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The Link Between Trade Openness, Economic Growth, Energy Use and Carbon Emissions: Analysis with a Conceptual Model Proposal[1]

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Ticari Açıklık, Ekonomik Büyüme, Enerji Kullanımı ve Karbon Emisyonları Arasındaki İlişki: Kavramsal Bir Model Önerisi ile Analiz[2]

Abstract

This study examines the relationship between trade openness, economic growth, energy consumption and carbon emissions (CO2) with Structural Equation Modelling (SEM) by offering a model proposal. In this context, a path analysis was carried out with SEM using the 2000-2020 period data of 83 developed and developing countries to examine the direct and indirect effects between the variables. The study's findings show that trade openness directly and significantly affects economic growth, energy consumption and CO2. When the indirect effects are examined, it has been determined that economic growth and energy consumption mediate the relationship between trade openness and CO2, and energy consumption mediates the relationship between economic growth and CO2.

Keywords : Energy Consumption, Economic Development, Trade Openness, Carbon Emissions, Structural Equation Modelling.

JEL Classification Codes : C00, F43, F49, Q43.

Öz

Bu çalışmanın amacı, ticari açıklık, ekonomik büyüme, enerji tüketimi ve karbon emisyonları (CO2) arasındaki ilişkiyi bir model önerisi sunarak Yapısal Eşitlik Modellemesi (YEM) ile incelemektir. Bu kapsamda, değişkenler arasındaki doğrudan ve dolaylı etkileri incelemek üzere gelişmiş ve gelişmekte olan 83 ülkenin 2000-2020 dönem verileri kullanılarak YEM ile yol analizi gerçekleştirilmiştir. Araştırmanın bulguları, ticari açıklığın ekonomik büyüme, enerji tüketimi ve CO2 üzerinde doğrudan pozitif ve anlamlı bir etkisi olduğunu göstermektedir. Dolaylı etkiler incelendiğinde ise ekonomik büyüme ve enerji tüketiminin ticari açıklık ile CO2 arasındaki ilişkide, enerji tüketimin ise ekonomik büyüme ile CO2 arasındaki ilişkide aracılık ettikleri tespit edilmiştir.

Anahtar Sözcükler : Enerji Tüketimi, Ekonomik Kalkınma, Ticari Açıklık, Karbon Emisyonları, Yapısal Eşitlik Modellemesi.

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1. Introduction

The need for energy is steadily rising due to industrial development, fast population rise, technological development, urbanisation, and expansion of business operations (Nasreen & Anwar, 2014; Yang et al., 2022). In line with this trend, traditional theories suggest that trade openness and economic growth contribute to the increase in energy consumption, as trade volumes and Gross Domestic Product (GDP) impact energy consumption (Zeeshan et al., 2022).

International trade has increased dramatically since the General Agreement on Tariffs and Trade (GATT) was established, which has resulted in trade liberalisation. Global trade has been facilitated by the World Trade Organization (WTO), which finally succeeded GATT. In the field of trade economics, Adam Smith's theory of absolute advantage and David Ricardo's theory of comparative advantage have shown that trade is reciprocal and that growing nations with sound economic policies benefit from reciprocal trade (Sun et al., 2019). The Industrial Revolution ushered in a time of widespread, quick economic success and gave rise to one of the most urgent issues of our day: climate change and global warming. The shift of the global economy from organic economies dependent on human and animal power to inorganic economies dependent on fossil fuels was one of the principal effects of the Industrial Revolution. Fossil fuel use has altered the carbon makeup of the atmosphere, increasing heat absorption. Climate change and global warming have been exacerbated by this mechanism (Kasman & Duman, 2015). Rising sea levels and increased global temperatures are only two examples of how climate change presents itself in the real world. Pollutant emissions, particularly carbon emissions from burning and using fossil fuels, are blamed for temperature increases. In addition to harming the planet, carbon emissions also endanger economic growth (Alola et al., 2019: 309; Omri & Saadaoui, 2023).

