Essays on Environmental Degradation

By

Fatima Bibi

Ph.D. Student

SCHOOL OF ECONOMICS
QUAID-I-AZAM UNIVERSITY, ISLAMABAD
April 3, 2023

Essays on Environmental Degradation

BY

Fatima Bibi

Ph.D. Student

Supervisor

Dr. Muhammad Jamil

Professor of Economics
Ghulam Ishaq Khan Memorial Chair (SBP)
Kashmir Institute of Economics
The University of Ayad Jammu & Kashmir, Muzaffarabad

School of Economics,
Faculty of Social Sciences,
Quaid-i-Azam University, Islamabad.
April 3, 2023

Dedicated To

My Beloved Parents

Declaration Form

I, Fatima Bibi, daughter of Ayub Khan, registration no: 03091411005, candidate for Ph.D. Economics at School of Economics, Quaid-i-Azam University Islamabad, hereby declare that the thesis "***Essays on Environmental Degradation***" submitted for the partial fulfillment of the Doctor of Philosophy (Ph.D.) degree in Economics is my work. All the errors and omissions are lonely goes to me, and I also somberly pronounce that it will not be submitted for attaining any other degree in the future from any institution.

Fatima Bibi

CERTIFICATE OF APPROVAL

This is to certify that the research work presented in this thesis, entitled "***Essays on Environmental Degradation***" was conducted by **Ms. Fatima Bibi** under the supervision of **Dr. Muhammad Jamil,** Professor of Economics.

No part of this thesis has been submitted anywhere else for any other degree. This thesis is submitted to the School of Economics, Quaid-i-Azam University, in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the field of Economics, School of Economics, Quaid-i-Azam University, Islamabad.

Student Name: Ms. Fatima Bibi **Signature:** ____________

Examination Committee:

a) **External Examiner:** **Signature:** ____________
Prof. Dr. Abdul Rashid
International Institute of Islamic Economics
International Islamic University
Sector H-10, Islamabad.

b) **External Examiner:** **Signature:** ____________
Dr. Muhammad Iqbal
Chief of Research (Rtd)
House No. 78, Street No. 02, B-Block,
CBR Town phase-1, Islamabad.

Supervisor Name:
Dr. Muhammad Jamil **Signature:** ____________
Professor of Economics
Kashmir institute of Economics
The University of Azad Jammu & Kashmir ,Muzaffarabad.

Dr. M. Tariq Majeed **Signature:** ____________
Director
School of Economics,
Quaid-i-Azam University, Islamabad.

Plagiarism Undertaking

I solemnly declare that research work presented in the thesis titled “Essays on Environmental Degradation” is solely my research work with no significant contribution from any other person. Small contribution/help wherever taken has been duly acknowledged and that complete thesis has been written by me.

I understand the zero-tolerance policy of the HEC and University, **Quaid-i-Azam University, Islamabad** towards plagiarism. Therefore, I as an Author of the above titled thesis declare that no portion of my thesis has been plagiarized and any material used as reference is properly referred/cited.

I undertake that if I am found guilty of any formal plagiarism in the above titled thesis even after award of PhD degree, the University reserves the rights to withdraw/revoke my PhD degree and that HEC and the University has the right to publish my name on the HEC/University Website on which names of students are placed who submitted plagiarized thesis.

Student /Author Signature: ____________________

Fatima Bibi

Acknowledgment

All praise be to Allah, the Lord of all the worlds.

This dissertation would not have been possible without the guidance and help of several individuals who, in one or the other way, contributed and extended their valued assistance in the preparation and completion of this dissertation. First, I would like to express my sincere gratitude to my supervisor. I owe my supervisor most of what I have learned during the entire period, not only in Economics but also in terms of valuable enhancement in my general knowledge. I cannot find words to thank and express gratitude to my teacher and mentor, Dr. Muhammad Jamil, for teaching me and guiding me in what I should aim for as a researcher. He was always able to find something remotely interesting inside my vague ideas and encouraged me to work hard and not give up through the toughest moments.

I am also very thankful to my parents and siblings, who have always prayed for my success and supported me throughout my research. I cherish my mother′s love for studies and her prayers for my success. I express deep admiration for my father, who has been a permanent source of love, hope, guidance, and kindness for me right from the beginning of my life.

I would take this opportunity to thank all my teachers, especially Dr. Eatzaz Ahmad, Dr. Javed Iqbal, Dr. Tariq Majeed, and Dr. Zahid Asghar at QAU, Islamabad. I would also like to thank all my colleagues and friends for their moral support and encouragement. To everyone, I wholeheartedly say two simple words: ―Thank You". They, however, bear no responsibility for any errors of omission and commission, which are entirely mine.

Fatima Bibi

Table of Contents

List of Tables

List of Figures

List of Abbreviations

CO_2	Carbon Dioxide Emission
EKC	Environment Kuznets Curve
ERE	Environmental Regulation Effect
EIA	Energy Information Administration
FDI	Foreign Direct Investment
FEM	Fixed Effect Model
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product per Capita
IEA	International Energy Agency
IMF	International Monetary Fund
KLE	Capital-Labour Effect
NAFTA	North American Free Trade Agreement
PWT	Penn World Table
REM	Random Effect Model
SAC	Spatial Autocorrelation Model
SAR	Spatial Autoregressive Model
SDM	Spatial Durbin Model
SEM	Spatial Error Model
WDI	World Development Indicator
WGI	World Governance Indicator

Abstract

Reducing natural resources like air, soil, and water through which the environment has deteriorated is called environmental degradation. It's also defined as any change that is undesirable to the environment. The main drivers of ecological change are population growth, economic growth, and technological innovation. Both developed and developing countries are conscious of environmental damage. Developed countries partially reduce the environmental damage by shifting some of their production to developing countries, thus shifting their pollution towards developing countries. This benefits the countries' development because it creates employment and reduces poverty and migration. So, there is a need for technological innovation in developing countries to reduce environmental damage.

An indirect effect of trade openness on the quality of the environment is described in chapter 2. The impact of trade openness on environmental quality is investigated through three channels: scale, composition, and technique effect. The spatial econometric approach is used to obtain empirical results, and data from 2000-2018 for the whole world is used. Scale effect increases carbon dioxide emission. Environmental quality improves due to the technique effect. The composition effect is harmful to the quality of the environment. In developed countries, the scale effect positively impacts carbon dioxide emissions. The technique effect and composition effect reduce carbon dioxide emission. In contrast, the scale effect and composition effect worsen the environmental quality, and the technique effect improves the quality of the environment in developing countries.

In the third chapter, this study analyzes the link between economic growth and air pollution based on the concept of the Environment Kuznets Curve (EKC) hypothesis, which implies a reversed U-shaped association between economic development and air pollution in six dissimilar regions comprising Latin America and the Caribbean, East Asia and the Pacific, South Asia, the Middle East, and North Africa, Europe, and Central Asia, and Sub-Saharan Africa from 2000 to 2018. Panel data econometric models (random and fixed effect models) and spatial panel data models (spatial error models) are employed to get empirical results. The EKC hypothesis is validated in all the regions stated above, excluding Sub-Saharan Africa. Hence, the hypothesis that dissimilar regions have unlike EKC relationships is verified.

A trade-environment association is affected by institutional quality. So, chapter 4 is about the non-linear link between trade openness and the quality of the environment for the whole world and then for developed and developing countries from 2000-2018. The panel threshold model is employed, and the findings are that trade openness is harmful to the quality of the environment in the low institutional quality regime, and it is favorable to environmental quality in the high institutional quality regime. Trade openness worsens the environmental quality before and after the threshold in developing countries. Scale effect increases carbon dioxide emission before and after the threshold. The technique effect improves the environmental quality before and after the threshold. In developed countries, only the composition effect reduces carbon dioxide emission before and after the threshold.

Chapter 1

Introduction

Environmental degradation occurs due to technological, institutional, and socio-economical activities. Environmental degradation occurs due to the depletion of the earth's natural resources. Air, water, and soil are affected by this degradation. It also impacts plants, animals, and wildlife.

The scientific and technical debate on environmental deterioration started in 1980. One of the most severe problems of modern societies is environmental degradation. The emission of greenhouse gasses, especially Carbon Dioxide (CO_2) emissions, is the principal reason for climate change. Many factors are responsible for environmental degradation, such as poverty, population, transportation, industrialization, congestion, and traffic.

In the Northern Hemisphere, 30 years from 1983 to 2012 is the warmest period of the last 1400 years, as reported by a study by the Intergovernmental Panel on Climate Change (IPPC, 2014). In this period, 0.85 C^0 warming is recorded globally. It is anticipated that in 2100, there will be a rise in sea level from 15.8 to 16.5 cm and a rise in global temperature between 1.1 to 6.4 C^0 due to these catastrophic consequences occurring in people's lives. The emission of carbon dioxide accounts for 60% of GHGs. Fossil energy sources are the major contributors to CO_2 emissions and are the primary energy input for economic growth.

The consequences of environmental degradation are affecting both developed and developing countries. All the world's nations are badly affected by Green House Gas (GHGs) accumulation around the earth's surface. Environmental degradation might be the reason for major catastrophes, such as a flood in Australia and Pakistan, a tsunami in Japan, and Haiti earthquakes in the past. These events damage infrastructure, agricultural land, natural resources (forests and wildlife), and the lives of precious humans. Both economists and environmentalists consider that these events occurred due to fast economic growth.

Environmental degradation is a worldwide concern, and the whole world faces its harmful consequences, but it is the responsibility of those countries to save the world from these destructive consequences, which are the major emitters of these GHGs. Carbon dioxide is the most noticeable GHG. India, China, Russia, the United States of America, Brazil, and the OECD group are the main emitters of CO_2. The commitment of these main emitters can reduce CO_2 emissions. When energy production is the cause of CO_2 emission, it becomes difficult for countries to reduce its emission because energy is related to economic growth. So, there is a need to find how both objectives (high economic growth and low carbon dioxide emission) are achieved. Financial development can accomplish these objectives.

Those pollutants which only affect the area in which they are emitted are called local air pollutants, and they cause respiratory problems and smog. Sulfur dioxide (SO_2), nitrogen oxides (NOx), carbon monoxide (CO), and delicate particulate matter (PM_{10} and $PM_{2.5}$) are included in these types of pollutants. Originators of acid rain are NOx and SO_2, which have the transboundary effect. Energy generation through power stations is the primary cause of $SO_{2,}$ and industry is the second largest cause of SO_2. Road transport is the most significant cause of CO and NOx. Industry, transport, and power stations are responsible for CO_2 and PM_{10} emissions (OECD, 1999).

The World Health Organization (WHO) calculated that life expectancy for every person is shortening by 8.6 months in European Union (EU) due to air pollution. Environmental degradation is often brought about by economic development. China and India are the two fastest-growing economies, and they are the major contributor to global emissions. A fifty-seven percent increase in emission level is taking place in India, and a 33 percent increase in emission level occurred in China from 1992 to 2002.

This dissertation aims to determine the impact of trade openness and economic growth on environmental quality. The effect of trade openness on the quality of the environment is discussed in chapter 2. Chapter 3 analyzes the Environment Kuznets Curve in separate regions of the world. The role of institutional quality in a trade-environment correlation is presented in chapter 4.

The decomposition of trade openness into scale, composition, and technique effect is described in chapter 2. The spatial econometric approach is used to find out empirical results. So, in this way, it fulfils the gap in the literature. In the previous literature, traditional methods are used to verify the consequence of trade on environmental quality. The findings are that the scale effect increases carbon dioxide emissions. It means pollution rises with the increase in economic activities. Pollution reduces due to the technique effect, which shows that clean production methods are adopted along with economic development. The composition effect also increases carbon dioxide emissions. These countries adopt the capital-intensive technique of production. The trade effect and energy effect also increase carbon dioxide emissions.

Then the same analysis is done for developed and developing countries. The scale effect has a positive impact on carbon dioxide emissions. Technique effect and composition effect are favorable to environmental quality. Trade and energy effects degrade the environment in developed countries. In contrast, the composition effect and scale effect boost carbon dioxide emission, whereas the technique effect diminishes CO_2 emission in developing countries.

In the third chapter, the Environment Kuznets Curve (EKC) hypothesis, which is the reverse U-shaped relationship between economic growth and environmental quality, is discussed for six world regions. These six regions include Europe and Central Asia, the Middle East and North Africa, South Asia, East Asia, the Pacific, Sub-Saharan Africa, Latin America, and the Caribbean. CO_2 emissions is taken as an indicator of environmental quality. This chapter aims to determine whether the EKC hypothesis is different in different regions of the world or not. Data from 2000 to 2018 is taken for that purpose. The findings are that the EKC hypothesis is not confirmed in Sub-Saharan Africa and is supported in all remaining regions. The EKC hypothesis is validated by many studies for a single country, the Asian region, and the Middle East and North Africa region and uses one or two additional variables. This study fulfills the literature gap by using a multivariate framework and analyzing the EKC hypothesis in whole regions.

High institutional quality leads to strict environmental regulation, and low institutional quality gives rise to lax environmental regulation. In this way, the trade and environmental quality relationship in the presence of low and high institutional quality is studied in the third essay. The findings are that trade raises CO_2 emissions in low institutional quality and reduces when the quality of an institution is high. In the case of developing countries, trade openness enhances CO_2 emissions before and after the threshold. Scale effect deteriorates the environmental quality before and after the threshold. The technique effect is advantageous for environmental quality before and after the threshold. In contrast, the composition effect is helpful for environmental quality before and after the threshold in developed countries.

Chapter 2

Trade and Environmental Quality: A Spatial Econometric Approach

2.1. Introduction

Economic growth affects people's basic needs, such as education, health, quality of life, and employment. The environment contributes to economic activities such as manufacturing, agriculture, and services by providing the necessary raw material. Therefore, the atmosphere is vital for sustainable development and economic growth for present and future generations. Many environmental changes, for example, climate change, biodiversity loss, and ozone layer depletion have occurred due to the industrial revolution (El-Alaoui, 2015).

Trade accelerates economic growth, often just as an investment and technological progress. Economic growth is initially harmful to the environment, and as the country becomes more prosperous, it starts to pay for a clean environment. Trade lowers environmental regulation and harms environmental quality due to competition. This is known as the race to the bottom hypothesis (Frankel, 2008).

Trade can influence the environment in three ways: scale, composition, and technique. Economic activity increases due to increased international trade, which increases the pollution level of the country. This is called the scale effect of trade. The income of a country increases due to boosting economic activities. Demand for a clean environment also rises with the rise in income. So, the pollution level increases in the initial phases of economic development but decreases after achieving a threshold income level.

According to neoclassical growth theories, the driving forces of growth are human capital and technological innovations. Most of the research and development activities are taking place in developed countries. Environment-friendly technologies are transferred to developing countries due to FDI and international trade. The environment improves due to this technology spillover effect. This is so-called the technique effect of international trade (Jobert *et al*., 2015).

The third influence of trade is called the composition effect. The composition effect of trade depends upon the stringency of its environmental policy and the resource abundance of the country. These are named the Environmental Regulation Effect (ERE) and Capital-Labour Effect (KLE). Countries specialize and trade those goods wherein they have got a comparative advantage. Capital-intensive goods are those in which developed countries have a comparative advantage. They produce more and more capital-intensive goods with trade, and pollution levels increase in these countries. While labor-intensive goods are those in which developing countries have a comparative advantage, the environment improves with international trade. This is known as the Capital-Labour Effect (KLE) effect.

On the other hand, pollution-intensive industries relocate from developed countries where environmental regulations are strict to developing countries where environmental regulations are weak. So, developing countries are becoming pollution-intensive countries. This is termed the pollution haven hypothesis and ERE. The pollution halo hypothesis is that inward FDI and international trade bring environmentally friendly products, equipment, and technology to developing countries, improving these countries' environmental conditions (Jobert *et al*., 2015).

Exports are goods and services produced by the domestic country and consumed by the receiver country. Therefore, carbon dioxide emissions linked to exports shall emit in the receiver country. Imports are goods and services produced by overseas countries and consumed by domestic countries. These goods shall emit carbon dioxide domestically. Carbon emission related to the production process remains in the host country.

There are two different economic policy views on trade liberalization and the quality of the environment. Those who favor lessening trade barriers to safeguard the environment are the defenders or supporters of trade liberalization. The supporters of trade openness say that environmental quality is a normal good and people demand a clean environment whose income level increases due to trade openness. Production techniques that are old and outdated are discouraged by the authorities. This way, trade creates a win-win situation because the economy and ecosystem improve with trade openness. Others are a supporter of inward-looking trade policy and strict environmental regulation. They are called the rivals of trade openness. The rivals of trade openness say that economic activity is stimulated due to trade openness, and it causes environmental deterioration if production techniques do not change. If environment quality is standard, firms in developing countries develop pollution-intensive production due to lax environmental regulations. The income distribution may increase due to this process at the world level. Pollution-intensive industries grow in developing countries due to trade openness because developed countries have stringent environmental laws, harming environment quality (Ling *et al.*, 2015).

2.1.1 Background of the study

Air and water pollution is the most important universal concern. The natural ecosystems and health of all living organisms are affected by air pollution. Importance has been given to environmental issues during the last four decades. In advanced countries, the focus of public anxiety about the environment started in 1960, and it was the problem of industrial pollution. In trade analysis, environmental issues appeared in the late 1970s. The debate about the effect of trade liberalization on the quality of the environment in developing and developed countries was introduced by The United Nations Stockholm Conference on Development and Environment held in 1972. This issue is also discussed in agreements like GATT (General Agreement on Tariffs and Trade) and NAFTA (North American Free Trade Agreement). Transboundary environmental problems appeared in trade negotiations during the period of the 1980s. It was felt in the 1990s that environmental regulations are different across countries and affect the competitiveness of other countries and industries. Ecological problems also started to dwell on the global agenda during this period (Mousavi, 2015).

Trade and environmental quality are interacted by three environmental problems: local, transboundary, and global. Local environmental issues are biochemical oxygen demand, lead, municipal waste, and particulate. They have different abatement costs and are local environmental problems, and their control measures are determined locally. Environmental degradation of natural resources such as lakes, coastal seas, and rivers is called a transboundary environmental problem, and many countries are responsible for these problems. Climate change, ozone layer depletion, and biodiversity loss are global environmental problems. It is also called an environmental externality.

2.1.2 Problem Statement

CO_2 emissions and international trade have been simultaneously increasing for decades. From 1980 to 2012, there was a 75% increase in carbon dioxide emissions and a 450% increase in international trade. Carbon dioxide emission is increasing in developing countries, and it is anticipated that by 2040, the volume of carbon emission will be 127% higher in underdeveloped countries than in advanced countries, Energy Information Administration (EIA, 2004). A significant energy demand may be the reason for this expectation in developing countries, or it may be because of trade policies, as developed countries lessen the production of polluted goods due to globalization. Therefore, significant discussions about the impact of trade on the ecosystem are carried out at both political and academic levels in current years. Developing countries increase the living standard of their people and prosperity at the cost of the environment through the entrance of dirty industries.

They were shifting dirty industries from developed to developing countries, and international trade caused environmental degradation. The emission level of developing countries has been increasing in recent years, although most emissions were caused by developed countries historically. It is said by International Energy Agency (IEA, 2014) that 80% of global emission is caused by CO_2 emissions, which is produced by the top 25 countries, out of which developing countries were responsible for 60% of emissions in 2012. It is anticipated that emerging countries will cause 80% of discharges in the future because they give more importance to economic growth and better quality of life (Ertugrul *et al.*, 2016).

2.1.3 Objectives of the Study

This study investigates the influence of trade on CO_2 emissions from a spatial perspective. One country's pollution emission can affect its neighboring countries' pollution levels. Previous literature uses the traditional method of estimation, which does not capture this effect.

