategies and policymakers and stakeholders are advanced to adopt approaches to mitigate the CO2 emissions.

## 6. Conclusion

This study examines the relationship between carbon emissions (CO2) and export of goods and services and population growth as a moderate variable and gross domestic product (GDP) as a control variable. Robust analysis and various statistical methods such as correlation matrices, linear regressions, and tests for slope heterogeneity and cross-sectional dependency tell the insights into a complex dynamic that governs CO2 emissions. It shed light on relationships between economic activities, demographic trends and environmental sustainability and stressed the need to adopt holistic approaches to address carbon emission effectively. Finally, it tells the huge importance of considering various determinants when formulating strategies to reduce CO2 emissions by recognizing policymakers can develop sustainable solutions to tackle climate change and promote global environmental sustainability.

## 7. Recommendations

The research provides several recommendations to policymakers and stakeholders in formulating effective strategies to reduce CO2 emissions and promote sustainable development. They can devise integrated policy approaches that prioritize investments in clean energy technologies, renewable energy sources, and encourage sustainable economic development. Population management strategies can help in sustainable urbanization and reducing per capita energy consumption can help alleviate the environmental impacts. Further advancing cross-sector collaboration between government, academia, and industry is essential for the implementation and scaling up reducing efforts effectively.

## 8. Limitations

The study encounters several limitations in interpreting findings and its implications. The data constraints present a huge challenge as the analysis relies on the availability, quality and comprehensiveness of a dataset and its sample size with 10-year data is also concerning ranging from 2012 to 2021. The study on CO2 emissions and its predictors faces several limitations, including missing or incomplete data variations in data reliability across regions or countries and the sole reliability on the World Bank. Endogeneity concerns, such as bidirectional causality, present a methodological challenge. Its context-specific and interdisciplinary nature may limit its generalizability to various settings, and it might not fully cover the long-term dynamics in CO2 emissions relationships and suggest a need for further research.

## Conflict of Interest Statement

This is to declare that the authors do not have any conflict of interest with the topic, data or any other aspect. If you need any further information, we will be happy to provide you with it all.

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## References

Ahmed, K., Rehman, M. U., & Ozturk, I. (2017). What drives carbon dioxide emissions in the long-run? Evidence from selected South Asian Countries. Renewable and Sustainable Energy Reviews, 70, 1142–1153. https://doi.org/10.1016/j.rser.2016.12.018

Al Mamun, Md., Sohag, K., Hannan Mia, Md. A., Salah Uddin, G., & Ozturk, I. (2014). Regional differences in the dynamic linkage between CO2 emissions, sectoral output and economic growth. Renewable and Sustainable Energy Reviews, 38, 1–11. https://doi.org/10.1016/j.rser.2014.05.091

Amin, M., Zhou, S., & Safi, A. (2022). The nexus between consumption-based carbon emissions, trade, eco-innovation, and energy productivity: Empirical evidence from N-11 economies. Environmental Science and Pollution Research, 29(26), 39239–39248. https://doi.org/10.1007/s11356-021-18327-z

Anser, M. K. (2019). Impact of energy consumption and human activities on carbon emissions in Pakistan: Application of STIRPAT model. Environmental Science and Pollution Research, 26(13), 13453–13463. https://doi.org/10.1007/s11356-019-04859-y

Bekhet, H. A., & Othman, N. S. (2017). Impact of urbanization growth on Malaysia CO2 emissions: Evidence from the dynamic relationship. Journal of Cleaner Production, 154, 374–388. https://doi.org/10.1016/j.jclepro.2017.03.174

Chang, C.-P., Wen, J., Dong, M., & Hao, Y. (2018). Does government ideology affect environmental pollutions? New evidence from instrumental variable quantile regression estimations. Energy Policy, 113, 386–400. https://doi.org/10.1016/j.enpol.2017.11.021

De Silva, P. N. K., Simons, S. J. R., & Stevens, P. (2016). Economic impact analysis of natural gas development and the policy implications. Energy Policy, 88, 639–651. https://doi.org/10.1016/j.enpol.2015.09.006