Global warming is the main factor causing climate change, and greenhouse gas emissions are the leading cause of global warming (Gozgor, 2017). In recent years, the growing threat posed by global warming and climate change has emerged as one of the leading global concerns. Since the 1990s, much research has been done on how global warming affects the international economy. Through intergovernmental and legally binding agreements, international organisations like the United Nations work to reduce the harmful effects of global warming (Halilcioglu, 2009). The massive increase in carbon dioxide (CO2) emissions around the globe is what is primarily driving people's heightened interest in global warming and climate change. Since CO2 is believed to be the primary greenhouse gas source contributing to global warming, governments must regulate it. The 1997 Kyoto Protocol aims to lower greenhouse gas emissions contributing to climate change and global warming in this context (Ajmi et al., 2015). Governments have set CO2 reduction goals under the Kyoto Protocol to tackle climate change. The carbon emission trading (CET) system is one of the critical policy tools that has been put into place in Europe since January 2005. According to this system, businesses, particularly industries, must own CO2 emission licenses (Chappin & Dijkema, 2009).

The immediate deployment of energy regulation measures is required because many of these greenhouse gas emissions now come from emerging nations (Magazzino et al., 2021). Fossil fuel energy is the most widely used component globally, and it is essential for maintaining the development of nations. However, the proliferation of energy-consuming activities in developed and developing countries and waste in affluent countries raises significant concerns. These concerns primarily revolve around the depletion of energy resources, particularly oil, and the associated problems of rapidly increasing greenhouse gas emissions, such as CO2 and methane, contributing to global warming. The effective management and usage of renewable energy sources are necessary due to the worldwide nature of energy concerns (Sebri & Ben-Salha, 2018). Due to its advantages for the environment and general well-being, renewable energy is recognised as a significant energy source. It is a sustainable source that can increase energy security and lessen a nation's reliance on fossil fuels (Al-Mulali et al., 2015). Renewable energy is crucial to address the issues facing the globe today, such as climate change, energy security, and access to clean and inexpensive energy.

In terms of costs, the relationship between economic growth and energy consumption is significantly influenced by technical advancements. In economic theory, prices are considered a measure of scarcity, so the cost of a relatively scarce factor is expected to be higher. With the rapid increase in energy prices since the 1970s, technologies that consume less energy have been developed. Therefore, when examining the relationships between energy consumption and economic growth, it is necessary to include energy prices as an efficiency variable (Şengül & Tuncer, 2006). It is known that trade liberalisation boosts local output, which raises energy consumption (Cole, 2006; Topcu & Payne, 2018). Trade considerably boosts economic activity, but it also poses serious environmental risks since it causes a rise in pollutant emissions that have a negative impact on human health (Akbar et al., 2020). Trade liberalisation causes emissions in low-income economies, and there is a link between trade openness and CO2 emissions. However, the least developed nations produce less environmental deterioration than industrialised nations. However, these nations pose the highest environmental risks due to inadequate living circumstances, poor infrastructure, and a lack of systems for catastrophe prediction and control. To develop their infrastructure, adapt to changing climatic conditions, and increase their disaster management, prediction, and mitigation systems, low-income economies predominantly dependent on an agricultural economy need special attention and technology subsidies (Shahbaz et al., 2017).

In recent years, trade and environmental relations have become a topic frequently debated between advocates and opponents of trade globalisation (Ibrahim & Law, 2016). In his study, Sadorsky (2011) emphasises that trade activities can affect energy consumption differently. Firstly, the distribution process from one country to another requires a transportation network, which requires fuel energy. On the other hand, producing durable goods such as cars, air conditioners, and refrigerators also consumes significant energy. Increases in the quantity and trade of such products lead to a rise in energy demand and consumption (Sadorsky, 2011). The environment is impacted by free trade through

economic expansion. Due to the scale effect of increased energy consumption, economic expansion often has a negative environmental impact in the early phases of development. Early in development, economic expansion is prioritised over pollution control, leading to more economic activity and energy consumption, enhancing the likelihood of increased pollution emissions (Mahmood et al., 2019). As a result, increasing international trade expands the economy's growth potential by providing access to new markets. An economy in the process of growth may need more energy resources. If energy is obtained from fossil fuels, carbon emissions may increase, which may cause environmental problems such as climate change.