2.1.4 Plan of the Study

This essay consists of six sections to examine the influence of trade openness on the quality of the environment. Section 2.2 is about the theoretical and empirical literature review. The methodology which is adopted by this study is discussed in section 2.3. The description of variables, construction of variables, and data sources are discussed in section 2.4. The empirical results are shown in section 2.5. Section 2.6 consists of a summary and conclusion of the study.

2.2 Literature Review

This section divides into two sub-sections. The first subsection is about the theoretical literature review, and the second is about the empirical literature review.

2.2.1 Theoretical Literature Review

Trade promotes economic growth, but it deteriorates the environment as well. Trade is detrimental to the ecosystem in countries with lax environmental regulations. This is called the pollution heaven hypothesis. Pethig (1976) uses the two-sector Ricardian model and shows that a country with a less restrictive environment policy than another country will produce and export environment-intensive goods.

Another study by Siebert (1977) uses a two-sector model and assumes a small open economy. The home country produces and exports pollution-intensive goods after the trade and deteriorates the environmental quality. With the environmental policy, the production of pollution-intensive goods decreases as resources are used for abatement.

Perroni and Wigle (1994) used the general equilibrium model to show the association between international trade and environmental quality. The result is that international trade slightly harms the ecological quality. Welfare advantages from environmental policies are little affected by international trade policies, and gains from trade are somewhat affected by environmental policies.

Bommer and Schulze (1999) investigate that trade agreement harms the environment if environmental policy is considered exogenous. Results are reversed when environmental policy is taken as endogenous. In this case, trade policy and better environmental quality become mutually compatible. Trade liberalization improves environmental quality.

Dean (2002) uses Heckscher-Ohlin (HO) trade model wherein a clean environment supply is taken as endogenous to develop a different approach. Thus, a system of equations is formed to capture the effect of trade liberalization on the quality of the environment via two channels: trade liberalization's direct influence on the quality of the environment using the term of trade and the indirect influence of trade liberalization on the environment through income growth. Chinese provincial data over the period 1987 to1995 is used to estimate the model, and this study shows that trade liberalization increases the emissions growth through the composition effect when the price of export to import improves, and it decreases the emission growth through the technique effect when income growth takes place due to trade liberalization.

2.2.2 Empirical Literature Review

There are six strands of literature. The first-strand detrimental impact of trade openness on CO_2 emissions is discussed. The second part is on the beneficial effects of trade openness on the quality of the environment. The third strand decomposes the trade into scale, composition, and technique effect. The ambiguous influence of trade openness on environmental degradation is discussed in the fourth strand. Fifth, consider trade openness and CO_2 emissions in developed and developing countries. Studies with Spatial Effects are described in the sixth strand of literature.

2.2.2.1 Detrimental impact of trade openness on the environmental quality

Various empirical studies have analyzed the trade-environment relationship. Time series as well as panel data studies examine the relationship between trade and environmental quality by using different econometric techniques. Results of some studies show that trade has a detrimental impact on the quality of the environment in both time series and panel data studies. For Pakistan, Azhar *et al.* (2007) examine the impact of trade liberalization on the quality of the environment from 1972 to 2001. The Johanson-Juselius cointegration technique is used to obtain the long-run link among variables. The result of this study is that trade liberalization increases both water and air pollution. Water and air pollution increased by 1.21% and 5.11%, respectively, due to a 1% increase in trade liberalization. In the case of Tunisia, Chebbi *et al*. (2011) examine the association between trade openness, growth, and CO_2 emissions. The Cointegration technique is used to get the long-run and short-run links between trade openness, development, and CO_2 emissions. The relationship between trade openness and pollution emissions is positive both in the short and long run. Moreover, trade openness causes environmental degradation in Tunisia.

For instance, Nguyen (2020) studies the influence of FDI and trade openness on CO_2 emissions. Data from 1990 to 2018 is used, and the ARDL model is used to obtain estimation results. FDI benefits the environment in the short run but does not affect it in the long run. Trade openness is dangerous for the environment.

The detrimental effect of trade openness on the quality of the environment is also analyzed in the case of panel data studies. Using panel data, Atici (2012) examines the link between trade openness and the environmental quality of ASEAN countries from 1970 to 2006. Fixed Effect Model (FEM) and Random Effect Model (REM) are employed for estimation. The results are that export has a damaging effect on the quality of the environment in the region. CO_2 emissions increases by o.33% due to a 1% increase in the export to GDP ratio. FDI does not pollute the region.

An almost similar result is obtained in the following study. By using the data from 2004-2011, Lin (2017) explores the relationship between trade openness and the quality of the environment in the case of China. The random-effect model and fixed effect model are used to obtain estimation results. The study finds that trade is destructive to the environment because exports are more significant than imports in China, and exports cause industrial pollution. A 1% increase in trade openness causes a 0.188% increase in NO_2 emission.

Using the data from 1971 to 2011, Ertugrul *et al*. (2016) explores the relationship between real income, energy consumption, trade openness, and carbon dioxide emission for the top ten carbon dioxide emitter countries among emerging countries. The Zivot-Andrews unit root test, structural breaks, ARDL test with structural breaks, and VECM Granger causality method are used for estimation. The findings are that co-integration is found in real GDP, carbon emission, trade openness, and energy consumption for India, Turkey, Thailand, China, Brazil, Korea, and Indonesia. Energy consumption deteriorates the environment in most countries under study. Trade openness progressively affects carbon dioxide emissions in India, Turkey, China, and Indonesia because the environmental standard is lax in these countries, and pollution-intensive industries have shifted to these countries from developed countries. A 1% increase in trade openness causes 0.062%, 1.062%, 0.056%, and 0.110% increase in CO_2 emissions in China, Indonesia, Turkey, and India respectively. However, it has no impact on carbon dioxide emissions in Brazil, Korea, and Thailand because neither effect (scale, composition, and technique) dominates the other. Real GDP and trade openness are critical factors in the quality of the environment in the long run, and many causal relationships among these variables are also found. EKC is supported by Korea, India, China, and Turkey.

Moreover, Hakimi and Hamdi (2016) examine the link between trade liberalization, FDI, and environmental quality in two countries, Tunisia and Morocco, using data from 1971 to 2013. A VECM and cointegration technique is used for individual country cases, and panel VECM and panel cointegration techniques are used in the case of both countries. The study indicates that bidirectional causality exists among FDI and CO_2, showing that FDI is not clean in Tunisia and Morocco. Trade liberalization negatively affects environmental quality because these countries import fossil fuels and oil. CO_2 emissions increased by 3.14% due to a 1% increase in trade openness. Although trade liberalization created jobs in both countries, liberalization of trade is dangerous to the quality of the environment.

The impact of trade openness and then separately the impact of imports and exports on the environment quality is analyzed by Dou et al. (2021) from 1970 to 2019. The result is that trade openness increases carbon dioxide emissions in Japan, South Korea, and China. Exports reduce carbon dioxide emissions, while imports increase carbon dioxide emissions. More recently, Li and Haneklaus (2022) found that trade openness and per capita GDP increase CO_2 emissions while urbanization reduces CO_2 emissions in G7 economies. Panel Autoregressive Distributed Lag (ARDL) model is employed, and data from 1979-2019 is used in this study. Similarly, Rahman and Alam (2022) find that trade openness, financial development, and energy consumption deteriorate the environment quality in 17 Asia-Pacific countries by using the data from 1960 to 2020.

2.2.2.2 Beneficial impact of trade openness on the environment:

The beneficial impact of trade openness on the environment is found in both time series and panel data studies. In the case of China, Yang *et al*. (2008) find that FDI and import trade have a beneficial effect on environmental quality, and export harms the environment in China. Data from 1982 to 2006 is used in this study. The variance decomposition method and VAR model are used to study the association between export, import, FDI, and environmental quality.

Using the ARDL bounds test, Rahman and Vu (2020) analyze the influence of trade, economic growth, and renewable energy on CO_2 emissions in Australia and Canada over the period 1960 to 2015. In the short run, trade openness and renewable energy consumption reduce CO_2 emissions, while economic growth enhances CO_2 emissions both in the long and short run in Australia. In Canada, trade openness positively affects carbon dioxide emissions in the long run and short run, although economic growth positively impacts carbon dioxide emissions only in the short run.

From 1971-2007, Hossain (2011) explored the causal link between economic growth, carbon dioxide emission, trade openness, and energy consumption for newly industrialized countries (NIC). This study uses the panel unit root, cointegration, and Granger causality tests. The study finds no long-run link among variables, and a short-run relation is acquired between trade openness and economic growth to carbon emission. There is a positive relationship between energy consumption and carbon emission, while trade openness and economic growth influence negatively. A 1% increase in trade openness causes a 0.217% decrease in carbon dioxide emission, while a 1% increase in energy consumption increases carbon dioxide emission by 1.219%. The reason is that energy consumption increases over time in newly industrialized countries due to increasing industrial output for economic development.

2.2.2.3 Scale, composition and technique effect

Some studies find the indirect effect of trade openness on the quality of the environment by decomposing it into Scale, technique, and Composition effects. In the same way, Cole and Elliott (2003) examine the trade-induced composition effect. The study results in support both KLE and ERE effects on SO_2 emission. Furthermore, the trade induces a more negligible composition effect than scale, technique, and direct composition effect. Trade liberalization decreases Biochemical Oxygen Demand (BOD) emissions while increasing nitrogen oxide (NO_x) and CO_2 emissions.

Using the Quarterly data from 1970 to 2011 for Malaysia, Ling *et al.* (2015) examine the influence of trade on the environment by disintegrating trade openness into technique, scale, comparative advantage, and composition effect. PP and ADF unit root tests are used. ARDL test is used to find the long-run link among variables. The study finds that there occurs a long-run link among variables. Moreover, the scale effect positively affects CO_2 emissions, and the technique effect declines CO_2 emissions. Energy consumption increases CO_2 emissions. Trade and composite effects benefit the environment, while comparative advantage effects harm the environment. Bidirectional causality is attained between energy consumption and CO_2 emissions.

Using the data from 1991 to 2007, Tayebi and Younespour (2012) examine the impact of inter-industry trade on the quality of the environment of Iran with other countries in East Asia, the Middle East, and the OECD. This study found that the scale effect boosts CO_2 emissions in the case of East Asia and Middle East countries. A 1% rise in per capita GDP due to trade liberalization increases pollution by .00071%. The technique effect negatively impacts the quality of the environment in the Middle East and OECD countries. The coefficient of the capital-labor ratio is favorable in OECD countries. CO_2 emissions increases by .00061% due to a 1 unit rise in the capital-labor ratio because the production of dirty goods increases with trade. Iran has a comparative advantage in contaminated products.

For the Belt and Road Countries, Chen *et al.* (2021) examines the direct and indirect consequences of trade openness on CO_2 emissions by using the data from 2001 to 2019. The panel quantile regression approach is used in this study. The result of the study is that trade asserts a positive effect on carbon dioxide emissions. Moreover, the indirect impact of a trade employing the substitution channel and the technology channel reduces carbon dioxide emission, but the economic track enhances carbon dioxide emission.

Löschel *et al*. (2013) examine the influence of trade on the environment for 40 countries using the World Input-Output Database (WIOD) database. The result is that trade is favorable to the quality of the environment because the technique effect dominates the scale effect. Pollution decreases by .010% due to a 1% rise in trade openness.

Moreover, Loibikiene and Butkus (2019) examine the impact of economic growth, trade, foreign direct investment (FDI), and urbanization on GHG emissions directly and indirectly through composition and technique effects. Data utilized in this study is for 147 countries from 1990 to 2012, and the system GMM estimation method is applied. The result is that economic growth enhances GHG emissions, and trade reduces GHG emissions. In all variables, the composition effect does not affect GHG emissions. In technique effect, urbanization, GDP, and trade decrease GHG emissions through energy efficiency but not renewable energy.

From 1991 to 2016, Ansari and Khan (2021) investigated the consequence of trade openness on the quality of the environment for thirty-five Asian countries. A fully modified ordinary least square (FMOLS) is employed in this study. The findings are that the scale effect has got a positive, and the impact of technology asserts a negative impact on the ecological footprint. The composition effect reduces the ecological footprint. Trade openness decreases the ecological footprint in Asian upper-middle-income and high-income counties while it rises in lower-middle-income countries.

Gale and Mendez (1998) investigate the empirical relationship between trade, environment, and growth. An increase in economic activity lowers the environmental quality while the rise in income per capita improves the environmental quality, but the relationship between them is linear. Trade intensity has an insignificant effect on the environment. Countries with different endowments have a distinct influence on the environment. The capital-abundant country has a detrimental impact on the environment, while labor and land-abundant countries benefit the environment.

2.2.2.4 Ambiguous impact of trade openness on environmental degradation:

The following studies examine short- and long-run links between trade openness and different variables. They use Perron's unit root test, the Vector Error Correction Model, and Gregory and Hansen cointegration test. Palamalai *et al.* (2015) examine the link between economic growth, energy consumption, CO_2 emissions, and trade in India. The long-run link exists between energy consumption, CO_2 emissions, economic development, and trade. Trade has a long-run effect on non-renewable energy consumption. However, in the short run, only crude petroleum promotes trade. High economic activity enhances the use of different sources of energy consumption jointly in the long run and short run.

Using the ARDL test, Mehrara (2014) finds the association between trade, growth, and the quality of the environment in Iran from 1979 to 2011. The coefficient of the error correction model is -.62, which shows the stable long-run link among variables, and variables adjust to the long-run equilibrium of 62% after every year. GDP has a significant long-run and short-run link with CO_2 emissions. There is a weak association between trade openness and CO_2 emissions in the long and short run.

Using time-series data from 1980 to 2006, Boulatoff and Jenkins (2010) examine the link between income, trade, and CO_2 emissions for G7, BRIC, and middle and low-income countries. CO_2 emissions is disaggregated by oil, gas, and coal sources. This study finds a long-run link between economic growth, trade, and CO_2 emissions from oil.

2.2.2.5 Trade openness and environmental degradation in developed and developing countries:

Trade openness affects the environment in developed and developing countries differently. In many studies, trade openness benefits the environment in developed countries and is harmful to the environment in developing countries. Similarly, Dinda (2006) examines the effect of globalization on the pollution level, relative change of pollution, and pollution intensity for developed countries, developing countries, and the world. A panel data estimation technique is used in this study. The factor endowment hypothesis and pollution heaven hypothesis are examined in this study. Globalization increases CO_2 emissions in developing countries and decreases CO_2 emissions in developed countries, thus supporting the pollution heaven hypothesis. Globalization increases pollution in the whole world.

For both non-OECD and OECD countries, Managi (2012) examines the association between trade openness and the environment. Trade openness benefits the environment in OECD countries by reducing SO_2, CO_2, and BOD both in the long and short term. Trade openness harms the environment in non-OECD countries by raising SO_2 and CO_2 both in the long and short time. Trade openness liberalization reduces the BOD in both non-OECD and OECD countries.

Using data from 1990 to 2011, Al-Mulali and Sheau-Ting (2014) examine the bidirectional long-run link between energy consumption, trade, and CO_2 emission for 189 counties from six regions. Panel fully modified OLS (FMOLS) is applied to obtain empirical results. The study attains a positive bidirectional relationship between energy consumption, trade, and CO_2 emission in all regions except Eastern Europe.

Moreover, Jobert *et al*. (2015) examine the link between trade and the environment using annual data from 1970-2013 for 55 countries. Estimation techniques used in this study are dynamic fixed effects and empirical iterative Bayes estimators. When heterogeneity of countries is considered, trade positively impacts the environment in some countries and has an adverse impact on others. Some countries confirm the pollution heaven hypothesis, while others do not.

Using the panel unit root test, panel causality test, and panel cointegration test, Bekmez and Ozsoy (2016) examines the link between trade and the environment in developed and developing countries from 1960 to 2010. This study indicates that trade openness declines CO_2 emissions in developed countries, whereas trade openness positively affects CO_2 emissions in less developed and developing countries. The pollution heaven hypothesis is valid in less developed and developing countries.

For 131 developed and developing countries, Kim *et al.* (2019) examined the link between trade openness and the environment from 1960 to 2013. The panel data quantile approach is used to obtain empirical results. The result is that trade with North countries increases the carbon dioxide emission while trade with South countries decreases the CO_2 emissions for host countries. Trade with the South and North reduces CO_2 emissions for developed countries. Trade with the South declines the CO_2 emissions in developing countries, while trade with the North increases the carbon emission. Overall, trade is beneficial for developed countries and harmful for developing countries while they trade with developed countries.

Using the data from 1985 to 2018, Khan *et al.* (2021) investigate the impact of trade openness and renewable energy consumption on environmental quality for developed and developing countries. OLS, System GMM, and Fixed Effect are used to obtain empirical results. The findings are that trade openness damages the quality of the environment in developing countries while benefiting the quality of the environment in developed countries. Renewable energy consumption enriches the quality of the environment in both developed and developing countries. FDI boosts carbon dioxide emissions in developed counties and decreases carbon emissions in developing countries.

2.2.2.6 Studies with Spatial Effects

Literature using a spatial data model that covers an environmental area is reviewed in this strand. Using the data from 1992-2014, Samreen and Majeed (2020) explore the effect of financial development (FD) on CO_2 emissions for 89 countries. The spatial econometric technique is used to obtain an empirical result. The study finds that FD lessens CO_2 emissions in developed countries and increases them in developing countries. Financial development (both local and spillover) decreases local carbon dioxide emissions.

Using the data from 2005 to 2015, Tang et al. (2020) examine the effect of FDI and corruption in China using a spatial econometric approach. The result is that FDI improves environmental quality while corruption reduces environmental quality. The interaction of FDI and corruption lowers the environmental quality as corruption reduces the advantageous effects of FDI on the quality of the environment.

Zhang *et al*. (2020) analyzed the link between energy consumption, economic growth, and air pollution from 2008 to 2018 in 31 provinces of China. A spatial panel model is used in this research. The study supports the Environment Kuznets Curve hypothesis. Moreover, environmental quality improves due to the structure effect and deteriorates because of technological pollution and energy consumption.

Using spatial panel data models, Majeed and Mazhar (2021) examine the influence of carbon dioxide emission on output volatility for 127 countries from 1996 to 2014. The findings are that carbon dioxide emission positively affects output volatility in all models. Neighboring countries' carbon dioxide emissions also increase local output volatility.

Using the Spatio-temporal Durbin model, Jankiewicz and Szulc (2021) examine the impact of renewable energy and economic growth on carbon dioxide emissions for 75 countries from 2013 to 2019. The Environment Kuznets Curve hypothesis is supported in this study. Renewable energy consumption reduces CO_2 emissions in selected countries. Change in renewable energy share in Norway, Italy, and China has the most significant impact on CO_2 emissions of nearby neighbors than faraway neighbors.

Trade openness has a positive, negative, and ambiguous effect on the quality of the environment, and trade openness exhibits a different impact in developed and developing countries. It depends upon the net result of scale, technique, and composition effect. Some researcher finds that trade is harmful to the quality of the environment. In their studies scale effect of trade is stronger than the composition and technique effect. Some studies concluded trade's a positive effect on the environment's quality. In these studies, the combined technique and composition effect is stronger than the scale effect.

Table 2.1 shows that trade has a beneficial effect on the environment in developed countries and a harmful effect on developing countries. The reason is that income is high in developed countries and people of these countries demand high environmental standards. They use environment friendly goods. Environment-friendly technology is used and fewer pollutant products are produced. On the other hand, priority is given to economic growth rather than environmental quality in developing countries. Those goods are produced which pollute the environment in these countries. Environmental standards are relaxed in these countries.

Table 2.1; Summary of Empirical Findings related to scale, composition, and trade effect.