Esquivias, M. A., Sugiharti, L., Rohmawati, H., Rojas, O., & Sethi, N. (2022). Nexus between Technological

Journal of Social Sciences and Economics
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ISSN (Online) 2958-1532
https://finessepublishing.com/jsse

Innovation, Renewable Energy, and Human Capital on the Environmental Sustainability in Emerging Asian Economies: A Panel Quantile Regression Approach. Energies, 15(7), 2451. https://doi.org/10.3390/en15072451

Grossman, G., & Krueger, A. (1991). Environmental Impacts of a North American Free Trade Agreement (w3914; p. w3914). National Bureau of Economic Research. https://doi.org/10.3386/w3914

Heil, M. T., & Selden, T. M. (2001). International Trade Intensity and Carbon Emissions: A Cross-Country Econometric Analysis. The Journal of Environment & Development, 10(1), 35–49. https://doi.org/10.1177/107049650101000103

Hossain, S. (2012). An Econometric Analysis for CO<sub>2</sub> Emissions, Energy Consumption, Economic Growth, Foreign Trade and Urbanization of Japan. Low Carbon Economy, 03(03), 92–105. https://doi.org/10.4236/lce.2012.323013

Jiborn, M., Kander, A., Kulionis, V., Nielsen, H., & Moran, D. D. (2018). Decoupling or delusion? Measuring emissions displacement in foreign trade. Global Environmental Change, 49, 27–34. https://doi.org/10.1016/j.gloenvcha.2017.12.006

Johnsson, F., Kjärstad, J., & Rootzén, J. (2019). The threat to climate change mitigation posed by the abundance of fossil fuels. Climate Policy, 19(2), 258–274. https://doi.org/10.1080/14693062.2018.1483885

Khan, M. K., Teng, J.-Z., Khan, M. I., & Khan, M. O. (2019). Impact of globalization, economic factors and energy consumption on CO2 emissions in Pakistan. Science of The Total Environment, 688, 424–436. https://doi.org/10.1016/j.scitotenv.2019.06.065

Knight, K., & Schor, J. (2014). Economic Growth and Climate Change: A Cross-National Analysis of Territorial and Consumption-Based Carbon Emissions in High-Income Countries. Sustainability, 6(6), 3722–3731. https://doi.org/10.3390/su6063722

Konuk, F., Zeren, F., Akpınar, S., & Yıldız, Ş. (2021). Biomass energy consumption and economic growth: Further evidence from NEXT-11 countries. Energy Reports, 7, 4825–4832. https://doi.org/10.1016/j.egyr.2021.07.070

Leitão, N. C., & Lorente, D. B. (2020). The Linkage between Economic Growth, Renewable Energy, Tourism, CO2 Emissions, and International Trade: The Evidence for the European Union. Energies, 13(18), 4838. https://doi.org/10.3390/en13184838

Liddle, B. (2018). Consumption-based accounting and the trade-carbon emissions nexus. Energy Economics, 69, 71–78. https://doi.org/10.1016/j.eneco.2017.11.004

Luo, Y., Long, X., Wu, C., & Zhang, J. (2017). Decoupling CO2 emissions from economic growth in agricultural sector across 30 Chinese provinces from 1997 to 2014. Journal of Cleaner Production, 159, 220–228. https://doi.org/10.1016/j.jclepro.2017.05.076

Majumder, S. C., Rahman, Md. H., Ferdaus, J., Rahman, M. M., Abedin, M. Z., & Roni, N. (2022). Nexus between Energy Consumption, Economic Growth and Quality of Environment in BRICS and Next 11 Countries: A Panel Dynamic Study. https://doi.org/10.21203/rs.3.rs-1864209/v1

Namahoro, J. P., Wu, Q., Xiao, H., & Zhou, N. (2021). The Impact of Renewable Energy, Economic and Population Growth on CO2 Emissions in the East African Region: Evidence from Common Correlated Effect Means Group and Asymmetric Analysis. Energies, 14(2), 312. https://doi.org/10.3390/en14020312