This study investigates the connection between trade openness, economic growth, energy use, and CO2 emissions. In this regard, a model suggestion is made, and analysis is done using Structural Equation Modelling (SEM) with data from 83 developed and developing nations between 2000 and 2020. This study is expected to guide policymakers in developing and implementing environmentally friendly strategies and provide important information that can be used to evaluate environmental risks for researchers, investors and the business world. SEM is a powerful statistical method to assess and model complex relationships between variables. SEM provides a flexible framework for examining causal relationships between variables in more detail than traditional statistical methods. Therefore, this study takes a comprehensive approach to understand more deeply the relationships between trade openness, economic growth, energy consumption and CO2 emissions by using structural equation modelling. In this respect, the method used within the scope of the study distinguishes the study from other studies in the literature. It makes it possible to address these complex relationships more systematically and in integrity. This study is crucial for examining the interactions between variables inside a single model from an integrated perspective. This study consists of four sections. After the introduction, the second section includes a literature review and summarises the studies on the subject. In the third section, the econometric method and analysis section is included. First, the technique used in the study is introduced, and then the necessary analyses are made. Finally, in the fourth section, the conclusion is included, and the importance of the study, main findings and recommendations are summarised.

2. Literature Review

Trade openness affects the economy in various ways, affecting energy use, CO2 emissions, and economic growth. Researchers and decision-makers have long focused on the links between trade openness, economic growth, and energy use. Numerous authors have used a variety of techniques utilising various periods for various countries to determine the direction of causality between these factors (Şengül & Tuncer, 2006; Halilcioglu, 2009; Hossain, 2011; Naranpanaw, 2011; Nasreen & Anwar, 2014; Bozkurt & Okumuş, 2015; Kyophilavong et al., 2015; Kesgingöz & Karamelikli, 2015; Ajmi et al., 2015; Bhattacharya et al., 2016; Shahbaz et al., 2017; Cetin et al., 2018; Ansari et al., 2019; Akbar et al., 2020; Khan et al., 2021; Zeeshan et al., 2022; Rahman & Alam, 2022; Ntiamoah et al., 2023;

Adebayo et al., 2023). The empirical findings on these interactions, however, are not clear. In this section, a summary of related studies is given.

Şengül and Tuncer (2006) examined the causal relationships between commercial energy consumption, real energy price index and economic growth using Türkiye's 1960-2000 period data using the VAR method. When the study's findings were examined, a one-way causality relationship was found between commercial energy consumption and economic growth, while a two-way causality relationship was found between real energy prices and economic growth.

Halilcioglu (2009) examined the causal relationships between carbon emissions, energy consumption, income and foreign trade using Türkiye's 1960-2005 data with a cointegration analysis and bounds test approach. Research findings show that there are two types of long-term relationships between variables. In the first form of the long-term relationship, carbon emissions are determined by energy consumption, income and foreign trade; in the second long-run relationship, income is determined by carbon emissions, energy consumption and foreign exchange.

Hossain (2011) analyses the dynamics between carbon emissions, energy consumption, economic growth, trade openness and urbanisation using 1971-2007 data for industrialising countries (Brazil, China, India, Malaysia, Mexico, Philippines, South Africa, Thailand and Türkiye). They examined causal relationships with panel causality and cointegration tests. Granger causality test results support no evidence of a long-term causality relationship but a unidirectional short-term causality relationship from economic growth and trade openness to carbon dioxide emissions, economic growth to energy consumption, and trade openness to the economy.

Naranpanaw (2011) examined the relationship between trade openness and carbon emissions in Sri Lanka using the ARDL bound test and data from 1960-2006. The results show no long-term causality between trade openness and carbon emissions but a short-term relationship.

Nasreen and Anwar (2014) examined the causal relationship between economic growth, trade openness, and energy consumption using panel cointegration analysis and data from 15 Asian countries from 1980 to 2011. Empirical findings show that economic growth and trade openness positively impact energy consumption. The Granger causality analysis also indicates a bidirectional causality relationship between economic growth and energy consumption, trade openness and energy consumption.

Ajmi et al. (2015) examined the relationships between energy consumption, carbon dioxide (CO2) emissions and GDP in G7 countries with the Granger causality test using 1960-2010 period data. The study's findings show that there is bidirectional causality between GDP and energy consumption for Japan, unidirectional causality from GDP to energy consumption for Italy, and unidirectional causality from energy consumption to GDP

for Canada. Additionally, the results show a bidirectional causality between energy consumption and CO2 emissions for the USA and a unidirectional causality from energy consumption to CO2 emissions for France.