Study	Objective	Period of Analysis	Region of Analysis	Methodology	Empirical results	Conclusion
Managi *et al*. (2009)	To examine the effect of trade on the environment	1980-2000	OECD countries	Differenced GMM	Scale and technique effect: -2.388 Composition effect: 2.202 Trade effect: -0.186	Trade openness has a beneficial effect on the environment by reducing the CO_2 both in the long and short-term
Managi *et al*. (2009)	To examine the effect of trade on the environment	1980-2000	Non-OECD countries	Differenced GMM	Scale and technique effect: 0.513 Composition effect: 0.369 Trade effect: 0.883	Trade openness has a harmful effect on the environment by raising CO_2 both in the long and short term.
Cole and Elliott (2003)	To analyze trade-induced composition effect is due to differences in environmental regulation or differences in capital-labor ratio.	1975-95 for carbon dioxide (CO_2),	32 developed and developing countries	Fixed effect and Random effect	Scale and technique effect: 0.46 Composition effect: 0.45 Trade effect: 0.049	Trade openness has a harmful effect on the quality of the environment
Antweiler *et al*. (1998)	To examine the trade is good or bad for the environment	1976-1990	Primarily developed countries	Random effect and fixed effect	Scale: 0.193 technique: -1.611 Composition: 1.135 Trade intensity: -0.869	Trade is good for the environment, as openness to the international market changes pollution intensity of output and reduces the pollution.
Cole (2006)	To analyze the effect of trade on the environment	1975-95 for per capita energy	32 developed and developing countries	Fixed effect	Scale and technique effect: 0.3 Composition effect: 0.7 Trade effect: 1.7	Trade openness has a positive effect the energy use.
Gale and Mendez (1998)	To analyze the roles of scale, technique, and composition effects in CO_2 pollution	1979	34 cities in 25 countries.	OLS	Scale:0.018 technique: -3.02E-4 Capital: 35.33 Labor: -4.16 Land:-1.84 Trade intensity: -2.07	An increase in economic activity lowers the environmental quality while an increase in income per capita improves the environmental quality. The environmental Kuznets curve is not inverted U-shaped but linear. Capital abundant country has a

						detrimental effect on the environment while labor and land-abundant countries have a beneficial effect on the environment.
Loibikiene and Butkus (2019)	To examine the effect of economic growth, trade, foreign direct investment (FDI), and urbanization on GHG emission not only directly but also indirectly through composition and technique effect	1990 to 2012	147 countries	system GMM estimation method	Scale: -0.0045 technique: -0.1179 Composition: -0.0214 Trade: -0.0618	Economic growth enhances GHG emissions and trade reduces GHG emissions. In all variables, the scale and composition effect does not affect GHG emissions. In technique effect, urbanization, GDP, and trade have a negative effect on GHG emission through energy efficiency but not through renewable energy.
Tayebi and Younespour (2012)	To examine the effect of inter-industry trade on environment quality	1991-2007	Selected countries in East Asia, Middle Asia, and OECD countries	The random effect, fixed effect	Scale: 0.0006234 technique: 0.0006579 Composition: 0.0000588 Trade intensity: 2.207383	Scale effect has a positive effect on CO_2 emissions in the case of East Asia and Middle East countries. Technique effect has a detrimental effect on the environment in the Middle East and OECD countries. The coefficient of the capital-labor ratio is positive in OECD countries. It means the composition effect has a negative effect on the environment.
Löschel *et al* (2013)	To find out whether a trade is beneficial or harmful to the environment.	1995-2009	40 countries 27 EU and 13 major countries	OLS, FE, and RE	Scale and technique effect: –0.270 Composition effect: –0.371 Trade effect: –0.003	Trade is beneficial to the environment
Azhar *et al* (2007)	To analyze the effect of trade liberalization on the environment	1972 to 2001	Pakistan	Johanson-Juselius cointegration technique	Scale: 1.72 technique: -0.62 Composition: -0.23 Trade intensity: 5.11	Trade liberalization has a positive effect on both water and air pollution.
Ling *et al*.	To examine the effect of	1970-Q1	Malaysia	ARDL bound testing	Scale: 2.2691	Scale effect has a positive effect on

(2015)	trade on the environment by decomposing the trade openness into technique, scale, composition, and comparative advantage effect	to 2011-Q4		approach	technique: -0.1686 Composition: -0.5742 Trade openness: -0.6866	CO_2 emissions and the technique effect has a negative effect on CO_2 emissions. Energy consumption increases CO_2 emissions. Trade effects and composite effects are beneficial to the environment while the comparative advantage effect is harmful to the environment.

Trade boosts the quality of the environment in Malaysia. Malaysia is a developed country and if we compare the empirical results of Malaysia with other developed countries which are in panel data form. The results are similar. Trade openness harms the quality of the environment in Pakistan. A comparison of the case study of Pakistan with other developing countries (panel data) shows similar results.

Scale, composition, and technique effects boost the CO_2 emissions in those studies in which both developed and developing countries are considered while scale and technique effect reduces carbon dioxide emission in developed countries. The scale effect has a large effect in the case of a single country and has a small effect in panel data studies.

2.3 Methodology

The theoretical framework determines the reliability of the study. It determines how independent variables affect the dependent variables. It provides channels through which variables affect each other and thus helps econometric specification and choosing a specific methodology to obtain an empirical result. To find out about trade and the environmental quality relationship, we follow the model of Antweiler *et al.* (1998).

2.3.1 Model for scale, composition, and technique effect

Trade openness affects the environment through three channels: scale effect, composition effect, and technique effect.

2.3.1.1 Scale effect

The scale effect is defined as economic growth caused by increased market access or trade, resulting in production, pollution, and energy consumption (Cole, 2004). The level of economic activity increases due to trade openness. Suppose there are no production technique changes and the pollution level increases. For example, air pollution increases if fossil fuel is used in industries. The demand for energy increases due to the rise in economic growth. If the methods of generating energy remain the same, then the number of harmful pollutants increases to increase economic output. The demand for transportation services increases due to trade openness. Then trade creates air pollution if fossil fuels are used in trucks and any mode of transportation (Grossman & Krueger, 1991).

Trade openness and investment lead to more industrialization and exacerbate the pollution level—market size increases due to trade openness. Firms are a sight on economies of scale due to significant market sizes. In this way, production and consumption increase, creating more pollution. Trade also facilitates specialization, and better allocation of resources takes place. Production and exchange of goods increase, and pollution also increases (Kim *et al.* 2019).

2.3.1.2 Technique effect

The change in the production technique due to liberalized trade is called the technique effect. This effect is caused by increased access to that environmentally friendly production techniques (Cole, 2004).

Pollution levels do not remain the same as economic activity increases. Pollution level decreases due to trade liberalization because of two reasons. Firstly, modern technologies are transferred to less developed countries by foreign producers. Current technologies produce less pollution because there is growing awareness about environmental concerns globally (Grossman & Krueger, 1991).

Secondly, economic development increases due to trade openness, and willingness to pay for the environment also increases, leading to the implementation of environmental regulation. Improvement in environmental quality might occur due to this. If clean production techniques are explored due to trade openness, then increased economic activities due to trade openness lead to a reduction of emissions. Income gains due to trade openness cause some countries to specialize in clean production (Le *et al*., 2016).

Efficient technologies are used by countries due to increased competition and thus reduce pollution. Local firms are encouraged to use new technology due to increased competition from foreign firms, and they have little motivation to do that before trade liberalization. This is called the defensive innovation hypothesis. Trade can reduce corruption and improve developing countries' environmental standards (Kim *et al.,* 2019).

Trade openness positively affects the environment because it encourages technological and managerial innovations beneficial for environmental improvement and economic growth (Frankel, 2008).

2.3.1.3 Composition effect

The composition effect relates to a modification in the economy's composition caused by trade liberalization because countries increase the specialization in those activities wherein they have a comparative advantage. Pollution increases or decreases to this composition effect depending on whether the country has a comparative advantage in dirty or cleaner goods production as industrial countries move away from heavy industries and specialize in services and light manufacturing industries. At the same time, there is increased specialization in the heavy industrial sector in developing countries (Cole, 2004).

There are many determinants of comparative advantage because of cross-country differences in factor endowment, environmental regulation, and natural resources. In the neoclassical theory of trade, such as Samuelson, Heckscher, and Ohlin, it is stated that trade pattern is determined by factor endowment (capital and labor). Assume agriculture is less polluting than other economic activities such as manufacturing. Since agriculture is labor-intensive, specialization takes place in cleaner goods in a country with a low capital/labor ratio, such as Pakistan, and specialization takes place in dirtier goods in a country with a high capital/labor ratio, such as the United States.

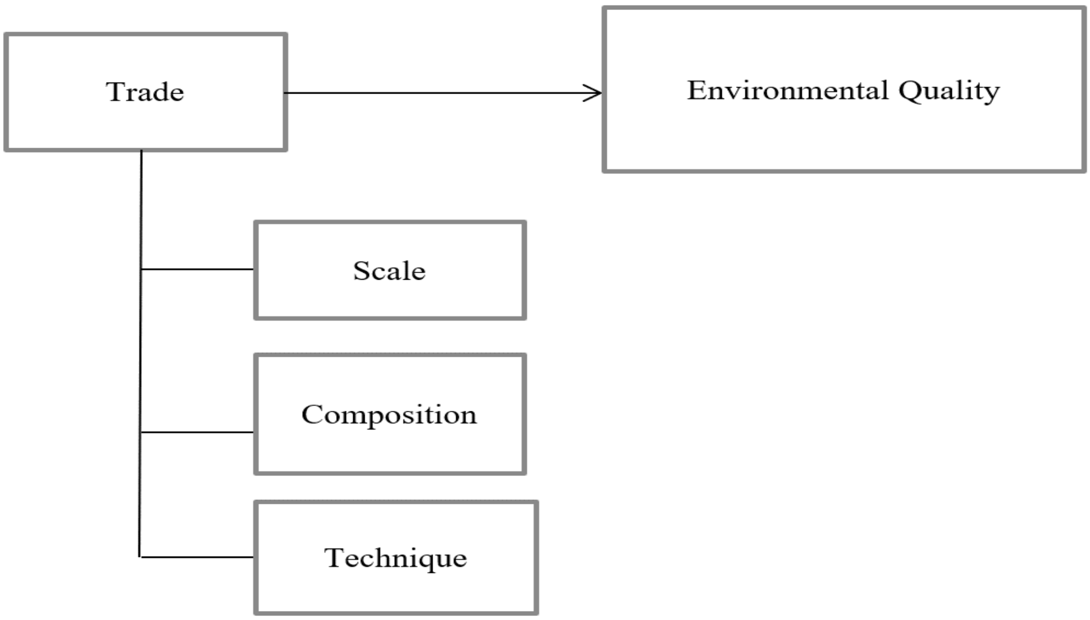
Secondly, the endowment of natural resources is the determinant of comparative advantage. A country with abundant mine resources will export them if it has the opportunity of trading with other countries.

Third, comparative advantage is generated by other environmental regulation differences in different countries. The demand for environmental quality is dissimilar due to the difference in per capita income which is the reason for an extra level of environmental regulation. Or reason for a different level of environmental law is that the supply of environmental quality is dissimilar due to differences in population density (Frankel, 2008).

Consistent with the pollution heaven hypothesis, developed countries reduce their pollution by reallocating their dirty industries to those developing countries with low environmental regulation through free trade. So, the number of firms manufacturing pollution-intensive goods increases due to less limited environmental regulations in developing countries. Developing countries care little about environmental quality than developed countries. The preference for higher income is more than higher environmental quality in those pollution heaven countries. In this way, the composition effect of trade is advantageous for the quality of the environment in developed countries and harmful to the environment in developing countries (Ertugrul *et al*., 2016).

In this way, industrialists do not produce those products with high abatement costs. The net effect depends upon whether pollution-intensive activities increase or decrease in countries with strict environmental regulations (Grossman & Krueger, 1991). Figure 2.1 shows the three channels of trade openness mentioned above: scale, composition, and technique effect.

Figure 2.1: Relationship between trade and quality of the environment



Source: Compiled by the author from the literature review

2.3.2 Theoretical framework for scale, composition, and technique effect

Antweiler *et al.* (1998) developed a model to analyze the scale, technique, and composition effect. They assume a small open economy in which N agents live. It produces two goods X and Y, with the help of two factors of production, capital (K) and labor (L). Good X is capital intensive and produces pollution, and good Y is labor-intensive and does not produce pollution. It is assumed that there is a constant return to scale. Their unit cost function can term production technology of both goods $c^x(w,r)$ and $c^y(w,r)$. Let $p_y = 1$, then the relative price of X is denoted by p.

Production of one unit of X generates 1 unit of pollution. This is called base level pollution, which is denoted by B. Abatement technology is used by the producer, and it is assumed that it uses only X as input. The function $\lambda A(x_a, B)$ represent the volume of pollution abated A for a given base level pollution B where x_a represent the number of resources used for abatement, and λ is affected by technological changes. Pollution emission is calculated by B minus A or:

$$z = [x - \lambda A(x_a, x)] \qquad (2.1)$$

z is pollution emission, and the Gross output of X is denoted by x. It is assumed that $A(x_a, x)$ is increasing, linearly homogenous, and concave in x and x_a. So, it can be written as:

$$A(x_a, x) = xa(\theta) \qquad (2.2)$$

Where the portion of X output attached to abatement is denoted by $\theta = \frac{x_a}{x}$ and $a(\theta) \equiv A(\theta, 1)$. Here the assumption is that without inputs, there is no abatement and full abatement of pollution is not possible: i.e.,$a(0) = 0$ *and* $\lambda a(1) < 1$. This indicates that there is a diminishing marginal return to abatement activity.

By substituting equation (2.2) into (2.1), equation (2.1) is written as follows:

$$z = x[1 - \lambda a(\theta)] \qquad (2.3)$$

Producers

Now equilibrium condition of the production side of the economy is stated. Here it is assumed that government imposes pollution taxes "τ" to decrease pollution. Profit π^x The firm that produces X is then calculated by subtracting revenue production, abatement, and pollution taxes.

$$\pi^x = \mathrm{p}\mathrm{x} - c^x(w,r)x - \tau[1 - \lambda a(\theta)]x - \mathrm{p}\theta x \qquad (2.4)$$

To maximize the profit firm will choose the abatement fraction θ and gross output x. It is given by:

$$\tilde{\mathrm{p}} = p(1-\theta) - \tau[1 - \lambda a(\theta)] \qquad (2.5)$$

$$\pi^x = \tilde{\mathrm{p}}\mathrm{x} - c^x(w,r)\mathrm{x} \qquad (2.6)$$

Individual firm output is indeterminate because of constant return to scale, but the first-order condition for choice of θ for any level of production is given by:

$$p = \lambda\tau a'(\theta) \qquad (2.7)$$

Equation (2.8) defines the optimal abatement θ^* as follows:

$$\theta^* = \theta\left(\lambda\frac{\tau}{p}\right) \qquad (2.8)$$

Optimal abatement θ^* is increasing the function of $\frac{\tau}{p}$. Firms will enter the industry until profits become zero in case of free entry. For industry X, by using equation (2.4), we have:

$$c^x(w,r) = \tilde{p} \qquad (2.9)$$

We have for industry Y

$$c^y(w,r) = 1 \qquad (2.10)$$

It is assumed that both firms are active. Factor prices w and r are a function of $\tilde{p}$ in equation (2.9). Factor prices then determine unit input coefficients. For example, the unit labor requirement in sector X is determined by $c_w^x = \partial c^x / \partial w$. Output is determined by complete employment conditions.

$$c_w^x\, x + c_w^y\, y = L \quad (2.11)$$

$$c_r^x\, x + c_r^y\, y = K \quad (2.12)$$

The gross output of X is denoted by x. Net out of X is $x_n = x - x_a = x(1 - \theta)$.

Consumers

Each consumer wants to maximize the utility and treats the pollution as given. So, it is supposed that the marginal disutility of pollution is constant, and preferences for consumer goods are homothetic. The indirect utility function of the consumer is written as follows:

$$V\left(p, \frac{G}{N}, z\right) = U\left(\frac{G/N}{\rho(p)}\right) - \delta z \quad (2.13)$$

When we substitute the prices and income for commodities, it becomes an indirect utility function. Where $\frac{G}{N}$ is per capita income, δ is the marginal disutility of pollution, ρ represents a price index, and U is concave and increasing. Pollution is pure public bad and has a damaging effect on all consumers. Real per capita income is defined as:

$$I \equiv \frac{G/N}{\rho(p)} \quad (2.14)$$

$\rho(p)$ are price index and indirect utility function is written as $U(I) - \delta z$.

Trade openness

It is assumed that there exist trade barriers. The relative price of X is p, which is different from the world price by trade friction.

$$p = \beta p\text{w} \tag{2.15}$$

Where pw denotes the relative world price of X and β is the trade friction. If the country imports X, then β>1, and if the country export X, then β<1. Pollution is decomposed into scale, technique, and composition effects by ACT.

$$z = \hat{S} + \widehat{Te} + \hat{C} \tag{2.16}$$

Where percentage change is denoted by ^ and S is the scale effect and denotes the variation in emission because of a change in the size of the economy. Te represents the technique of production. The composition effect stands for the portion of dirty goods in the total output.

ACT obtains the private sector emphasis for pollution by decomposing the equation (2.16). Demand for pollution is positively related to scale, the world price of polluted goods, and capital abundance and is negatively associated with pollution tax. The degree of trade friction has a positive or negative effect on pollution demand depending upon whether a country is a net importer or exporter of polluted goods. Pollution supply in the ACT model is determined by pollution tax, and real income is the factor of pollution tax. It means a rise in income increases the demand for quality of the environment. Joining the supply and demand for pollution gives the following reduced-form equation.

$$\hat{Z} = \alpha\hat{S} + \gamma\,\widehat{KLR} + \delta\,\hat{P}w - \vartheta\hat{I} - \varepsilon\hat{T} + \theta\hat{\beta} \tag{2.17}$$

Where T is country type, and KLR is a capital-labor ratio. β<1 for a dirty products exporter and $\hat{\beta} > 0$ after trade liberalization. It means trade liberalization boosts pollution in a country having a comparative advantage in dirty goods. $\beta > 1$ for an importer of polluting goods and $\hat{\beta} < 0$ after trade liberalization. Trade liberalization decreases pollution in a country having a comparative advantage in cleaner goods.

2.3.3 Empirical Methodology

The influence of trade openness on carbon emission is studied using a spatial econometric approach. The spatial econometric approach is made in two phases. The first phase explores spatial autocorrelation using Moran's I test. If spatial autocorrelation exists, then spatial models are estimated. Four types of spatial econometric models are the spatial autoregressive model (SAR), the Spatial Error Model (SEM), Spatial Autocorrelation Model (SAC), and Spatial Durbin Model (SDM) in spatial analysis.