Ohlan, R. (2015). The impact of population density, energy consumption, economic growth and trade openness on CO2 emissions in India. Natural Hazards, 79(2), 1409–1428. https://doi.org/10.1007/s11069-015-1898-0

Peters, G. P., Davis, S. J., & Andrew, R. (2012). A synthesis of carbon in international trade. Biogeosciences, 9(8), 3247–3276. https://doi.org/10.5194/bg-9-3247-2012

Polcyn, J., Voumik, L. C., Ridwan, M., Ray, S., & Vovk, V. (2023). Evaluating the Influences of Health Expenditure, Energy Consumption, and Environmental Pollution on Life Expectancy in Asia. International Journal of Environmental Research and Public Health, 20(5), 4000. https://doi.org/10.3390/ijerph20054000

Rahman, M. M. (2017). Do population density, economic growth, energy use and exports adversely affect environmental quality in Asian populous countries? Renewable and Sustainable Energy Reviews, 77, 506–514. https://doi.org/10.1016/j.rser.2017.04.041

Rahman, Md. H., & Majumder, S. C. (2022). Empirical analysis of the feasible solution to mitigate the CO2 emission: Evidence from Next-11 countries. Environmental Science and Pollution Research, 29(48), 73191–73209. https://doi.org/10.1007/s11356-022-20908-5

Raihan, A., Muhtasim, D. A., Farhana, S., Rahman, M., Hasan, M. A. U., Paul, A., & Faruk, O. (2023). Dynamic Linkages between Environmental Factors and Carbon Emissions in Thailand. Environmental Processes, 10(1), 5. https://doi.org/10.1007/s40710-023-00618-x

Sadorsky, P. (2012). Energy consumption, output and trade in South America. Energy Economics, 34(2), 476–488. https://doi.org/10.1016/j.eneco.2011.12.008

Shahbaz, M., Nasreen, S., Ahmed, K., & Hammoudeh, S. (2017). Trade openness–carbon emissions nexus: The importance of turning points of trade openness for country panels. Energy Economics, 61, 221–232. https://doi.org/10.1016/j.eneco.2016.11.008

Shao, X., Zhong, Y., Liu, W., & Li, R. Y. M. (2021). Modeling the effect of green technology innovation and renewable energy on carbon neutrality in N-11 countries? Evidence from advance panel estimations. Journal of Environmental Management, 296, 113189. https://doi.org/10.1016/j.jenvman.2021.113189

Usman, A., Ozturk, I., Naqvi, S. M. M. A., Ullah, S., & Javed, M. I. (2022). Revealing the nexus between nuclear energy and ecological footprint in STIRPAT model of advanced economies: Fresh evidence from novel CS-ARDL model. Progress in Nuclear Energy, 148, 104220. https://doi.org/10.1016/j.pnucene.2022.104220

Voumik, L. C., Islam, Md. A., Ray, S., Mohamed Yusop, N. Y., & Ridzuan, A. R. (2023). CO2 Emissions from Renewable and Non-Renewable Electricity Generation Sources in the G7 Countries: Static and Dynamic Panel Assessment. Energies, 16(3), 1044. https://doi.org/10.3390/en16031044

Wang, R., Mirza, N., Vasbieva, D. G., Abbas, Q., & Xiong, D. (2020). The nexus of carbon emissions, financial development, renewable energy consumption, and technological innovation: What should be the priorities in light of COP 21 Agreements? Journal of Environmental Management, 271, 111027. https://doi.org/10.1016/j.jenvman.2020.111027

Zafar, M. W., Zaidi, S. A. H., Sinha, A., Gedikli, A., & Hou, F. (2019). The role of stock market and banking sector development, and renewable energy consumption in carbon emissions: Insights from G-7 and N-11 countries. Resources Policy, 62, 427–436. https://doi.org/10.1016/j.resourpol.2019.05.003

Zhang, J., Ahmad, M., Muhammad, T., Syed, F., Hong, X., & Khan, M. (2023). The Impact of the Financial Industry and Globalization on Environmental Quality. Sustainability, 15(2), 1705. https://doi.org/10.3390/su15021705