Shahbaz et al. (2017) examined the relationship between trade openness and CO2 emissions for three groups of 105 low, middle, and high-income countries using Pedroni (1999) and Westerlund panel cointegration tests. Panel causality results show a bidirectional relationship between trade openness and carbon emissions in middle-income countries, but trade openness causes CO2 emissions in low- and high-income countries.

Cetin et al. (2018) examined the effects of economic growth, energy consumption, trade openness and financial development on carbon emissions using Türkiye's 1960-2013 period data with cointegration analysis. The findings reveal a long-term relationship between economic growth, energy consumption, trade openness, financial development and per capita carbon emissions. The Granger causality analysis also shows a long-term unidirectional causality from economic growth, energy consumption, trade openness, and financial development to carbon emissions.

Ansari et al. (2019), in their study, the effects of international trade, economic growth and energy consumption on carbon emissions in the USA, Japan, Canada, Iran, Saudi Arabia, England, Australia, Italy, France and Spain, which are among the countries that emit the most carbon emissions, 1971-2013. It was examined using panel cointegration and causality tests using period data. The research findings reveal a long-term relationship between carbon emissions and their determinants, with energy consumption being the primary determinant of carbon emissions.

In their study, Akbar et al. (2020) used data from 1991-2018 to examine the relationship between trade liberalisation, energy consumption, CO2 emissions, and health expenditures in Southeast Asian countries with SEM. Empirical results reveal a relationship between trade openness, energy consumption, CO2 emissions and healthcare expenditure in Southeast Asian countries. CO2 emissions have a direct impact on healthcare expenditures. It was concluded that trade and energy consumption indirectly affect the increase in health expenditures. It has been determined that energy consumption mediates all indirect effects.

Khan et al. (2021) examined the relationship between economic development, financial development, trade openness, energy use and carbon emissions in Bangladesh using the 1980-2016 autoregressive distributed lag bounds test method. The research findings reveal that energy use significantly impacts carbon emissions in both the short term and long term. The effect of economic development is among the findings that it substantially affects the long term, but there is no effect in the short term. Trade openness and financial development factors are equally negative and insignificant in the short and long term.

Zeeshan et al. (2022) examined the relationship between trade liberalisation, CO2 emissions, energy consumption and economic growth comparatively for Southeast Asian and Latin American countries with SEM using 1991-2018 data. The study shows that trade positively and statistically significantly impacts energy consumption, CO2 emissions and economic growth in Southeast Asian countries. In Latin American countries, while trade has an insignificant effect on energy consumption, a positive and statistically significant impact has been detected on CO2 emissions and economic growth.

Ntiamoah et al. (2023) examined the effects of carbon emissions, economic growth, population growth, trade openness and agricultural employment on the food security of East African countries using the 1990-2020 period with panel data analysis. The findings show that their variables have long-run equilibrium links. It has been found that the increase in CO2 emissions increases food security in East Africa in the long term, and long-term food security is positively affected by economic expansion, population growth, trade openness and employment in agriculture.

When the literature is generally evaluated, it can be seen that various studies use relevant variables and that traditional analysis techniques are used in most of these studies. Although the analysis findings vary, the general conclusion reached in these studies is that these variables have a positive and significant relationship.

3. Econometric Method and Analysis

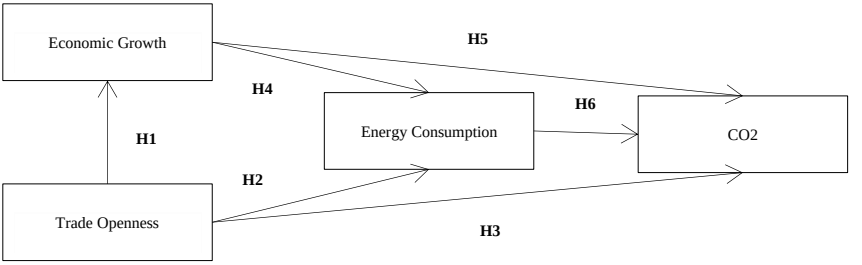
3.1. Structural Equation Modelling and Hypotheses

SEM is a tool for analysing complicated relationships among several constructs that are increasingly chosen for idea and theory building in management (Lei & Wu, 2007; Mia et al., 2019; Singh & Ahuja, 2020). Path analysis serves as the ancestor of SEM. Due to the inclusion of simultaneous estimates of several multiple regression models or equations, path analysis is seen as an extension of multiple regression analysis. This technique makes it possible to more directly and effectively model indirect effects, indirect mediation, and other intricate interactions between variables (Lei & Wu, 2007). Therefore, SEM is an advanced multivariate analysis technique that may examine intricate causal links between several variables.