2.3.3.1 Spatial autoregressive model (SAR)

Spatial econometrics is a field that incorporates the dependence between nearest neighbors by using the analytical technique. There exists a potential relationship between countries, cities, and regions. Spatial econometric methods deal with the problem when the dependent variable of one country (for example, Carbon Emission) interacts with the dependent variable of other countries. For example, there exist environmental externalities. An increase in one country will affect neighboring countries, but more distant countries are less affected by this increased pollution. The Spatial Autoregressive Model (SAR) can be written as follows

$$\begin{aligned}\ln CO_{it} = \alpha_{1i} + \alpha_2 \ln GDP_{it} + \alpha_3 \ln GDPS_{it} + \alpha_4 lnKLR_{it} + \alpha_5 lnTRD_{it} + \\ \alpha_6 lnENG_{it} + \alpha_7 FDI_{it} + \alpha_8 EDU_{it} + \alpha_9 IFD_{it} + \alpha_{10} IQ_{it} + \\ \rho W lnCO_{it} + \varepsilon_{it} \qquad (2.18)\end{aligned}$$

CO_{it} is carbon emission and the dependent variable. GDP_{it} and $GDPS_{it}$ are Gross Domestic Product and its square represents the scale and technique effect. KLR_{it} represents the capital-labor ratio and represents the composition effect. ENG_{it} shows energy effect, and ε_{it} represents the error term. FDI_{it} denotes Foreign Direct Investment, EDU_{it} represents primary school enrollment IQ_{it} symbolizes the Institutional Quality Index, and IFD_{it} denotes the Financial Development Index, and these are the control variables. The only difference from the OLS model is the weight matrix W and ρ which is the coefficient of $\ln CO_{it}$. In reduced form, it can be written as:

$$\ln CO_{it} = (1-\rho W)^{-1}[\alpha_{1i} + \alpha_2 \ln GDP_{it} + \alpha_3 \ln GDPS_{it} + \alpha_4 lnKLR_{it} + \alpha_5 lnTRD_{it} + \alpha_5 lnENG_{it} + \alpha_7 FDI_{it} + \alpha_8 EDU_{it} + \alpha_9 IFD_{it} + \alpha_{10} IQ_{it} + \varepsilon_{it}] \quad (2.19)$$

The spatial relationship which is existed in the data is represented by ρ. It is assumed that the value of spatial relationships will be positive. It means a positive spatial relationship has existed in the study. Air pollution is positively linked to the air pollution of neighboring countries. The weight matrix is a contiguity-based version in which neighboring countries are represented by 1, and countries that do not share a common border are shown by 0.

2.3.3.2 Spatial error model (SEM)

The spatial relationship is explained differently: the spatial dependence in the error term. SEM can be written as follows:

$$\ln CO_{it} = \alpha_{1i} + \alpha_2 \ln GDP_{it} + \alpha_3 \ln GDPS_{it} + \alpha_4 lnKLR_{it} + \alpha_5 lnTRD_{it} + \alpha_5 lnENG_{it} + \alpha_7 FDI_{it} + \alpha_8 EDU_{it} + \alpha_9 IFD_{it} + \alpha_{10} IQ_{it} + \varepsilon_{it} \quad (2.20)$$

$$\therefore \varepsilon_{it} = W\varepsilon_{it} + {}_{it} \quad (2.21)$$

Where is the spatial autoregressive coefficient, and the spatial weight matrix is represented by W. ε_{it} represents the spatial autoregressive error term.

2.3.3.3 Spatial Autocorrelation Model (SAC)

SAC is the mixture of both models, namely SAR and SEM. So, the SAC model includes spatial dependencies in error terms and dependent variables. The SAC model can be written as:

$$\ln CO_{it} = \alpha_{1i} + \alpha_2 \ln GDP_{it} + \alpha_3 \ln GDPS_{it} + \alpha_4 lnKLR_{it} + \alpha_5 lnTRD_{it} + \alpha_5 lnENG_{it} + \alpha_7 FDI_{it} + \alpha_8 EDU_{it} + \alpha_9 IFD_{it} + \alpha_{10} IQ_{it} + \rho W lnCO_{it} + \varepsilon_{it} \quad (2.22)$$

$$\therefore \varepsilon_{it} = W\varepsilon_{it} + {}_{it} \quad (2.23)$$

2.3.3.4 Spatial Durbin Model (SDM)

The SDM model includes spatially lagged dependent variables and spatially lagged independent variables that consider the spillover effect of neighboring countries. The model can be written as:

$$
\begin{aligned}
\ln CO_{it} = {} & \alpha_{1i} + \alpha_2 \ln GDP_{it} + \alpha_3 \ln GDPS_{it} + \alpha_4 lnKLR_{it} + \alpha_5 lnTRD_{it} + \\
& \alpha_6 lnENG_{it} + \alpha_7 FDI_{it} + \alpha_8 EDU_{it} + \alpha_9 IFD_{it} + \alpha_{10} IQ_{it} + \\
& \rho W lnCO_{it} + {}_1 \mathrm{Wln}\, GDP_{it} + {}_2 W \ln GDPS_{it} + {}_3 W lnKLR_{it} + \\
& {}_4 W lnTRD_{it} + {}_5 W lnENG_{it} + {}_6 W FDI_{it} + {}_7 W EDU_{it} + \\
& {}_8 W IFD_{it} + {}_9 W IQ_{it} + \varepsilon_{it} \qquad (2.24)
\end{aligned}
$$

2.4 Data and Data Source

Panel data is taken for empirical analysis of the study, and those countries are selected for which information is available. CO_2 emissions is the dependent variable, and independent variables are GDP per capita, capital-to-labor ratio, financial development, trade openness, primary school enrolment, energy consumption, foreign direct investment, and institutional quality. Data on all variables are taken from World Development Indicators (WDI), World Governance Indicator (WGI), and Penn World Table 9.1. Yearly data from 2000 to 2018 is used. The description of different variables is as follows:

2.4.1 Per capita income:

Scale and technique effects are captured by real per capita income and real per capita income square. It indicates the economic functioning and living standard of a country.

2.4.2 Capital to labor ratio:

The capital-labor ratio is utilized to find the composition effect. It means how compositional variation of emission is affected by capital accumulation. Energy-efficient accumulation of capital decreases pollution. On the other hand, a dirty capital stock that is energy inefficient and uses old production techniques produces more pollution. If eco-friendly new machines replace old machinery and represent capital accumulation, capital accumulation increases and decrease environmental degradation.

2.4.3 Trade Openness:

Trade openness, measured as exports plus imports divided by GDP, is the primary variable of the study, and it is used in the model to find the direct effect of trade openness on the quality of the environment. Trade openness is the sum of exports plus imports divided by GDP [$TRD = (X + M)/GDP$].

2.4.4 Energy use (kg of oil equivalent per capita)

The environmental quality of any country is determined by its people's energy use and living standard. Energy consumption in a different form is responsible for greenhouse gas emissions.

2.4.5 Institutional quality

Institutional Quality consists of six components: Voice and Accountability, Regulatory Quality, Government Effectiveness, Political Stability, the rule of law, and Control of Corruption.

For computing the institutional quality index (IQ), all dimensions are converted into the same scale for the purpose of aggregation. Then normalization is used as follows:

$$X_i = \frac{[IQl_i - IQl_{min}]}{[IQl_{max} - IQl_{min}]} \quad (2.25)$$

Where X_i denotes the six dimensions of institutional quality as Voice and Accountability, Government Effectiveness, Political Stability, Rule of law, Regulatory Quality, and Control of Corruption. Parameter IQl_i is an indicator for an individual country. The maximum value of the indicator is represented by IQl_{max} and minimum value is shown by IQl_{min}. Equal weight is assigned to all indicators to calculate aggregate index value. Mathematically institutional quality (IQ) index is computed as follows:

$$IQ = \frac{\sum_{i=1}^{6} X_i}{6} \quad (2.26)$$

2.4.6 Financial Development Indicator

The financial development indicator consists of financial institutions and the financial market. Each part has three sub-indices such as depth, access, and efficiency. These sub-indices are made up of different indicators of financial systems.

2.4.7 School enrollment, primary (% gross)

The gross enrollment ratio is obtained by dividing total enrollment by population, and we follow Zafar *et al.* (2020) to choose this variable. In my data, most of the variation is in cross-section as countries are 119 and time is of 19 years. The difference in enrollment is not in this specific time rather it is come out due to the difference in enrollment between countries.

Table 2.2 shows descriptive statistics of a variable. CO_2 emissions has a mean value of 5.27 thousand tons per capita, varying from 0.015 to 41.11 thousand tons per capita. The average value of GDP per capita is $9.422, which runs between $9.422 and $11.728. Trade openness ranges from 0.167 to 408.36, with an average value of 4.306. Capital labor has the lowest mean value in the sample. Energy consumption fluctuates from 4.728 to 10.004 kg of oil equivalent and has a mean value of 7.328 kilograms of oil equivalent. The mean value of education is the highest. IQ ranges from 0.026 to 1. FDI has a mean value of 5.253.

Table 2.2: Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
CO	2261	5.27	5.89	0.015	41.11
GDP	2261	9.422	1.11	9.422	11.728
GDPS	2261	90.006	20.495	39.707	137.552
KLR	2261	0.166	0.148	0.002	0.785
TRD	2261	85.521	46.583	0.167	408.362
ENG	2261	7.328	1.034	4.728	10.004
IQ	2261	0.54	0.225	0.026	1
IFD	2261	0.377	0.233	0.024	1
EDU	2261	102.938	10.913	32.356	150.786
FDI	2261	5.253	17.21	-58.323	451.716

Source: Author's calculations

Standard deviation is used to calculate the dispersion in the data. If the standard deviation value is different from the mean, it shows dispersion in the data set. The carbon dioxide emission standard deviation is larger than the means. It means more dispersion in the data. In the case of GDP, GDPS, TRD, EDU IFD, and IQ, the mean value is larger than the standard deviation and shows less dispersion. The standard deviation is more than the mean in KLR and FDI and indicates more dispersion, and that data distribution is not normal.

2.5 Results and Discussion

First, the global Moran's I test is employed to check spatial autocorrelation's presence before estimating spatial econometric models. Table 2.3 shows the result of the global Moran's I test. The result is that positive spatial autocorrelation exists. The null hypothesis of "no spatial autocorrelation" has been rejected because all coefficients are statistically significant. To reduce the fluctuations in the data, some variables are in logs. Other variables are not in logs, and the reason is that some are in percentage form.

Table 2.3: The results of the global Moran's I test.

Variables	Moran's I test	
Log of carbon emission	0.9805***	(0.000)
Log of GDP per capita	0.9717***	(0.000)
Log of trade openness	0.7921***	(0.000)
Log of the capital-labor ratio	0.9739***	(0.000)
Log of energy consumption	0.9811***	(0.000)
Foreign direct investment	0.2682***	(0.000)
Primary school enrolment	0.7176***	(0.000)
Financial development index	0.9627***	(0.000)
Institutional Quality	0.9783***	(0.000)

*Source: Author's calculations; Probability value in parenthesis (*** P<0.01)*

2.5.1 Impact of trade openness on environmental quality (overall data)

Table 2.4 shows the findings of spatial econometric models. Column 1 represents the findings of the SAR FE model. The results of the SEM FE model are displayed in column 2, and column 3 is about the SAC FE model. The results of the SDM FE model are illustrated in column 4. The model selection is made through AIC and BIC values, where small values of AIC and BIC denote that the SEM model is preferred.

The impact of scale effect on carbon dioxide emission is positive and significant. 1% increase in economic activities due to trade increases the carbon dioxide emission by 2.753% (column 1), 3.085% (column 2), 2.708 % (column 3), and 2.545% (column 4) respectively in four models. CO_2 emissions decreases due to the technique effect in these countries. New technology is adopted for increased income, so cleaner production is promoted. Willingness to pay for the environment also increases due to economic development. These empirical findings follow the results of (Azhar *et al.*, 2007; Managi, 2012).

Table 2.4: Spatial model result

	1		2		3		4	
	SAR		SEM		SAC		SDM	
lnGDP	2.753***	(17.89)	3.085***	(20.78)	2.708***	(17.03)	2.545***	(15.14)
lnGDPS	-0.144***	(-17.31)	-0.160***	(-19.67)	-0.142***	(-16.73)	-0.127***	(-14.02)
lnKLR	0.062***	(2.940)	0.068***	(3.20)	0.061***	(2.93)	0.039**	(1.80)
lnTRD	0.018*	(1.99)	0.016	(1.73)	0.018*	(1.97)	0.029***	(3.070)
lnENG	0.720***	(34.36)	0.748***	(35.77)	0.715***	(33.11)	0.685***	(31.36)
FDI	0.042*	(2.56)	0.044***	(2.65)	0.042*	(2.58)	0.047***	(2.89)
EDU	0.213***	(4.91)	0.256***	(5.77)	0.204***	(4.62)	0.204***	(4.55)
IQ	0.590***	(7.61)	0.545***	(6.94)	0.592***	(7.68)	0.550***	(6.85)
IFD	-0.019	(-0.30)	0.031	(0.48)	-0.026	(-0.41)	0.030	(0.45)
WlnGDP							0.836***	(3.03)
WlnGDPS							-0.054***	(-3.68)
WlnKLR							0.046	(1.370)
WlnTRD							-0.038***	(-2.67)
WlnENG							0.115***	(2.980)
WFDI							0.049	(1.07)
WEDU							-0.111**	(-1.78)
WIQ							-0.281*	(-2.09)
WIFD							-0.084	(-0.88)
ρ	0.133***	(7.09)			0.153***	(5.580)	0.107***	(4.190)
			0.119***	(4.48)	-0.041	(-1.020)		
σ^2	0.012***	(33.58)	0.013***	(33.55)	0.013***	(35.25)	0.012***	(33.57)
AIC	3479.93		3450.45		3478.97		3516.98	

BIC	3416.97	3387.49	3410.29	3402.51
Observations	2261	2261	2261	2261
Groups	119	119	119	119
R-squared	0.9003	0.8987	0.8998	0.9106

Source: Author's calculations; z-values are in parenthesis (P<0.10, ** P<0.05, *** P<0.01)*

The capital-labor ratio represents the composition effect, and its positive sign indicates that emission increases due to an increase in the capital-labor ratio. Carbon emission increases by 0.062% (column 1), 0.068% (column 2), 0.061% (column 3), and 0.039 % (column 4) respectively due to a 1% rise in the capital-labor ratio in four models. The use of capital-intensive modes of production increases in these countries, due to which carbon emission rises. Moreover, pollution abatement expenditure is small in these capital-intensive industries, resulting in a higher pollution level. These results are consistent with those (Tayebi & Younespour, 2012; Managi, 2012).

Trade openness has a positive effect on carbon emission, and a 1% increase in trade openness causes a 0.018% (column 1) to 0.029 % (column 4) increase in carbon emission. The reason may be that Polluting industries are shifting from developed to developing countries due to trade openness because environmental regulations are low in developing countries. These results are consistent with those (Bekmez & Ozsoy, 2016).

Carbon emission increases by energy consumption and carbon emission increase by 0.720%, 0.748%, 0.715%and 0.685% respectively due to a 1% increase in energy consumption. Production requires energy and emerging countries use fossil fuels to fulfill their energy demand. The reason is that renewable energy projects are not mature in these countries, and deterioration of the environment occurs due to the continuous use of fossil fuels.

Foreign direct investment positively affects CO_2 emissions. A 1% increase in foreign direct investment leads to 0.042% (column 1), 0.044% (column 2), 0.042% (column 3), and 0.047% (column 4) increase in carbon dioxide emission. These results follow the study of Ren *et al.* (2014). Primary school enrolment is harmful to environmental quality. Carbon dioxide emission increases by 0.213% (column 1), 0.256% (column 2), 0.204% (column 3), and 0.204% (column 4) due to a 1% increase in education.

The reason is that productivity levels and skills increase due to increased education. As a result, they will purchase and consume more goods. Institutional quality also increases carbon dioxide emissions. A 1% increase in institutional quality boosts up carbon dioxide emission by 0.590% (column 1), 0.545% (column 2), 0.592% (column 3), and 0.550% (column 4). Financial development has an insignificant effect on carbon dioxide emissions in all models.

The spatial rho ρ (coefficient of spatial autocorrelation) is positive and significant, indicating a positive effect of neighboring countries' carbon dioxide emissions on the local country's carbon dioxide emission. A 1% increase in CO_2 emissions in neighboring countries leads to a 0.133%, 0.153%, and 0.107% increase in CO_2 emissions in the local region. The lambda, the autoregressive parameter, outlines that the spatial consequence implies that the local economy‘s carbon emissions increase by 0.119% due to a 1% increase in the neighboring economy‘s carbon emissions. A spillover effect exists because weight matrix coefficients are statistically significant in all models.

In the SDM model, the spillover effect of the scale effect is positive and significant. The spillover effect of technique affect and trade openness is negative. The direct effect of FDI, education, and institutional quality on carbon dioxide emission is positive and significant in all four models, while the spillover effect of education and institutional quality is negative on carbon dioxide emission. The spillover effect of FDI on carbon dioxide emission is insignificant.

2.5.1 Impact of trade openness on the Quality of the Environment (developed countries)

Table 2.5 shows the spatial model result for developed countries. The model selection is made through AIC and BIC values, where small values of AIC and BIC denote that the SEM model is preferred. Scale effect positively and significantly impacts carbon dioxide emission in all four models. A 1% increase in scale effect increases carbon dioxide emission by 0.999% (column 1), 1.251% (column 2), 0.999 % (column 3), and 0.683% (column 4). The industrialization process and exports increase due to trade openness, and economic activity increase this way. Environmental deterioration increases due to an increase in economic activities. Carbon dioxide emission decreases due to the technique effect. Efficient technologies and clean production techniques are used in developed countries. Income gain due to trade openness leads to strict environmental standards, and hence less pollution is produced in these countries.

Table 2.5: Spatial model result for developed countries.

	1		2		3		4	
	SAR		**SEM**		**SAC**		**SDM**	
lnGDP	0.999***	(4.88)	1.251***	(5.94)	0.999***	(4.99)	0.683***	(3.37)
lnGDPS	-0.049***	(-4.68)	-0.061***	(-5.63)	-0.049***	(-4.81)	-0.027***	(-2.62)
lnKLR	-0.074***	(-3.18)	-0.070***	(-2.80)	-0.082***	(-3.61)	-0.034	(-1.45)
lnTRD	-0.022	(-1.53)	-0.020	(-1.22)	-0.022	(-1.60)	0.035***	(2.18)
lnENG	0.701***	(38.49)	0.722***	(36.75)	0.686***	(35.89)	0.638***	(34.34)
FDI	0.027**	(2.42)	0.031***	(2.71)	0.027*	(2.44)	0.033***	(3.06)
EDU	-0.047	(-1.03)	-0.030	(-0.63)	-0.056	(-1.25)	-0.083*	(-1.84)
IQ	0.565***	(8.10)	0.505***	(6.78)	0.581***	(8.550)	0.410***	(5.91)
IFD	0.012	(0.24)	0.091*	(1.79)	-0.009	(-0.19)	0.110*	(2.20)
Wx								
WlnGDP							1.907***	(5.21)
WlnGDPS							-0.103***	(-5.58)
WlnKLR							-0.158***	(-4.32)
WlnTRD							-0.077***	(-3.46)
WlnENG							0.108***	(2.77)
WFDI							0.025	(0.78)
WEDU							-0.070	(-1.05)
WIQ							0.436***	(3.67)
WIFD							-0.094	(-1.33)
ρ	0.228***	(11.38)			0.286***	(10.77)	0.194***	(6.70)
			0.219***	(6.57)	-0.137***	(-3.07)		
σ^2	0.006***	(27.45)	0.006***	(27.27)	0.006***	(28.20)	0.005***	(27.39)
AIC	3533.75		3454.55		3540.71		3655.63	
BIC	3475.16		3395.963		3476.79		3549.10	
Observations	1520		1520		1520		1520	
Groups	80		80		80		80	
R-squared	0.5562		0.7891		0.4680		0.4680	

Source: Author's calculations; z-values are in parenthesis (P<0.10, ** P<0.05, *** P<0.01)*

The country's comparative advantage determines the sign of the composition effect. Production of cleaner goods increases with trade openness if that country has a comparative advantage in environmentally friendly and clean industries. In countries with a comparative advantage in dirty industries, production of those goods increases with trade, polluting the environment. The composition effect reduces the CO_2 emissions in the case of developed countries. A 1% increase in capital-labor ratio leads to a 0.074% (column 1), 0.070% (column 2), 0.082 % (column 3), and 0.034% (column 4) decrease in carbon dioxide emission. Developed countries have a comparative advantage in environmentally friendly and cleaner goods. These results are in line with the finding of Azhar *et al.* (2007).

The trade effect has a negative but insignificant impact on carbon dioxide emission in the SAR, SEM, and SAC models but has a positive and significant effect in the SDM model. A 1% rise in trade openness enhances carbon dioxide emission by 0.035%.

Energy consumption is detrimental to the quality of the environment in all four models. Carbon dioxide increases by 0.701% (column 1), 0.722% (column 2), 0.686 % (column 3), and 0.683% (column 4) due to a 1% increase in energy consumption. These empirical findings are similar to Ansari and Khan (2021). Energy has a vital role in the production process, and the solution of renewable energy is not mature to a greater extent to fulfill all the demands of energy, so these countries rely on fossil fuels to meet the energy demand. Fossil fuel consumption deteriorates the environmental quality.

The association between foreign direct investment and carbon emission is positive and a 1% rise in foreign direct investment causes 0.027% (column 1), 0.031% (column 2), 0.027 % (column 3), and 0.033% (column 4) increase in carbon emission in developed countries. It indicates that FDI transfers polluting technologies from more developed countries to less developed countries.

Primary school enrollment reduces carbon dioxide emissions in the SDM model. Carbon dioxide emission reduces by 0.083% due to a 1% increase in education. Education has a negative but insignificant effect on carbon dioxide emission in SAR, SEM, and SAC models.

Institutional quality positively affects CO_2 emissions in all four models. Carbon dioxide emission is stimulated by 0.565% (column 1), 0.505% (column 2), 0.581 % (column 3), and 0.410% (column 4) due to a 1% rise in the quality of institutions in developed countries. Highly industrialized economies cause environmental degradation. Market failure is reduced due to good governance. Foreign and domestic investment rises in the stabilized economy.

Financial development positively and significantly affects CO_2 emissions in SEM and SDM models. CO_2 emissions increased by 0.091% and 0.110% due to a 1% increase in financial development. The reason is that financial development attracts foreign direct investment which negatively affects environmental performance.

The spatial lag coefficient ρ is positive and significant in all models. It shows that surrounding countries' CO_2 emissions positively affect local air pollution. Local pollution boosts up by 0.228%, 0.286%, and 0.194% due to a 1% increase in surrounding economy air pollution. Autoregressive parameter shows that a 1% rise in air pollution in neighboring countries causes a 0.219% increase and 0.137% decrease in air pollution in the local country. In the SDM model, the spillover effect of scale, energy, and institutional quality are positive and significant, while the spillover effect of technique, composition, and trade effects are adverse and significant.

In Table 2.5 and Table 2.6, the scale effect is the same in both models. Pollution level increases due to an increase in economic activities caused by trade openness. The technique effect is also the same in both models. Pollution decreases due to an increase in income and the demand for a clean environment increases. Only composition is different in both models. The reason is that the pollution heaven hypothesis is confirmed in the case of developing countries because developing countries have less stringent environmental regulations and emission increases due to trade openness. The factor endowment hypothesis is not confirmed in developed countries because carbon emission decreases due to trade openness although it has a high capital-labor ratio or has a comparative advantage in capital-intensive sectors. It is not due to some outlier but it is due to differences in environmental regulations and production techniques.

Table 2.4 is for the whole world and Table 2.6 is for developing countries. The results in both tables are quite similar. The reason is that in the case of the whole world, the effect of developing countries outweighs the effect of developed countries, and the pollution heaven hypothesis is confirmed.

2.5.2 Impact of Trade Openness on the Quality of the Environment (developing countries)

Table 2.6 describes the spatial model result for developing countries. The scale has a positive effect on air pollution. Pollution increases by 2.987% (column 1), 3.236% (column 2), 2.969 (column 3), and 3.184% (column 4) due to a 1% increase in scale effect. Trade openness leads to more economic activity. Specialization and economies of scale are facilitated by trade openness. More production increases air pollution. The present study results are comparable to the study of Ansari and Khan (2021) and Ling *et al*. (2015).

Technique effect reduces air pollution. Environmental awareness among producers and people enhances, and as a result, demand and import of environmentally friendly production techniques rise due to increased income. Local firms use new technology in developing countries due to increased competition caused by trade liberalization.

The composition effect increases carbon dioxide emission in all models. Carbon dioxide emission increases by 0.131% (column 1), 0.141% (column 2), 0.131% (column 3), and 0.079% (column 4) due to a 1% increase in composition effect. Due to free trade, dirty industries are shifting from developed to developing countries. Developing countries have a comparative advantage in pollution-intensive industries or heavy industries. Manufacturing of pollution-intensive export goods is increasing in developing countries due to lax environmental regulations. Trade effect has a positive but insignificant effect on CO_2 emissions.

The energy effect is positive and significant on carbon dioxide emission. Carbon dioxide emission enhances by 0.752% (column 1), 0.763% (column 2), 0.751% (column 3), and 0.783% (column 4) due to a 1% increase in energy effect. Energy is used in the production process and transportation. The growing industrialization sector leads to more use of energy. Demand for personal transport also increases; thus, demand for fossil fuel increases which causes air pollution.

Table 2.6: Spatial model result for developing countries

	1		2		3		4	
	SAR		SEM		SAC		SDM	
lnGDP	2.987***	(6.60)	3.236***	(7.16)	2.969***	(6.30)	3.184***	(6.79)
lnGDPS	-0.159***	(-5.81)	-0.171***	(-6.26)	0.158***	(-5.61)	-0.169***	(-6.07)
lnKLR	0.131***	(3.39)	0.141***	(3.62)	0.131***	(3.39)	0.079*	(1.89)
lnTRD	0.001	(0.08)	-0.00007	(0.000)	0.001	(0.08)	0.005	(0.29)
lnENG	0.752***	(15.68)	0.763***	(16.05)	0.751***	(15.54)	0.783***	(15.46)
FDI	0.292**	(2.35)	0.287**	(2.30)	0.292**	(2.35)	0.333***	(2.68)
EDU	0.276***	(3.27)	0.318***	(3.78)	0.274***	(3.20)	0.279***	(3.15)
IQ	0.585***	(3.39)	0.587***	(3.37)	0.582***	(3.37)	0.685***	(3.84)
IFD	0.169	(0.84)	0.114	(0.56)	0.174	(0.85)	0.035	(0.17)
Wx								
WlnGDP							-1.195	(-1.56)
WlnGDPS							0.067	(1.44)
WlnKLR							0.124**	(2.20)
WlnTRD							-0.050**	(-1.92)
WlnENG							0.101	(1.29)
WFDI							0.205	(0.770)
WEDU							0.071	(0.63)
WIQ							0.734**	(-2.29)
WIFD							0.265	(0.92)
ρ	0.083***	(2.66)			0.088**	(1.98)	0.045	(1.07)
			0.073**	(1.79)	-0.008	(-0.14)		
$σ^2$	0.024***	(19.23)	0.024***	(19.22)	0.025***	(20.260)	0.024***	(19.24)
AIC	635.31		631.48		633.33		635.40	
BIC	584.63		543.24		578.04		580.79	
Observations	741		741		741		741	
Groups	39		39		39		39	
R-squared	0.2976		0.7925		0.2675		0.4408	

Source: Author's calculations; z-values are in parenthesis (P<0.10, ** P<0.05, *** P<0.01)*

Primary school enrolment increases carbon dioxide emissions. A 1% rise in education leads to 0.276% (column 1), 0.318% (column 2), 0.274% (column 3), and 0.279% (column 4) rise in carbon dioxide emission. The reason is that educated people increase the consumption and use of vehicles, electricity, and other things. Institutional quality positively affects carbon dioxide emissions. Carbon dioxide boosts up by 0.585% (column 1), 0.587% (column 2), 0.582% (column 3), and

0.685% (column 4) due to a 1% increase in institutional quality. Degradation of the environment is caused by institutional failure. Lax environmental regulations are implemented due to poor quality institutions, and producers and consumers can escape from the consequences of the environmental damage they create. Financial development has a positive but insignificant effect on air pollution.

The spatial autoregressive coefficient (ρ) has a positive and significant effect on CO_2 emissions. 1% rise in CO_2 emissions of adjacent countries leads to 0.083% and 0.88% increase in carbon dioxide emission of the local country. The coefficient of spatial autocorrelation ( ) positively affects carbon dioxide emission. Local carbon dioxide emissions were boosted by 0.073% due to a 1% increase in adjacent countries' carbon dioxide emissions. In the SDM model, the spillover effect of composition effect and institutional quality is positive and significant on CO_2 emissions, while the spillover effect of trade openness on carbon dioxide emission is negative and significant.

The composition effect is different in developed and developing countries in this study. It decreases carbon dioxide emission in developed countries and increases carbon dioxide emission in developing countries. Developed countries have a comparative advantage in capital-intensive production techniques and have strict environmental regulations. The negative sign of the composition effect in developed countries indicates that environmental regulation dominates the capital-labor effect in developed countries. Developing countries have a comparative advantage in labor-intensive production techniques, and environmental regulations are lax in these countries. A positive sign of the composition effect in developing countries reflects that the environmental regulation effect dominates the capital-labor effect in developing countries. Thus, the environmental regulation effect dominates the capital-labor effect in developed and developing countries.

2.6 Conclusion

This study investigates whether trade has a destructive or favorable effect on the quality of the environment. Carbon dioxide emission is used to represent environmental quality. Trade is decomposed into scale effect, technique effect, and composition effect to investigate the effect of trade on environmental quality at different transition points. Data from 2000 to 2018 for the whole world are used, and a spatial econometric approach is applied. The scale effect positively and significantly impacts carbon dioxide emission, while the technique effect lowers CO_2 emissions in four models. The trade effect and composition effect increase CO_2 emissions in all four models. The energy effect also raises CO_2 emissions.

In the case of developed countries, the scale effect increases carbon dioxide emissions. Environmental quality improves by reducing carbon dioxide emission in technique and composition effects. Trade and energy effects positively and significantly impact carbon dioxide emissions. In the case of developing countries, the scale effect and composition effect deteriorate the environmental quality by increasing carbon dioxide emission. Alternatively, the technique effect negatively impacts carbon dioxide emissions. The energy effect also increases carbon dioxide emissions.

Chapter 3

Testing Environment Kuznets Curve Across Different Regions

3.1 Introduction

World economies tend to reduce CO_2 emissions due to the adverse effects of climate change. Developing countries are responsible for significant emissions of CO_2 because of their fast-economic growth and hence suffer from environmental degradation. Currently, there is no concession on achieving high economic growth at the expense of the environment due to pollution, global warming, and increased utilization of non-renewable resources. Therefore, environmentally friendly economic growth is needed of the hour (Ahmed & Long, 2012). The improvement in an environment with an increase in per capita income is reflected through Environment Kuznets Curve (EKC). There are regional differences in the relationship between economic growth and air pollution. The Environment Kuznets Curve (EKC) hypothesis does not exist in those regions where most countries are low-income, and their income level is below the turning point.

Economic growth and development remain admirable goals of every government. Achieving this goal increases the production of agriculture and industrial sectors, promotes trade, and builds infrastructure (Zafar *et al.*, 2013). For example, developing countries and the poorest people in Latin America, South Asia, and Sub-Saharan Africa are experiencing environmental damage. It causes air pollution, water scarcity, and drought in urban areas, affecting agricultural income, water supply, and food security in rural areas (El-Alaoui, 2015).

Unfortunately, countries give importance to economic growth and creating jobs at the early stages of industrialization instead of lowering water and air pollution. There is a lack of strong environmental regulations and practical resources in developing countries to tackle environmental degradation. As a result, the pollution level of these countries worsens with industrialization. When a nation becomes more prosperous, demand for regulatory institutions increases because people give more importance to the environment. Consequently, there is a possibility that prominent industrial sectors will turn out to be cleaner, and the pollution level will reach its peak at some threshold level of income and then declines with a further increase in income (Dasgupta *et al*., 2002).

Environmental-friendly economic development is required to achieve sustainable growth. Environmental degradation caused by economic growth is a heated debate among economists and environmentalists. Environmental degradation also affects economic activity in many ways. For instance, it adversely affects human health and thus lowers labor productivity. Rising sea levels, melting glaciers, and changes in rainfall due to climate change affect wildlife and agricultural productivity. Therefore, extensive research is carried out to find the impact of economic growth on the quality of the environment, which is recognized as EKC (Nasir & Rehman, 2011).

The EKC hypothesis is tested using different environmental indicators and econometric techniques for many countries. Carbon emissions are the most used indicator of environmental quality because it is the primary cause of greenhouse gas emissions. The results are diverse for these countries because the countries are different in geographical location, population size, and many other aspects. Different regions consist of very different countries. Some regions comprise more developing countries, while some have more developed countries. Comparing other regions is vital to recognize the critical contributors to carbon dioxide emissions in various regions.

As far as we know, the earlier studies on the EKC hypothesis for the regions use a basic model with one or two more variables. This study uses a multivariate framework to understand the EKC hypothesis in different regions better and fill the literature gap in this way.

The purpose of this essay is to examine the effect of economic growth on CO_2 emissions in 122 countries, which are classified into six regions (Latin America and the Caribbean, Europe and Central Asia, East Asia and the Pacific, Middle East and North Africa, South Asia, and Sub-Saharan Africa). Annual data from 2000 to 2018 is used in this study. Financial development, education, trade openness, institutional quality, and foreign direct investment are additional control variables.

There are five sections in the remaining study—section 3.2 reviews existing literature on the topic. The theoretical framework and econometric specifications are presented in section 3.3. The data are discussed in section 3.4. The study‘s results are described in section 3.5, while the conclusion follows in section 3.6.

3.2 Literature Review

Environmental degradation is a global problem because greenhouse gases surround the whole earth‘s surface and damage both developed and developing countries. Floods and earthquakes are the consequences of environmental degradation, which destroy natural resources like forests, agricultural land, wildlife, and human life. Environmentalists and economists are more concerned about these issues because rapid economic growth is also responsible for environmental degradation.

The quality of the environment is affected by economic development in three ways: economic activity scale, composition effect or structure of the economy, and technique effect. Deterioration of the environment is directly linked with the economic activity scale. As economic activity increases, more resources in the economy are used, and wastes are generated. In this way, environmental degradation increases. Environmental quality is also affected by the composition of the economy. Agriculture or services are less pollution-intensive than manufacturing or industry. The composition effect has a beneficial or harmful impact on the quality of the environment as the economy‘s structure reflects it. The technique effect benefits the environment because cleaner production methods increase income. Public expenditure on environmental regulation and cleaner technologies increases as income derives from the private sector's spending on abatement technologies. The EKC hypothesis explains all these three effects. EKC assumes that pollution rises to a specific income level; afterward, pollution decreases (Grossman & Krueger, 1991, 1995).

Dinda (2005) provides a theoretical model for the existence of EKC built on the endogenous growth model‘s framework. According to this, capital is allocated to two sectors: production and abatement. Allocation of money for production creates pollution, and its allocation for reduction improves the environmental quality. In the beginning, insufficient productive investment for abatement activity is the basis of EKC.

Andreoni and Levinson (2001) describe a one-person model and derive a reversed U-shaped association between environmental pollution and income due to abatement technology and increasing return to reducing pollution.

First, Grossman and Krueger (1991) empirically find the reversed U-shaped correlation between environmental quality and economic growth. Holtz-Eakin and Selden conducted other studies which validate the hypothesis of the EKC (1995), Selden and Song (1994), Panayotou (1993), and Shafik and Bandyopadhyay (1992).

3.2.1 Environment Kuznets Curve Hypothesis is confirmed

The EKC hypothesis is analyzed by using both panel and time-series data. Most of these studies verify the EKC hypothesis. Using Auto-Regressive Distributed Lag (ARDL) methodology, Jalil and Mahmud (2009) find an EKC in China‘s case using 1975-2005. The turning point is found at RMB 12992 (USD 1893.27). Moreover, trade has a positive and insignificant effect on CO_2 emissions. Determinants of CO_2 emissions are energy consumption and income. Nasir and Rehman (2011) employ the Johansen cointegration test to find the EKC for carbon dioxide emission in Pakistan from 1972 to 2008. This study finds a quadratic long-run relationship between carbon dioxide emissions and income variables, confirming the presence of EKC. The turning point is obtained at USD 625.

Shahbaz *et al*. (2012) test the hypothesis of EKC for Pakistan from 1971 to 2009 and find that EKC confirms for Pakistan and a long-run correlation exists among variables. Granger causality approach and Bound test are applied in this study. By employing the VECM Granger Causality test and Cointegration approach, Shahbaz *et al.* (2013) obtained that EKC was supported in Turkey from 1970 to 2010. Cointegration occurs between variables, and bidirectional causality is attained between CO_2 emissions and economic growth. Using the Two-step Generalized Method of Moment (GMM), Ren et al. (2014) find that the correlation between income per capita and CO_2 emissions is a reversed U-shaped in the case of China.

Shahbaz *et al*. (2015) observe the EKC hypothesis for India by using the data from 1970 to 2012. ARDL bounds testing approach is employed, and findings are that financial development, economic development, and energy consumption raise CO_2 emissions. Using the Johansen multivariate cointegration method, Jabeen (2015) finds the EKC hypothesis in the case of Pakistan. Energy consumption and income growth deteriorate the atmosphere, while trade improves the atmosphere.

Rabbi *et al*. (2015) test the EKC hypothesis by utilizing the data from 1971 to 2012 for Bangladesh and confirming the presence of the EKC. Moreover, the Long-run association between variables and short-run dynamical variation between variables is also present. Using the ARDL, Saboori *et al.* (2016) found that EKC could be secured in the long run for Malaysia from 1980-2008. The turning point turned out to be USD 3953. Energy consumption and urbanization enhance environmental pollution. Conversely, trade openness reduces CO_2 emissions.

Ozatac *et al.* (2017) observed the EKC in the case of CO_2 emissions in Turkey, and the data from 1960 to 2013 is used. The turning point is estimated at 16,648 USD. ARDL approach is employed for empirical analysis, and long-run correlation among variables is observed. Dong *et al*. (2018) investigated the hypothesis of EKC in China from 1993 to 2016 and found that the EKC hypothesis is valid in China‘s case. The turning point is 96,680.47 yuan ($14,085.97) for the EKC of China. The results obtained from the ARDL methodology are that fossil fuel boosts CO_2 emissions while nuclear energy and renewable energy consumption decline the CO_2 emissions. Using the ARDL bound testing approach, Pata (2018) explores the presence of EKC in Turkey from 1971 to 2014. The hypothesis of EKC is confirmed for Turkey. The turning point is obtained at $14360.Exports and noncarbohydrate energy consumption negatively affect CO_2 emissions, while import, financial development, industrialization, coal consumption, urbanization, and economic growth enhance CO_2 emissions.

Some studies find that the EKC hypothesis is valid for some pollutants only. For example, Mousavi (2015) finds that the EKC exists in developing and developed countries in case of air pollution and is confirmed only for developed countries in terms of water pollution. Zuo *et al*. (2017) examine the interrelation between trade, economic growth, energy use, and pollution in South China. Data from 1990 to 2015 is used for each province. This study uses two stages of feasible general least square estimation techniques. Trade openness is found to have a detrimental impact on the environment because exporting goods is pollution intensive. The EKC for water pollution is placed in the results.

The EKC hypothesis is also tested by using panel data. Using the data from 1990-2011, Apergis and Ozturk (2015) observe that the hypothesis of EKC is supported in the case of 14 Asian counties. The turning point is estimated at $11,695.6. The methodology of GMM is utilized in this research. By employing panel fully modified OLS (FMOLS) and Kao cointegration test, Al-Mulali *et al*. (2015) observed the hypothesis of EKC in Latin America and Caribbean countries using data from 1980-2010. The cointegration among variables is also obtained. Using data from 1985 to 2014, Ayeche *et al*. (2016) analyzed the EKC hypothesis for 40 European countries. The estimation technique applied to obtain the result is the General Linear Model (GLM). The outcome of the study supports the presence of EKC.