SEM and path analysis were performed in this study using data from 83 developing and developed nations from 2000 to 2020. When the databases are examined, it is determined that the last updated common data regarding the variables is from 2020 (while the previously updated data on energy consumption and carbon emissions is from 2020, the last updated data on trade openness and economic growth from 2022). On the other hand, 47 of the 83 countries included in the study are in the developed country category, while 35 are in the developing country category. Considering developed and developing countries in the same sample within the scope of the analysis provides the opportunity to analyse and understand how they behave under similar conditions in the same period. The most significant advantage of this approach is that it reveals the relations between countries with different

economic structures in similar examples in more detail. IBM SPSS Statistics 28 and IBM SPSS Amos 28 software were used for the analyses. The proposed model of the study is illustrated in Figure 1.

Figure: 1
Proposed Model of the Study



The hypotheses of the proposed model in the study are as follows:

H1: Trade openness has a positive effect on economic growth.

H2: Trade openness has a positive effect on energy consumption.

H3: Trade openness has a positive effect on CO2 emissions.

H4: Economic growth has a positive effect on energy consumption.

H5: Economic growth has a positive effect on CO2 emissions.

H6: Energy consumption has a positive effect on CO2 emissions.

3.2. Analysis and Findings

This section includes the necessary analyses and findings made within the study's scope. Firstly, information about the variables discussed in the survey is included. The information regarding the variables is presented in Table 1.

Table: 1
Data Set of the Study

Variable Name	Variable Description	Source
Trade Openness	Trade (%GDP)	World Bank
Economic Growth	GDP Per Capita	World Bank
Energy Consumption	Oil equivalent energy consumption per capita	World Bank - Our World in Data
CO2	CO2 carbon emissions per capita (metric tons)	World Bank - Our World in Data

Then, descriptive statistics and correlation analysis findings are included. A correlation analysis was conducted while keeping the investigation's parameters in mind.

Correlation analysis, a statistical method, assesses a potential linear link between variables. It shows the strength and direction of the relationship between the variables and varies from +1 to -1 (Mukaka, 2012). The descriptive statistics and outcomes of the correlation analysis of the study's variables are displayed in Table 2 as follows.

Table: 2
Descriptive Statistics and Correlation Analysis

Descriptive Statistics					
Variables	Observation	Mean	Standard Deviation	Min	Max
Trade Openness	1421	92.30	56.73	19.56	437.33
Economic Growth	1428	18962.78	11789.27	157.18	113679
Energy Consumption	1314	3141.49	2322.66	141.35	20420.6
CO2	1390	6.67	6.12	.2	47.65
Correlation Analysis					
Variables	Trade Openness	Economic Growth	Energy Consumption	CO2	
Trade Openness	1.00				
Economic Growth	0.55	1.00			
Energy Consumption	0.57	0.59	1.00		
CO2	0.61	0.29	0.71	1.00	

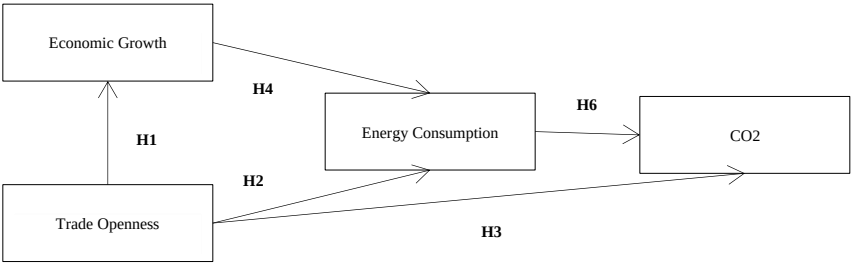
When Table 2 is examined, it is seen that the number of observations, mean, standard deviation, min and max value information of the variables are included. Upon reviewing the results of the correlation analysis in Table 2, it can be observed that trade openness has a positive correlation of 0.55 with economic growth, 0.57 with energy consumption, and 0.61 with CO2. The highest correlation value is 0.71 between energy consumption and CO2. The hypothesis test results of the proposed model conducted after the correlation analysis are presented in Table 3, as shown below.