One of the recent studies finds that the EKC hypothesis is supported if additional variables are added to the estimation equation. For example, Chen *et al.* (2019) examine the correlation between renewable energy, foreign trade, non-renewable energy, and CO_2 emissions in China using data from 1980-2014. The methodology of Autoregressive Distributed Lag (ARDL) and Vector Error Correction Model (VECM) are applied in this study. The study finds that EKC does not exist with the variables of foreign trade, non-renewable energy, GDP, and CO_2 emissions. When renewable energy is added, EKC is confirmed in the case of China.

Some authors explore that the EKC hypothesis is supported for some countries in their analysis, such as by using the data from 1982 to 2016, Sarkodie and Strezov (2019) examine the correlation among foreign direct investment, greenhouse gasses (GHG), energy consumption, and economic development for five significant emitters of GHG from fossil fuel consumption in developing countries: Indonesia, India, South Africa, Iran, and China. The hypothesis of EKC is verified in the case of Indonesia and China. Energy consumption positively affects greenhouse gas emissions in all countries, thus supporting the pollution heaven hypothesis for all countries. Foreign direct investment positively impacts CO_2 emissions in all five major emitters of GHG.

El-Alaoui (2015) examines the trade, growth, and environmental quality association for Morocco, Algeria, Tunisia, and Egypt from 1970 to 2010. Ordinary Least Square, Johension cointegration, and VECM models are used. The Johansen cointegration test result shows a long-run association between trade, environment, and growth in the case of Algeria and Tunisia. However, no long-run association exists among these variables for Egypt and Morocco. The patterns of the EKC are different for the countries mentioned above. For instance, in Algeria, a reversed U-shaped association is found. On the other hand, results remain insignificant in the case of Morocco and Tunisia. Inversely, a U-shaped relationship is located in the case of Egypt, and the reason is that pollution first decreases with a rise in income and then increases with a further rise in income.

Elmarzougui *et al.* (2016) conducted a study to estimate the EKC hypothesis for Sulfur dioxide (SO_2) and CO_2 emissions for OECD, MENA, Africa, Central America and the Caribbean, Eastern Europe countries, and former USSR, South America, and Asian countries from 1960 to 2007. The study results show that in Asia, Africa, and OECD countries, the EKC hypothesis is supported for CO_2 emissions. Carbon emissions increase at an increasing rate as income per capita rises in Central American and Caribbean countries and MENA countries. However, the per capita income does not influence CO_2 emissions in the former USSR, South American, and Eastern European countries.

Using data from 1980 to 2008, Anastacio (2017) observed that the EKC hypothesis is supported in North American countries. Simultaneously, Oh and Yun (2014) examines the EKC hypothesis in 90 middle-income countries from 1981 to 2010. A fixed effect model is used for estimation. The EKC hypothesis is confirmed in this study.

Omri *et al.* (2015) found the hypothesis of EKC for 12 MENA countries from 1990 to 2011. Using the data from 1980-2001, Lee *et al*. (2010) examined the hypothesis of EKC in 97 countries for water pollution, and these countries are divided into four regions (Asia and Oceania, Africa, Europe, and America). The system GMM approach is used to obtain the results. The hypothesis of EKC is not valid for the global sample. Looking at regions separately, the EKC hypothesis exists in Europe and America, but the case does not prevail in Asia, Oceania, and Africa, because the countries in these latter regions are primarily poor, and their income level does not attain the turning point.

For Turkey, Kirikkaleli and Kalmaz (2020) analyze the influence of energy consumption, urbanization, trade openness, and economic growth on carbon dioxide emissions from 1960 to 2016. In addition, urbanization interacted with all variables to check its moderating role. Fully modified ordinary least squares (FMOLS) and dynamic ordinary least square (DOLS) is employed. The Environment Kuznets curve is validated in this study. Energy consumption, economic growth, and urbanization increase carbon dioxide emissions in the long run. All coefficients become smaller when urbanization interacts with the abovementioned variables, confirming its moderating role.

Li *et al.* (2022) find that the EKC hypothesis is valid, and the pollution heaven hypothesis is not confirmed in Belt and Road Initiative countries from 1995 to 2017. The result for sub-regions is that EKC is not supported in Sub-Saharan Africa, Latin America, the Middle East, and North Africa. In contrast, EKC is confirmed in the European area, Asia, and the Pacific region.

Using the data from 1996 to 2015, Wang et al. (2022) investigated the non-linear influence of urbanization on EKC for 134 countries. The panel threshold model is employed for this purpose. The study finds that as the urbanization level increases, economic growth's positive influence on the environment becomes intense. Economic growth influences the environment worsens when the urbanization level increases in high-income countries. This relationship becomes reversed U-shaped in low-income countries. Renewable energy and population aging enhance the quality of the environment.

Based on the review, it can be safely stated that vast literature exists supporting the EKC hypothesis. These studies use time-series data as well as panel data. Panel data studies consider different regions individually. They investigated the EKC hypothesis separately in Latin American countries, Caribbean countries, Asian countries, MENA countries, North American countries, and European countries. However, quite a few studies consider whole regions of the world. Our study differs from them in that we use a broad sample of countries and subcategorize them into six regions according to the World Bank to explore the comparison of the EKC hypothesis for various regions. To bridge this research gap, the present study analyzes the EKC hypothesis for six world regions from 2000 to 2018.

3.2.2 Environment Kuznets Curve is not Supported

In contrast, studies that do not confirm the EKC hypothesis by applying time-series data are as follows. Zambrano-Monserrate *et al.* (2018) conduct a study to estimate the EKC hypothesis for Peru by using the data from 1980 to 2011. This study does not verify the EKC hypothesis because long-run elasticities are more than short-run. This indicates an increase in carbon emissions related to a high-income level over time. Using the data from 1971 to 2008, Ahmed and Long (2012) investigate the EKC hypothesis for Pakistan. The EKC hypothesis is not validated in Pakistan. ARDL bounds testing approach is applied to get findings. Energy consumption, population density, and economic growth are harmful to the environment, while trade openness upgrades the quality of the environment.

EKC is also not supported by several studies using panel data. For example, by utilizing updated and revised data on air pollution, Harbaug et al. (2002) examine the correlation between income and air pollution. They find little support for a reversed U-shaped association between different pollutants and national income. Instead, a U-shaped association is located. Using the data from 1980 to 2006, Duy (2010) finds no evidence of an EKC in East Asian countries, but a monotonically increasing link exists between air pollution and income per capita.

Özokcu and Özdemir (2017) explore the EKC hypothesis from 1980 to 2010. The analysis first uses 26 OECD high-income countries and then 52 emerging countries. The result of the first analysis with 26 OECD countries shows a reversed N-shaped association between income per capita and CO_2 emissions. The second analysis indicates the N-shaped link between income per capita and CO_2 emissions for 52 emerging countries. The reason is that degradation of the environment after reaching a specific minimum point starts rising again because environmentally friendly technologies cannot continuously improve the quality of the environment. Consequently, it starts to decline again. These two analyses do not support the hypothesis of EKC.

Liu (2021) examines the influence of trade openness, economic growth, renewable energy, and non-renewable energy on the quality of the environment in China from 1965 to 2016. ARDL model is employed, and the result is that China's Environment Kuznets curve hypothesis is not supported. The reduction in carbon dioxide emissions is caused by renewable energy. Trade openness and non-renewable energy lead to intensifying carbon dioxide emissions.

In summary, some studies also do not support the EKC hypothesis. Instead, these studies find that the correlation between per capita income and pollution is monotonically increasing, N-shaped, reversed N-shaped, or U-shaped.

A comparison of the turning points of different studies with my study indicates that the turning points of some countries are lower than the whole region, and some countries‘ situation is different. For example, a turning point for Turkey is estimated at 16,648 USD, and Turkey is located in Europe and Central Asia region, region 2 in my study. The turning point for Region 2 was $13,226.7, which is lower than for a single country. The reason may be that some countries have low turning points, and some have high turning points. So, their average is lower than the individual country. In the case of China, the turning point is calculated at $14,085.97, and China is located in East Asia and the Pacific region, region 3 in my study. The turning point for Region 3 is $1,20,571.7, which is higher than an individual country. The same results are obtained in the case of Pakistan and Malaysia.

Table 3.1: Summary of Empirical Findings Related to EKC

Study	Objective	Period of Analysis	Region of Analysis	Methodology	Empirical results TP: turning point	Conclusion
Time series data						
Jalil and Mahmud (2009)	To examine the long-run relationship between energy consumption, CO_2 emissions, trade openness, and economic growth	1975-2005	China	Autoregressive distributed lag (ARDL) model	LnY: 4.1001 LnY2: -0.5527 RMB 12992 (USD 1893.27)	The results of the study are that there exists Environment Kuznets Curve.
Nasir and Rehman (2011)	To examine the relationship between energy consumption, CO_2 emissions, trade openness, and financial development	1972-2008	Pakistan	Johansen cointegration test	Ln Y: 7.21 Ln Y^2: -0.56 TP: USD 625	This study finds a quadratic long-run relationship between income and CO_2 emission variables which confirms the existence of the Environment Kuznets Curve (EKC).
Ahmad and Long (2012)	To examine the Environmental Kuznets Curve (EKC) hypothesis for Pakistan	1971 to 2008	Pakistan	Autoregressive distributed lag (ARDL) bounds testing approach	LnY: 6.75 LnY^2: -0.49 TP: $982.4	Environmental Kuznets Curve (EKC) hypothesis is supported in long run but in the short run.
Shahbaz *et al.* (2013)	To investigate the relationship between energy intensity, trade openness, CO_2 emissions, and globalization	1970-2010	Turkey	Cointegration approach and VECM Granger Causality test	Ln Y: 7.3502 Ln Y^2: -0.4336 TP: $4447.06	The environmental Kuznets curve is supported in this study.
Shahbaz *et al*. (2015)	To investigate the relationship between globalization and environmental quality in the case of India	1970-2012	India	ARDL bounds testing approach	Ln Y: 8.5790 Ln Y^2: -0.4573 TP: $11271.13	Globalization deteriorates environmental quality. Environmental Kuznets Curve (EKC) hypothesis is also confirmed by the study.
Saboori *et al.* (2016)	To examine the relationship between energy consumption, carbon dioxide emission, trade openness, economic growth, and urbanization both in the short run and long run	1980-2008	Malaysia	Autoregressive distributed lag (ARDL) model	Ln Y: 16.9967 Ln Y^2: –1.0261 TP: $3827.63	Environment Kuznets Curve (EKC) is supported in long run.
Alaoui (2017)	To examine the relationship	1970 -	Tunisia and Egypt	OLS, Johension	**Tunisia**	The pattern of the Environment

	between trade, growth and the environment	2010		cointegration, and VECM models	Ln Y:7.350 Ln Y^2: -0.438 TP: $4402.82 **Egypt** Ln Y: -0.355 Ln Y^2: 0.105	Kuznets curve is very different for these countries.
Pata, U.K. (2018)	To explore the existence of the Environment Kuznets Curve (EKC) hypothesis	1971 to 2014	Turkey	Autoregressive distributed lag (ARDL) bound testing approach	Ln GDP: 7.4120 Ln GDP^2: -0.387 TP: $14360	Environmental Kuznets Curve (EKC) hypothesis is valid in the case of Turkey. The turning point is obtained at $14360 and is outside of the sample period.
Dong *et al.* (2018)	To investigate the role of renewable energy and nuclear energy in reducing carbon dioxide emission and also study the Environment Kuznets Curve (EKC) hypothesis	1993 to 2016	China	Unit root test with structural breaks, Autoregressive distributed lag (ARDL), vector error correction model (VECM) Granger causality approach, FMOLS, DOLS, and CCR	ln GDP: 0.1653 ln GDP^2: -0.0072 TP: 96,680.47 yuan ($14,259.65)	Environmental Kuznets Curve (EKC) hypothesis is supported in the case of China. The turning point is calculated as 96,680.47 yuan for EKC of China which is outside of the sample period
Monserrate *et al.* (2018)	To explore the relationship between CO_2 emissions from energy consumption, GDP per capita, renewable energy consumption, natural gas consumption, and petroleum consumption	1980 to 2011	Peru	Autoregressive distributed lag (ARDL), vector error correction model (VECM) Granger causality approach,	Ln GDPt: 0.5702 Δln GDPt: 0.2994 Long-run elasticities > short-run elasticities	The results of this study do not support the existence of the Environment Kuznets Curve (EKC) hypothesis and unidirectional causality exists between CO_2 emissions and its determinants.
Chen *et al.* (2019)	To explore the relationship between foreign trade, renewable energy, non-renewable energy, and CO_2 emissions	1980-2014	China	Autoregressive distributed lag (ARDL) and vector error correction model (VECM) Granger causality approach.	Y: -0.612 Y^2 0.012 Y: 1.293 Y^2 -0.132	Environmental Kuznets Curve does not exist with the variables of foreign trade, non-renewable energy, GDP, and CO_2 emission. When renewable energy is added then Environmental Kuznets Curve (EKC) is confirmed in the case of China.
Panel data						

Harbaug *et al.* (2002)	To investigate the relationship between income and pollution	1977-1988	Developed and developing countries	Random effects	GDP: 60.6 $(GDP)^2$: -3.58 TP: $4722.05	They find little support for the inverted U-shaped relationship between air pollutants and national income.
Duy (2010)	To analyze the relationship between trade liberalization and environment and economic growth and environment	1980-2006	Six East Asian countries	Random effects and fixed effect	GDP: 0.0194815 GDP^2: 0.4979969	The study finds no evidence for Environment Kuznets Curve (EKC) and factors endowment hypothesis.
Cho *et al.* (2014)	To investigate the relationship between CO_2 emissions, energy use, and economic growth	1971-2000	22 Organization for Economic Cooperation and Development (OECD) countries	Panel unit root, panel cointegration test, and fully modified ordinary least square (OLS) approach	Ln Y: 5.67 Ln Y^2: -0.69 TP: $60435.94	This study result shows that Environment Kuznets Curve (EKC) exists for OECD countries in the case of GHG.
Apergis and Ozturk (2015)	To test the EKC hypothesis	1990-2011	14 Asian countries	GMM	YC: 4.356 -YC^2: -0.225 TP: $15,994.49	The hypothesis of the Environment Kuznets Curve (EKC) is supported in the case of Asian counties.
Elmarzougui *et al.* (2016)	To examine the effect of trade openness, and domestic and foreign investment on the environment	1960-2007	OECD, MENA, Africa Central America and the Caribbean, Eastern Europe countries and former United Socialist Soviet Republic, South America, and Asian countries	ARDL bound testing approach	**ASIA** Ln Y: 1.251 Ln Y^2: −0.022 TP: 368,517,957.59 **AFRICA** Ln Y: 6.274 Ln Y^2: −0.469 TP: 7612.14 **OECD** Ln Y: 7.767 Ln Y^2: -0.126 TP: 18,980,285.27	In Asia, Africa, and OECD countries, the Environment Kuznets curve hypothesis is supported for CO_2 emissions.
Özokcu and Özdemir (2017)	They explore the relationship between energy consumption, economic growth, and CO_2	1980 to 2010	26 OECD countries and 52 emerging	Panel data estimation technique with Driscoll-Kraay Standard Errors	**26 OECD countries** Ln Y: -545.515	Environmental Kuznets Curve (EKC) hypothesis is not valid for both analyses (52 emerging countries and

	emissions		countries	(FE with Driscoll-Kraay Standard Errors)	Ln Y^2: 51.841 **52 emerging countries** Ln Y: -83.663 Ln Y^2: 8.177	26 OECD countries).
Sarkodie and Strezov (2019)	To examine the relationship between foreign direct investment, economic development and energy consumption, and greenhouse gasses (GHG)	1982 to 2016	India, Indonesia, South Africa, Iran, and China	Panel data regression, U-test approach, and panel quantile regression	Lngdppc: 270,000 $lnGDPP^2$: -39,278 TP: $31.0947	Environmental Kuznets Curve (EKC) hypothesis is confirmed in the case of Indonesia and China. Energy consumption has a positive effect on greenhouse gas emissions in all countries and thus supporting the Pollution heaven hypothesis for all countries.

It is found in Table 3.1 that the turning point of China and India is greater than Pakistan. Comparison with panel data studies shows that 14 Asian countries have higher turning points than individual countries turning points. The turning point of Turkey and Malaysia is lower than the turning point of developed countries. EKC exists in most time series and panel data studies. The turning point of China is higher in recent studies than in previous studies. The turning point of Turkey is higher in those studies which use data from more recent years.

3.3 Theoretical Framework and Econometric Specification

This section discusses the theoretical foundation that links economic growth, foreign direct investment, primary school enrollment, trade openness, index of financial development, and institutional quality with the environment‘s quality. First, the link between economic growth and the quality of the environment is discussed here. Then the association between all remaining variables and the quality of the environment is analyzed. Finally, based on the discussion, econometric specification is framed.

The EKC hypothesis describes the influence of economic growth on the quality of the environment and how the pattern of economic growth influences the quality of the environment. It is mentioned by Grossman (1995) that scale, composition, and technique effect are the three channels through which this impact is taking place. First, economic growth has a scale effect on the quality of the environment. Demand for natural resources upsurges due to rising economic activity. Consumption of natural resources increases due to the increase in production. Industrial wastes are generated due to the rise in production and economic growth, harming environmental quality. So, environmental degradation increases because of an increment in economic development.

The transformation of industrial structures occurs with the rise in income, changing the economy‘s composition. During this time, the economic growth effect on the quality of the environment shifts from negative to positive. This is referred to as the composition effect. Maturing of secondary structures occurs, and the industrial sector adopts cleaner technologies. Demand for a cleaner environment also increases with time. Therefore, cleaner technologies are incorporated by industries, raising overall energy efficiency. The phase during which progress in technological innovation occurs is called the technique effect. In this phase, the service sector's growth occurs, and gradually, the economy turns from capital-intensive to knowledge-intensive. Investment in research and development activities increases in the economy, and the substitution of polluting technologies occurs in the secondary sector. So, environmental quality increases during this phase of rising economic growth. When the phenomenon mentioned above, the link between environmental degradation and economic development is plotted graphically, it takes the shape of a reversed U-shaped curve. This phenomenon is called the EKC hypothesis.

There are three ways through which trade impacts the environment: the scale, technique, and composition effects. Economic activity increases due to increased international trade, which increases pollution. This is called the scale effect of trade. According to neoclassical growth theories, the driving forces of growth are human capital and technological innovations. Technology transfers from developed to developing countries due to Foreign Direct Investment (FDI) and international trade. During the course, environment-friendly technologies are transferred to developing countries as well. As a result, the environment improves due to this technology spillover effect. This is known as the technique effect of international trade (Antweiler *et al*., 2001).

The third impact of trade is called the composition effect. It depends upon the resource abundance and the stringency of its environmental policy. Developed countries see a relative benefit through capital-intensive production. With trade, they produce more and more capital goods, and eventually, pollution level increases in these countries. In contrast, developing countries see a relative benefit through labor-intensive production, so the environment improves with international trade. On the other hand, the environmental policies of developed countries are stricter than those of developing countries. So, there is a harmful and beneficial impact of the composition effect on the quality of the environment.

Education plays a vital role in improving environmental quality. Education influences the mentality of people so that they choose environment-friendly goods. People can change themselves with the help of education. So that to engage in economic activities which are helpful to the environment, such as using renewable energy or producing agricultural products that are less harmful to the environment. Through education, people can attain the skills, determination, and knowledge to prevent natural resources from becoming scarce by using them more efficiently (Constantinescu, 2014).

Per capita income increases due to education, facilitating polluting technologies such as cars. In contrast, strict environmental standards are enforced due to a rise in social awareness, and cleaner technologies are incorporated due to further understanding. Economic growth increases due to education, and the necessary resources for pollution abatement increase (Balaguer & Cantavella, 2018).

Well-developed financial institutions support technological innovation and thus reduce pollution emissions. They also lessen the investment cost for environmental protection projects and positively affect the environment (Li *et al*., 2015).

Foreign direct investment is attracted by financial development associated with advanced research and technology, improving environmental quality. Registered companies use energy-efficient technology due to economic growth. Household items such as washing machines, cars, and air conditioners are purchased by financial intermediation, increasing energy usage and contributing to carbon dioxide emissions (Shahbaz *et al*., 2016).

Institutions that control environmental degradation include informal constraints such as customs, sanctions, and traditions and formal limitations like property rights, laws, and constitutions. Governance has direct and indirect effects on environmental quality. The presence of well-functioning institutions can minimize market failure in the case of the environment. Productive cooperation is facilitated among market players by the quality of institutions. Control technology for CO_2 reduction is easily imposed on businesses under a robust rule of law. Foreign direct investment is attracted by the quality of institutions which increases economic growth and positively affects the quality of the environment. Economic growth can be decreased by poor political institutions that focus on environmental externalities (Abid, 2016).

Poor quality of institutions has a negative effect on environmental regulations. Weak environmental laws are implemented due to the poor quality of an institution, and producers and consumers can evade penalties for the environmental damage they create (Hosseini & Kaneko, 2013). Based on the discussion mentioned above, this study estimates the following equation:

$$\ln CO_{it} = {}_{1i} + {}_{2}\ln GDP_{it} + {}_{3}\ln GDPS_{it} + {}_{4}TRD_{it} + {}_{5}FDI_{it} + {}_{6}EDU_{it} + {}_{7}IFD_{it} + {}_{8}IQ_{it} + \varepsilon_{it} \quad (3.1)$$

Where CO_{it} is per capita CO_2 emissions (thousand tons), GDP_{it} which stands for Gross Domestic Product per capita and $GDPS_{it}$ is its square, both are used as indicators of economic growth, FDI_{it} denotes Foreign Direct Investment, TRD_{it} denotes trade openness, EDU_{it} represents primary school enrollment, IQ_{it} symbolizes the Institutional Quality Index, and IFD_{it} denotes the Financial Development Index. If ${}_{2} > 0\ and\ {}_{3} < 0$, then the inverted U-shaped hypothesis of EKC is supported whereas ${}_{4}$, ${}_{5}$ and ${}_{7}$ may be positive or negative while ${}_{6}$ and ${}_{8}$ are expected to be negative.

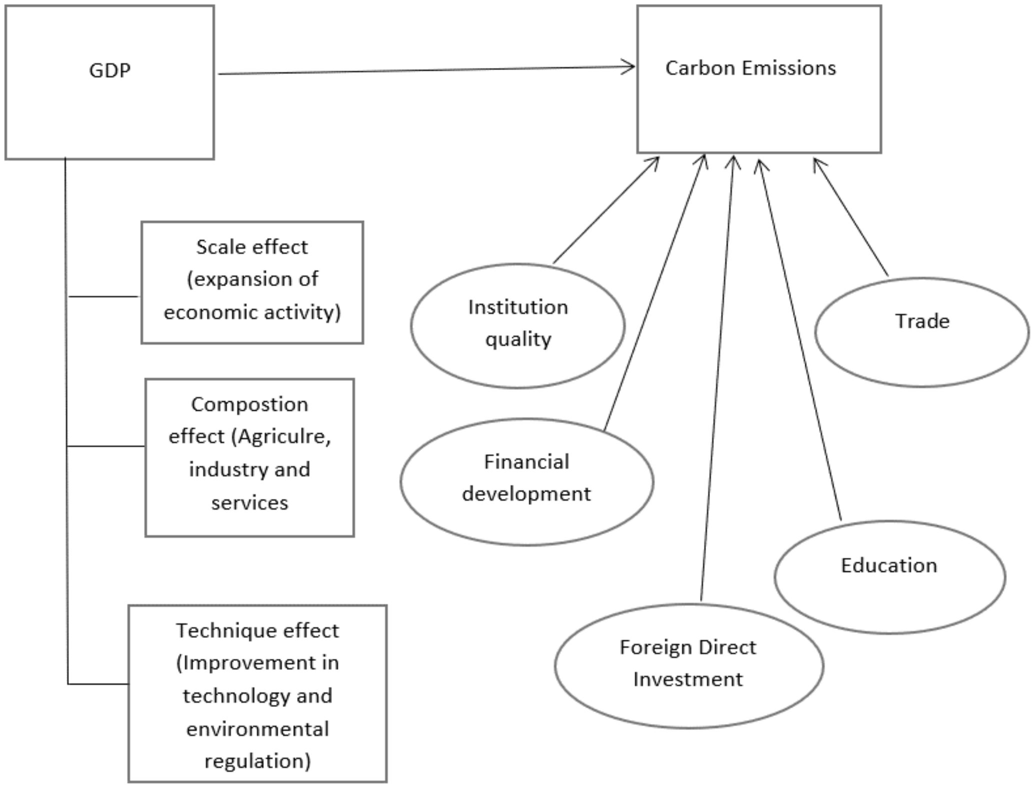
EKC- hypothesis is also estimated by using a spatial econometric model. The equation for the spatial error model is written as follows.

$$\ln CO_{it} = {}_{1i} + {}_{2}\ln GDP_{it} + {}_{3}\ln GDPS_{it} + {}_{4}TRD_{it} + {}_{5}FDI_{it} + {}_{6}EDU_{it} + {}_{7}IFD_{it} + {}_{8}IQ_{it} + \varepsilon_{it} \quad (3.2)$$

$$\therefore \varepsilon_{it} = W\varepsilon_{it} + {}_{it} \quad (3.3)$$

Figure 3.1, plotted below, represents the link between the abovementioned variables, including Gross Domestic Product, education, trade, foreign direct investment, institutional quality, financial development index, and carbon emissions.

Figure 3.1: Effect of different variables on carbon emissions



3.4 Data

The data source for CO_2 emissions is the International Energy Agency (IEA). The financial development index data is obtained from the International Monetary Fund. The information for institutional quality is extracted from World Governance Indicator (WGI). All remaining variables are taken from World Development Indicator (WDI).

Other variables are included rather than GDP and its square because they also affect carbon dioxide emission. We take other variables as a control variables. For example, IQ affects the environmental quality holding GDP constant. Foreign direct investment affects the quality of the environment by producing environmentally friendly products in the home country by foreign investors.

Table 3.2 shows a description of the variables.

Table 3.2: Description of the variables

Variables	Notation	Description
CO_2 emissions (thousand tons per capita)	CO	CO_2 emissions per capita considers for population and is defined as carbon dioxide emission per person. Carbon dioxide emission is divided by the total national population to calculate it.
GDP per capita, PPP (constant 2011 international $)	GDP	Gross domestic product is divided by the country's total population to obtain the GDP per capita. It indicates the economic functioning and living standard of a country. It also measures the prosperity of a nation
Trade (% of GDP)	TRD	The sum of exports plus imports is divided by GDP to measure trade openness. It is used as a control variable.
Foreign Direct Investment (FDI), net inflow (% of GDP)	FDI	Foreign direct investment is an investment that an investor from another country carries out. In this investment type, the resources of one country are used by another country's businesses.
School enrollment, primary (% gross)	EDU	The gross enrollment ratio is obtained by dividing total enrollment by population.
Financial development Indicator	IFD	The financial development Indicator consists of financial institutions and the financial market. Each part has three sub-indices such as depth, access, and efficiency. These sub-indices are made up of different indicators of financial systems.
Institutional Quality	IQ	Institutional Quality is taken from the WGI. It comprises six components: Voice and Accountability, Government Effectiveness, Political Stability, the rule of law, Regulatory Quality, and Control of Corruption.

The association between economic growth and the quality of the environment is examined in this study for six regions from 2000 to 2018[1]. Estimation techniques of panel data, such as the Random Effect Model (REM) and Fixed Effect Model (FEM), are used in this study. The Hausman test is utilized to select between these panel data models. In addition, the spatial panel data model (Spatial error model) is also employed.

In model selection, we follow the general to the specific procedure, and those variables removed whose AIC and BIC values are the smallest. Lasso is also used for

[1] Detail about the countries included as each of the region is described in Appendix A.

model selection. The results of the LASSO are the same in our study. Model 24 is selected, which has a minimum BIC value. Less effective variables are removed in the LASSO regression model. LASSO regression indicates that all those variables used in this study are retained.

The obtained values of mean, minimum, maximum, and standard deviation are given in Table 3.3 for the datasets of all six regions. The standard deviation is used to measure the dispersion in the data set. It is shown in the table that in the datasets of the Latin America and Caribbean region, the standard deviations of variables are less than the mean value, which means there is less dispersion in the data set.

In the dataset of South Asia, Europe and Central Asia, Middle East and North Africa, East Asia and Pacific, and Sub-Saharan Africa, the mean value is greater than the standard deviation, which shows less dispersion. The average per capita income of the Middle East and North Africa region is the highest, i.e., $9972, which is followed by the areas of Europe and Central Asia, East Asia, and Pacific, and Latin America and Cariban, with an average income per capita of $9940, $9441, and $9402, respectively. South Asia and Sub-Saharan Africa are relatively poor regions with an average income per capita of $8206 and $8089. The largest emitter group of carbon emissions in the Middle East and North Africa, with an average emission of 1.78 thousand tons.

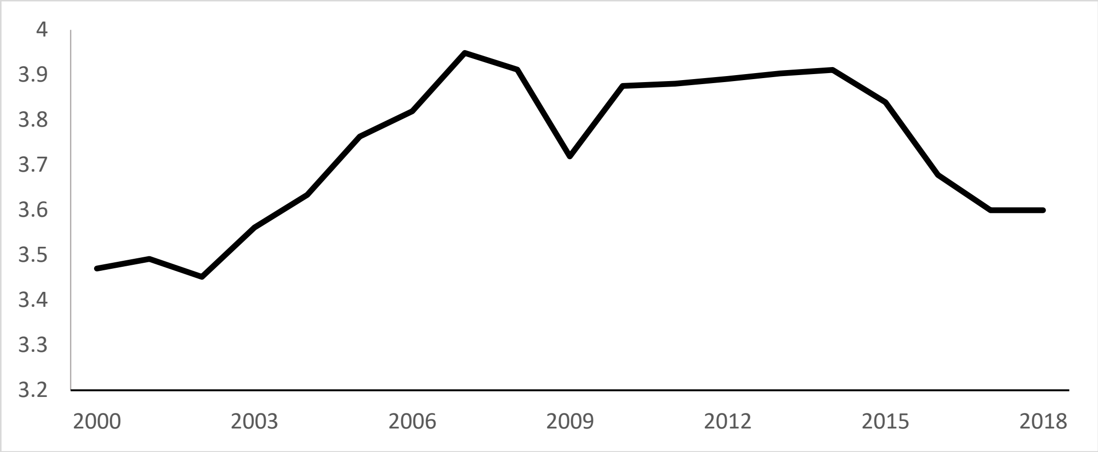
Table 3.3: Descriptive statistics of variables

Region	Variable	Observations	Mean	Std. Dev.	Min	Max
Region 1: Latin America and Cariban	CO	399	.824	.85	-.512	3.01
	GDP	399	9.402	.604	8.103	10.928
	GDPS	399	88.76	11.532	65.652	119.423
	TRD	399	.65	.281	.219	1.667
	FDI	399	.033	.031	-.156	.162
	EDU	399	1.082	.089	.898	1.508
	IFD	399	.317	.205	.061	.888
	IQ	399	.514	.176	.087	.928
Region 2: Europe and Central Asia	CO	836	1.653	.745	-1.201	3.205
	GDP	836	9.94	.854	7.078	11.491
	GDPS	836	99.535	16.291	50.094	132.051
	TRD	836	1.01	.5	.242	4.084
	FDI	836	.061	.124	-.583	1.986
	EDU	836	1.015	.05	.818	1.285
	IFD	836	.476	.242	.048	1
	IQ	836	.658	.23	.136	1
Region 3: East Asia and the Pacific	CO	266	1.151	1.359	-1.931	2.971
	GDP	266	9.441	1.07	7.162	11.355
	GDPS	266	90.279	20.152	51.289	128.944
	TRD	266	.857	.48	.002	2.204
	FDI	266	.034	.053	-.372	.439
	EDU	266	1.045	.07	.958	1.319
	IFD	266	.474	.251	.042	.952
	IQ	266	.549	.228	.086	.974
Region 4: the Middle East and North Africa	CO	304	1.78	1.14	-1.152	3.716
	GDP	304	9.972	.985	7.734	11.728
	GDPS	304	100.41	19.683	59.816	137.552
	TRD	304	.983	.549	.183	3.259
	FDI	304	.09	.409	-.106	4.517
	EDU	304	1.021	.087	.754	1.31
	IFD	304	.376	.133	.116	.654
	IQ	304	.485	.161	.026	.828
Region 5: South Asia	CO	95	-.707	.788	-2.343	.479
	GDP	95	8.206	.547	7.331	9.389
	GDPS	95	67.628	9.088	53.743	88.152
	TRD	95	.444	.133	.253	.886
	FDI	95	.011	.008	-.001	.037
	EDU	95	1.055	.182	.708	1.5
	IFD	95	.264	.097	.126	.47
	IQ	95	.357	.084	.227	.499
Region 6: Sub-Saharan Africa	CO	418	-1.014	1.31	-4.2	2.124
	GDP	418	8.089	.942	6.301	9.956
	GDPS	418	66.313	15.387	39.707	99.119
	TRD	418	.735	.291	.191	1.656
	FDI	418	.042	.061	-.061	.506
	EDU	418	.985	.188	.324	1.409
	IFD	418	.169	.12	.024	.627
	IQ	418	.386	.161	.042	.732

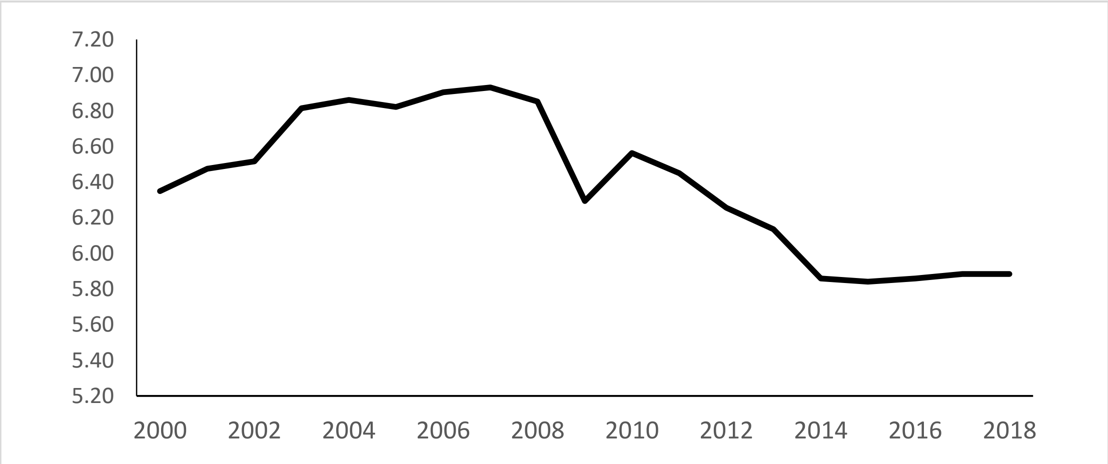
Source: Author's calculation

Figure 3.2: CO_2 emissions for different regions

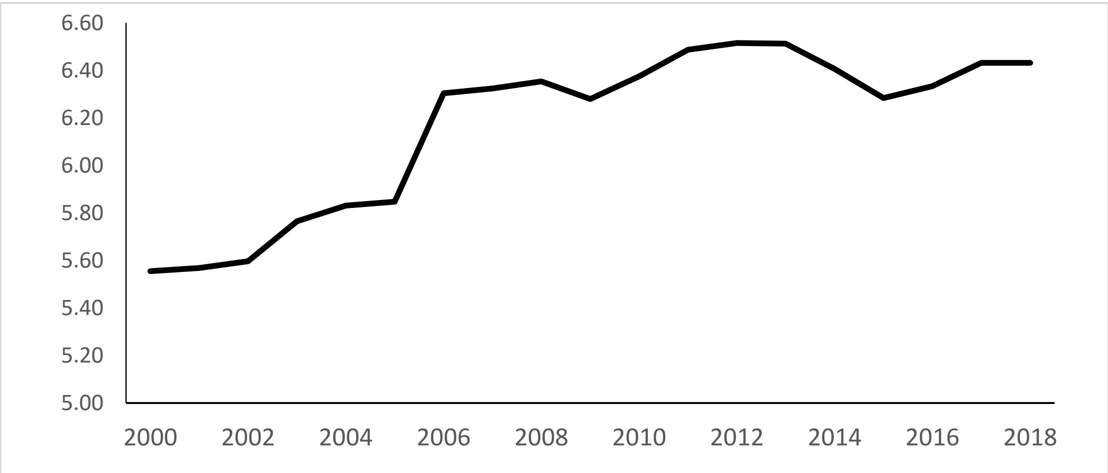
a. **Latin America and the Caribbean**



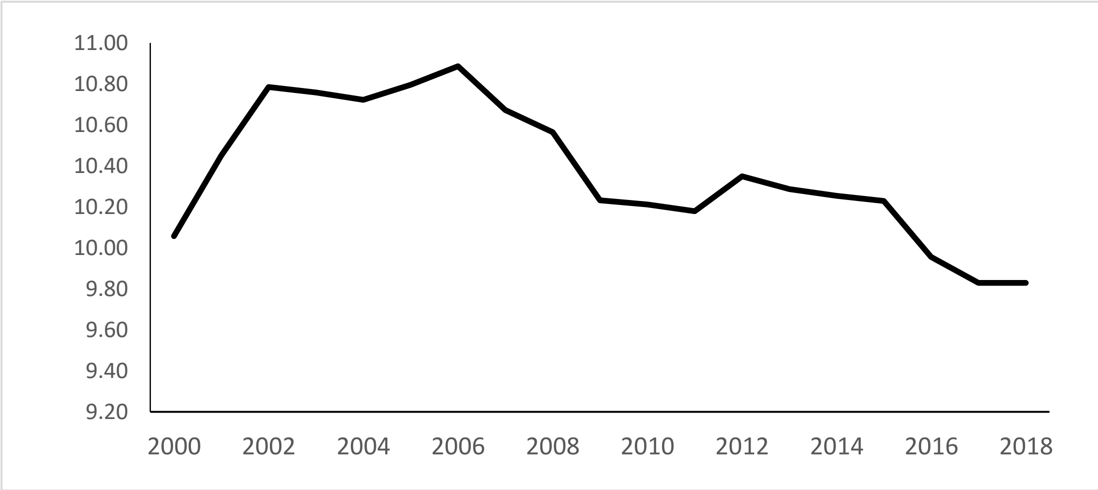
b. **Europe and Central Asia**



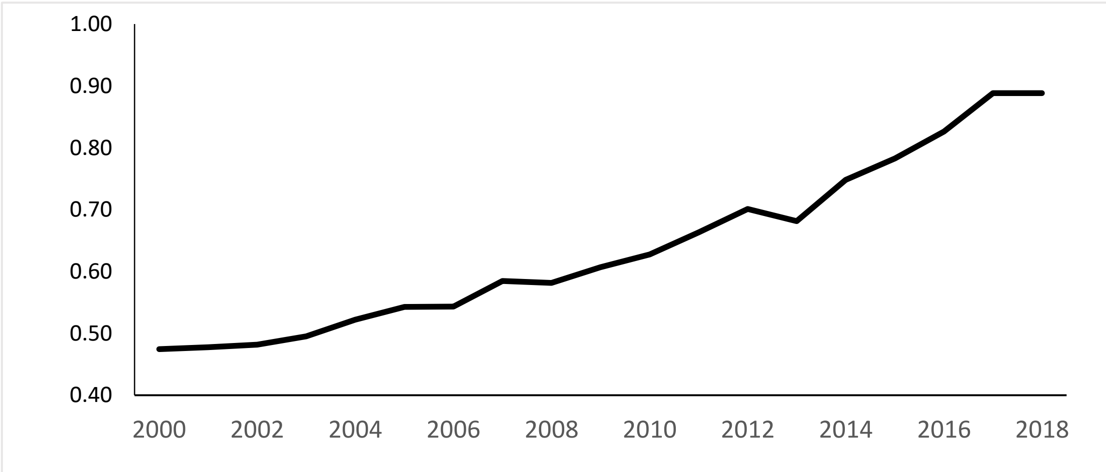
c. **East Asia and the Pacific**



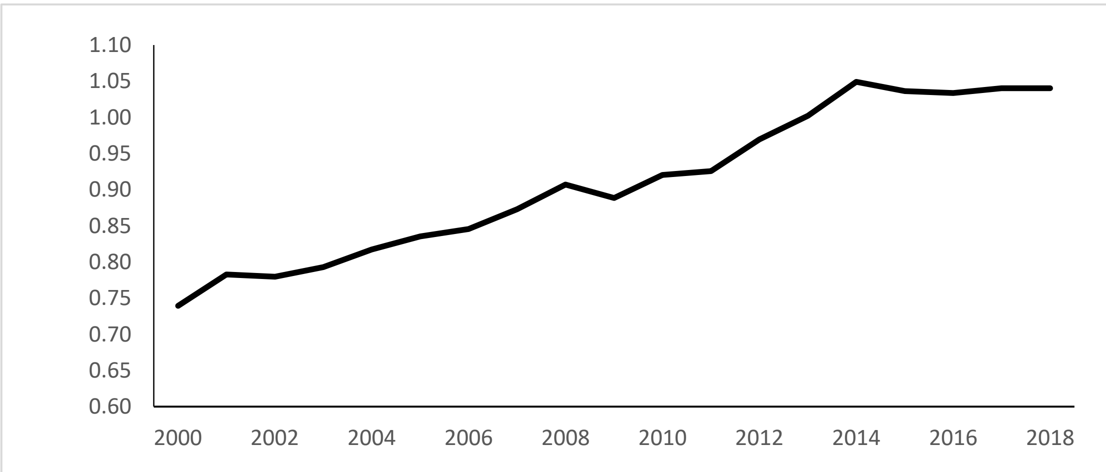
d. The Middle East and North Africa



e. South Asia



f. Sub-Saharan Africa



Source: Author's work

The first figure shows the carbon emissions for the Latin American and Caribbean regions. There is an upward and downward trend in carbon emissions. Carbon emissions increased from 2002 with about 3.4 thousand tons to 3.9 thousand tons in 2007, then decreased to 3.7 thousand tons in 2009. Carbon emissions again increased in 2014. After that, there is a decreasing trend with carbon dioxide emissions of about 3.6 thousand tons.