Table: 3
Hypothesis Results of the Proposed Model

H. Number	**Hypotheses**	**Standard β**	**P**	**Accept/Reject**
H1	Trade Openness > Economic Growth	.525	***	Supported
H2	Trade Openness > Energy Consumption	.395	***	Supported
H3	Trade Openness > CO2	.286	***	Supported
H4	Economic Growth > Energy Consumption	.523	***	Supported
H5	Economic Growth > CO2	.015	.484	Unsupported
H6	Energy Consumption > CO2	.610	***	Supported

When examining Table 3, it can be observed that out of the six hypotheses, five were supported, while the hypothesis (H5) regarding the positive impact of economic growth on CO2 was not supported. In structural equation models, hypotheses not supported by the data are excluded, leading to a redefinition of the model. This deduction allows the model to become more accurate and effective. This study's analysis was continued based on the accepted model shown in Figure 2 after excluding the unsupported hypothesis (H5) from the model.

Figure: 2
Accepted Model of the Research



SEM aims to enable researchers to understand the theory and develop the most appropriate model based on the theory. Furthermore, the test results are more accurately represented by the model's goodness-of-fit, which involves comparing fit indices and constructing the initial structural model based on the theory (Mia et al., 2019). Goodness-of-fit tests in SEM provide various indices concerning the compatibility of the collected data with the model. The most commonly used index in SEM programs, referred to as the initial fit index, is the chi-square ($\chi 2$) test, which indicates the level of compatibility between the model and the data (Meydan & Şeşen, 2015; Scaini et al., 2022). A value less than 3 indicates excellent fit, while a value between 3 and 5 indicates acceptable fit (Gürbüz, 2019). Upon reviewing the literature, I found that other frequently used indices for assessing model fit are CFI, NFI, and RMSEA. CFI and NFI are comparative fit indices, and values close to or equal to 1 indicate excellent fit, while values close to 0 indicate poor fit (Talwar et al., 2016). RMSEA is an index demonstrating the model's fit to the sample (Tanaka et al., 2017). Table 4 presents these indices' fit ranges and the accepted model's goodness-of-fit values.

Table: 4
Goodness of Fit Values of the Accepted Model

Good Fit Indices	Accepted Compliance Range	Model Fit Value
$\chi 2$/sd (CMIN/DF)	≤ 5	3.27
CFI	.90≤CFI≤1.00	0.98
NFI	.90≤NFI≤1.00	0.99
RMSEA	.00≤RMSA≤.08	0.05

The model fit index values in Table 4 fall within the accepted range. After checking the goodness-of-fit values, the accepted model was used for path analysis. The total, direct, and indirect effects among the variables are presented in Table 5 due to the path analysis.

Table: 5
Total, Direct and Indirect Effects Between Variables in the Accepted Model

Standardised Total Effects			
Variables	Trade Openness	Economic Growth	Energy Consumption
Economic Growth	0.52	0	0
Energy Consumption	0.67	0.52	0

CO2	0.70	0.32	0.62
Standardised Direct Effects			
Variables	Trade Openness	Economic Growth	Energy Consumption
Economic Growth	0.52	0	0
Energy Consumption	0.39	0.52	0
CO2	0.29	0	0.62
Standardised Indirect Effects			
Variables	Trade Openness	Economic Growth	Energy Consumption
Economic Growth	0	0	0
Energy Consumption	0.28	0	0
CO2	0.41	0.32	0

Table 5 shows that trade openness has an overall impact on economic growth, energy consumption, and CO2 of 0.52, 0.67, and 0.70, respectively. Regarding the direct effects, trade openness has a 0.52 impact on economic growth, a 0.39 impact on energy use, and a 0.29 impact on CO2. Trade openness indirectly affects energy consumption and CO2 emissions of 0.28 and 0.41, respectively.

According to the findings, nations that are more open to trade tend to use more energy and emit more CO2 to create and export more goods and services. This is due to the expectation that increased trade openness will boost factors like transportation and industrial activity, directly raising demand for and consumption of energy-intensive items. Research on indirect impacts shows that trade openness can impact economic growth, affecting energy use and CO2 emissions. Countries experiencing economic expansion typically consume more energy, increasing CO2 emissions. Therefore, the relationship between economic growth and CO2 emissions can be considered driven by energy use.

4. Conclusion

With increased international trade and easier access to new markets, businesses can operate globally and reach a wider audience. On the other hand, when a nation specialises in producing a particular good or service, efficiency increases. This, in turn, enhances productivity and spurs economic expansion. Trade and economic expansion, however, can cause a rise in energy use. Carbon dioxide and other greenhouse gases are emitted due to processes like burning fossil fuels for energy. By raising the air's temperature, these greenhouse gases contribute to major environmental issues, including climate change.

This study examines the relationship between trade openness, economic growth, energy consumption, and CO2 emissions in 83 developed and developing countries using the SEM method with data from 2000-2020. An important feature of SEM is that it examines the relationships between variables in an integrated way. This is where SEM differs from other statistical analysis methods. SEM can handle correlations, causal relationships and indirect effects between variables within the same model. In this way, a more comprehensive analysis can be performed to explain interrelated variables' interactions and complex relationships. Six hypotheses are examined in this case, and a sample proposal is put out. Based on the proposed model's path analysis findings, one hypothesis (H5) is deemed unsupported and is eliminated from the study, leaving the remaining five up for discussion. When the findings of the study are evaluated in general, it is seen that they are compatible

with the literature. Since SEM is a confirmatory method, not an exploratory one, it is expected that the model hypotheses created based on the literature will be accepted. The analysis results show that trade openness generally affects economic growth, energy use, and CO2 emissions of 0.52, 0.67, and 0.70, respectively. Additionally, the data show that trade openness indirectly affects energy use and CO2 emissions, with coefficients of 0.28 and 0.41, respectively. These coefficients show the direction and strength of the relationships between the relevant variables. In other words, the positive coefficient between trade openness and economic growth is 0.52, indicating that the increase in trade openness positively affects economic growth. Indirect effect coefficients show the effect of mediator variables on dependent variables through the impact of other independent variables.

The increase in production and transportation of goods and services and increased trade impact energy consumption. Since manufacturing and transportation activities frequently require a lot of energy, increased trade may result in higher energy demands. This entails increased energy resource use and CO2 emissions from electricity production. These results emphasise the necessity of integrating trade and energy policies and considering how trade policies may affect energy use and CO2 emissions. The results suggest that trade openness can significantly impact energy consumption and CO2 emissions, highlighting the need for policymakers to consider these effects when designing trade and energy policies. Promoting renewable energy sources and energy efficiency, in particular, is anticipated to help reduce the detrimental environmental impact of growing commerce and economic growth. Incentives and investments for sustainable energy resources, as well as raising awareness in society by conducting training and awareness programs on environmental impacts, may be strategic steps to be taken at this point. On the other hand, the limitation of this study is that the latest common data for the countries discussed is from 2020. For future studies, it is recommended that researchers make comparisons by performing analyses over a more comprehensive period and for different country groups.

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Annex: 1
Countries Included in the Analysis

Algeria	El Salvador	Kyrgyz Republic	Romania
Angola	Estonia	Latvia	Saudi Arabia
Australia	Finland	Lebanon	Senegal
Austria	France	Lithuania	Singapore
Bahrain	Germany	Luxembourg	Slovak Republic
Bangladesh	Ghana	Malta	Slovenia
Belgium	Greece	Mongolia	Spain
Benin	Haiti	Morocco	Sri Lanka
Bolivia	Honduras	Nepal	Sweden
Brunei Darussalam	Hungary	Netherlands	Switzerland
Cambodia	Iceland	New Zealand	Tajikistan
Cameroon	India	Nicaragua	Tunisia
Canada	Indonesia	Nigeria	Ukraine
Chile	Iran, Islamic Rep.	Norway	United Arab Emirates
Congo, Rep.	Ireland	Oman	United Kingdom
Cote d'Ivoire	Israel	Pakistan	United States
Croatia	Italy	Panama	Uruguay
Cyprus	Japan	Philippines	Uzbekistan
Czechia	Kenya	Poland	Vietnam
Denmark	Korea, Rep.	Portugal	Zimbabwe
Egypt, Arab Rep.	Kuwait	Qatar	

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