Carbon emissions in Europe and Central Asia are plotted in the second graph. Carbon emissions rose from 6.35 thousand tons to 6.93 thousand tons from 2000 to 2007, then declined to 6.29 thousand tons in 2009. It slightly rose to 6.56 in 2010, and after that, a decreasing trend occurred until 2014, with carbon emissions reaching about 5.86 thousand tons. Carbon emission slightly increases from 5.86 to 5.88 thousand tons during 2014-2018.

Carbon emissions in the case of the East Asian and Pacific regions are indicated in the third graph. There is an upward trend in carbon emissions from 2000, from about 5.55 thousand tons to 6.35 thousand tons in 2008. Carbon emissions amounted to about 6.28 thousand tons in 2009. From 2009 to 2013, carbon emissions rose to about 6.51 thousand tons, then declined to 6.28 thousand tons until 2015. During 2016 and 2017, carbon emissions rose again to 6.43 thousand tons and remained the same in 2018.

The fourth graph illustrates the Middle East's and North African carbon emissions. Carbon emissions raised from 10.45 thousand tons to 10.89 thousand tons from 2001 to 2006. A descending trend occurred in carbon emissions from 2006, with carbon emissions of 10.89 thousand tons to 10.18 thousand tons in 2011. Carbon emissions grew to 10.35 thousand tons in 2012, declining until reaching 9.83 thousand tons in 2017 and remaining constant in 2018.

Carbon emissions increase from 2000 to 2018 in the case of South Asia, as shown in the fifth graph. It amounted to 0.47 thousand tons in 2000 and rose to 0.89 thousand tons in 2018. In the Sub-Saharan African region, there has been a slight increase in carbon emissions from 0.74 thousand tons to 1.04 thousand tons from 2000 to 2018, as shown in the sixth graph.

3.5 Empirical Results

3.5.1 EKC-hypothesis in a different region by using a non-spatial econometric model

The result of the analysis using the Fixed Effect model is discussed in this section. Table 3.4 shows the impact of the growth rate of GDP, the square of the growth rate of GDP, foreign direct investment, trade openness, primary enrollment rate, institutional quality, and financial development on CO_2 emissions per capita for the regions, i.e., Latin America and the Caribbean, South Asia, Europe and Central Asia, Middle East, and North Africa, East Asia and Pacific, and Sub-Saharan Africa. Most of the coefficients of the variables are significant, and their signs are according to the theory.

The impact of economic growth on CO_2 emissions is significantly positive in Latin America and the Caribbean, East Asia and the Pacific, Europe, and Central Asia, the Middle East and North Africa, and South Asia. In contrast, a positive but insignificant effect is observed in Sub-Saharan Africa. Industrialization takes place with economic growth that leads to more production and pollution. Per capita income increases due to economic growth, which leads to purchasing vehicles, air conditioners, and other goods, enhancing air pollution. A 1% increase in economic growth leads to 7.137%, 1.56%, 2.178%, 4.77%, and 6.75% increases in carbon emissions in Latin America and the Caribbean, Europe and Central Asia, East Asia and Pacific, Middle East, and North Africa, and South Asia, respectively. These results are consistent with (Lee *et al.*, 2010).

The coefficient of the square of the GDP is negative and significant in all regions, which supports the EKC hypothesis, except for Sub-Saharan Africa. It means pollution increases in the initial phases of economic growth. However, after reaching a specific level, pollution decreases with economic growth. These studies support the EKC hypothesis (Jalil & Mahmud, 2009; Apergis & Ozturk, 2015; Ozatac *et al.*, 2017). Based on the results, turning points turned out to be $36315.5 for Latin America and the Caribbean, $13226.7 for Europe and Central Asia, $120571.7 for East Asia and Pacific, $89321.7 for the Middle East and North Africa, and $15521.79 for South Asia.

According to the World Bank Atlas Method, the EKC hypothesis in the Latin American and Caribbean region is that 18 out of 21 countries belong to high-income and upper-middle-income countries. Thus, their income levels reached a turning point.

Table 3.4: Results for EKC-hypothesis in a different region using a non-spatial econometric model.

	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
lnGDP	7.137***	1.556**	2.178***	4.771***	6.757***	0.422
	(8.14)	(4.45)	(4.83)	(8.83)	(5.58)	(0.68)
lnGDPS	-0.340***	-0.082***	-0.093***	-0.210***	-0.347***	0.033
	(-7.35)	(-4.32)	(-3.48)	(-7.67)	(-4.84)	(0.84)
TRD	0.139**	-0.117***	0.218***	-0.098**	0.032	0.040
	(2.57)	(-3.61)	(3.70)	(-2.03)	(0.17)	(0.50)
FDI	0.399	0.045	0.532***	0.083***	2.987	0.832***
	(1.56)	(1.10)	(2.71)	(3.94)	(1.24)	(4.23)
EDU	0.053	0.044	-0.432**	0.599***	-0.141	0.585***
	(0.41)	(0.36)	(-2.05)	(4.99)	(-0.65)	(4.38)
IFD	-0.370*	0.423***	0.884***	-0.100	-0.190	0.213
	(-1.82)	(4.00)	(3.34)	(-0.63)	(-0.49)	(0.44)
IQ	-0.097	1.557***	0.663**	0.494**	2.405***	-0.779**
	(-0.50)	(10.08)	(2.58)	(2.52)	(5.25)	(-2.30)
Constant	-36.12***	-6.82***	-11.55***	-25.41***	-33.37***	-7.00***
	(-8.66)	(-4.22)	(-6.00)	(-9.66)	(-6.78)	(-2.90)
T	18	18	18	18	18	18
N	21	44	14	16	5	22
NT	399	836	266	304	95	418
F-stat [Wald $\chi2$]	229.05	181.60	209.96	63.28	39.40	63.62
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Diagnostic Tests						
Hausman test	39.95	530.58	15.40	153.79	216.60	33.42
Prob > $\chi2$	0.0000	0.0000	0.0312	0.0000	0.0000	0.0000
Kuznets curve's turning point	$36315.5	$13226.7	$120571.7	$85819	$16983.54	

Source: Author's work. Values presented in parentheses are t-values, (P<0.10, ** P<0.05,* **In the

European and Central Asian region, 29 out of 44 countries belong to high-income countries and ten upper-middle-income countries. That is why the hypothesis of EKC is found valid in this region. The hypothesis of the EKC is confirmed for East Asia and Pacific, the Middle East, and North Africa because 9 out of 14 countries and 11 out of 16 countries are high-income and upper-middle-income countries in these regions, respectively.

The EKC hypothesis is supported in South Asia because all countries are part of the lower-middle-income category, and no country is part of the low-income category. So, the income levels of these countries have reached a turning point. The non-existence of the EKC hypothesis in the Sub-Saharan African region is that most countries are low-income and lower-middle-income. Their income levels are too low to reach the turning point.

The impact of trade openness on CO_2 emissions is positive in Latin America, the Caribbean, East Asia, and the Pacific. A 1% increase in trade openness causes a 0.139% and 0.218% increase in carbon dioxide emissions in these regions, respectively. The possible reason is that the scale effect of trade is more significant than both composition and technique effects. The positive link between trade openness and carbon emissions is supported by the following studies: (Zuo *et al*., 2017; Ayeche *et al*., 2016; Elmarzougui *et al.,* 2016; Ren *et al.,* 2014). Trade openness reduces carbon emissions in Europe, Central Asia, the Middle East, and North Africa. Where a 1% increase in trade openness leads to a 0.12% and 0.098% decrease in CO_2 emissions in these regions, the technical effect of trade is greater than the scale effect. Most of the countries in these regions are high-income countries. In high-income countries, production patterns are cleaner, and energy-efficient goods are imported under strict environmental regulations. These empirical findings follow the results of (Ahmad & Long, 2012; Shahbaz *et al*., 2012; Jabeen, 2015; Saboori *et al.,* 2016).

There exists a positive association between FDI and CO_2 emissions in East Asia and Pacific, the Middle East and North Africa, and Sub-Saharan Africa, where a 1% increase in FDI causes 0.532%, 0.083%, and 0.832% increase in CO_2 emissions in these regions, respectively. This supports the pollution heaven hypothesis, which means dirty industries are shifted from developed to developing countries because of the weak environmental regulations in developing countries, or polluting technologies are transferred from more developed countries to less developed countries through FDI. These findings are in line with the studies (Ren *et al.*, 2014: Elmarzougui *et al.*, 2016; Sarkodie & Strezov, 2019).

Primary school enrollment positively and significantly impacts CO_2 emissions in the Middle East, North Africa, and Sub-Saharan Africa. A 1% increase in education increases CO_2 emissions by 0.60% and 0.59% in these regions, respectively. The income per capita rises due to education, which increases the consumption and use of vehicles, electricity, and other things. A negative yet significant relationship exists between primary school enrollment and CO_2 emissions in East Asian and Pacific regions. Social awareness and more understanding can be implied by education. So, cleaner technologies are adopted by these countries. The effect of education on carbon emissions is positive but insignificant in Latin America, Caribbean Europe, and Central Asia. On the other hand, a negative but insignificant effect in the South Asian region is observed.

The impact of financial development on carbon dioxide emissions is positive in Europe and Central Asia, East Asia, and the Pacific. A 0.423% and 0.884% increase in carbon dioxide emissions are caused by a 1% increase in financial development in these regions. The reason is that financial development invites foreign direct investment, which increases economic growth and negatively affects environmental performance. Financial intermediation facilitates the purchase of cars, air conditioners, and washing machines. Energy usage increases through these household items, which causes higher CO_2 emissions. The positive link between financial development and CO_2 emissions is also reflected in the findings (Shahbaz *et al*., 2015; Pata, 2018). The impact of financial development on carbon emissions in Latin America and the Caribbean region is significantly negative, where a 1% rise in financial development declines the carbon emissions by 0.37%. Strong financial institutions are supporting technological innovations which help reduce pollution. The finding is in line with the results obtained by Al-Mulali *et al*. (2015).

Institutional quality has a positive and significant impact on the level of carbon emissions in Europe and Central Asia, South Asia, the Middle East, North Africa, and East Asia and Pacific, where a 1% increase in institutional quality stimulates the level of carbon emissions by 1.56%, 0.66%, 0.49%, and 2.41%, respectively. FDI is attracted by the quality of institutions which increases economic development and affects environmental quality. Poor quality of institutions has a negative effect on environmental regulations. Inadequate quality of institutions leads to weak environmental regulations. Consequently, consumers and producers can escape the fines for environmental destruction. Market failure cannot be minimized in the absence of well-functioning institutions. Productive cooperation is not facilitated among market players because of the low institutional quality. The quality of institutions has a negative effect on carbon emissions in the Sub-Saharan African region. And 1% increase in institutional quality reduces carbon emissions by 0.779%. That reduction in carbon emissions is the improvement of institutional quality.

3.5.2 EKC-hypothesis in a different region by Using Spatial econometric model

The EKC hypothesis is estimated by using the spatial econometric model in this section. Comparative analysis between the SEM FE model and the non-spatial FE model is done to get a better fitting effect.

Table 3.5 shows the analysis result using the spatial error model (SEM) fixed effect. Most of the coefficients are smaller in the spatial panel model than in the non-spatial panel model. This difference is that the spatial spillover effect present in data is ignored. Another cause is the feedback effect. The CO_2 emissions of neighboring countries affects the CO_2 emissions of the local country.

Table 3.5: Using spatial econometric model results for EKC-hypothesis in different regions

	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
lnGDP	7.255***	1.16***	1.662***	4.667***	6.225***	1.463**
	(8.97)	(3.17)	(3.31)	(9.14)	(5.23)	(2.01)
lnGDPS	-0.345***	-0.058***	-0.062**	-0.207***	-0.316***	-0.027
	(-8.06)	(-2.95)	(-2.10)	(-7.92)	(-4.48)	(-0.60)
TRD	0.105**	-0.089***	0.242***	-0.073	0.149	0.144*
	(2.12)	(-2.81)	(4.21)	(-1.62)	(0.74)	(1.82)
FDI	0.397	0.041	0.498***	0.085***	0.469	0.571***
	(1.53)	(1.07)	(2.67)	(4.29)	(0.19)	(3.07)
EDU	0.133	0.055	-0.519***	0.629***	-0.106	0.652***
	(1.18)	(0.48)	(-2.64)	(5.79)	(-0.53)	(4.93)
IFD	-0.116	0.266**	0.714***	-0.035	-0.051	-0.079
	(-0.68)	(2.48)	(2.73)	(-0.25)	(-0.14)	(-0.17)
IQ	-0.372**	1.339***	0.675***	0.443**	2.320***	-0.442
	(-2.26)	(8.82)	(2.70)	(2.34)	(5.97)	(-1.27)
Spatial	0.387***	0.284***	0.167**	-0.202***	-0.208*	0.251***
lambda ( )	(8.95)	(6.32)	(2.04)	(-2.90)	(-1.69)	(3.88)
Variance	0.007***	0.015***	0.016***	0.013***	0.009***	0.030***
(σ^2)	(13.42)	(20.20)	(11.44)	(12.21)	(6.82)	(13.63)
T	19	19	19	19	19	19
N	21	44	14	16	5	22
NT	399	836	266	304	95	418
R-square	0.3768	0.4030	0.8798	0.8348	0.7026	0.7743
EKC turning point	\$37049.1	\$22026.5	\$660003.2	\$87553.0	\$19532.7	

Source: Author's work. Values presented in parentheses are t-values, (P<0.10, ** P<0.05, *** P<0.01)*

Economic growth positively affects all regions. A 1% increase in economic growth causes 7.255%, 1.16%, 1.662%, 4.667%, 6.225%, and 1.463% increase in carbon dioxide emission in Latin America and the Caribbean, Europe and Central Asia, East Asia and Pacific, Middle East, and North Africa, and South Asia, Sub-Saharan Africa, respectively. Consumption of energy, especially fossil fuel, increases due to high economic growth, which causes environmental degradation. This study is in line with the study of Samreen and Majeed (2020). The square of GDP diminishes carbon dioxide emission from Region 1 to Region 5, thus supporting the Environment Kuznets Curve (EKC) hypothesis. Pollution increases in the early phases of economic growth because of industrialization and increased production. Income increases with time, and the need for a clean environment, research, and development activities, and the adoption of clean technology also increase. These results follow the study of Omri *et al.* (2015).

Trade openness reduces carbon dioxide emissions in Europe and the Central Asian region. Carbon dioxide emission reduces by 0.089% due to a 1% increase in trade openness. This shows that the technical effect of trade dominates the scale effect. Energy-efficient and environmentally friendly technology is used to produce goods. Transferring and exporting high-technology products for production lead to low emissions. The negative association between trade openness and environmental quality is supported by (Ling *et al.,* 2015; Löschel *et al*., 2013).

Due to trade openness, pollution increases in Latin America, the Caribbean, East Asia, the Pacific, and Sub-Saharan Africa. A 1% increase in trade openness causes a 0.144%, 0.242%, and 0.105% increase in carbon dioxide emission in Sub-Saharan Africa, East Asia, the Pacific, Latin America, and the Caribbean region. The reason is that the scale effect of trade is more incredible than the composition and technique effect. An increase in the volume of exports raises the pollution level. Environmental regulations and policies are not strict in developing countries. They produce and specialize in those goods which cause environmental degradation, thus supporting the pollution heaven hypothesis. On the other hand, developed countries have a comparative advantage in the clean production method. These results align with the study of Hakimi and Hamdi (2016).

There is a positive link between FDI and CO_2 emissions. Carbon dioxide emissions increased by 0.085%, 0.571%, and 0.498% in the Middle East, North Africa, Sub-Saharan Africa, East Asia, and Pacific regions. So, the pollution heaven hypothesis is supported in these regions. Pollution-specific industries are reallocated from developed to developing countries due to low environmental standards in developing countries. FDI promotes economic growth, producing more industrial pollution and worsening environmental quality.

Primary school enrolment reduces carbon dioxide emissions. A 1% increase in education leads to a 0.519% decrease in carbon dioxide emission in East Asia and the Pacific region. Education through training sets the mentality of people, so they choose environment-friendly goods. Environmental quality deteriorates due to education in the Middle East, North Africa, and Sub-Saharan Africa. CO_2 emissions increased by 0.629% to 0.652% due to a 1% increase in education in these regions. Educated people consume more material goods. The exploitation of natural resources occurs due to the overconsumption of material goods, and hence educated people cause environmental degradation. Energy-intensive activities such as the trade of goods are boosted with education, and per capita income increases due to education which facilitates the use of polluting technologies such as cars.

Financial development positively impacts carbon dioxide emissions in Europe, Central Asia, East Asia, and the Pacific regions. CO_2 emissions increased by 0.266% and 0.714% due to a 1% increase in financial development in these regions. Financial development increases economic growth. Therefore, industrial pollution and environmental degradation increase. Financial development also attracts FDI and leads to environmental degradation.

Institutional quality harms environmental quality in South Asia, the Middle East and North Africa, East Asia and Pacific, and Europe and Central Asia. A 1% rise in institutional quality leads to 2.320%, 0.443%, 0.675%, and 1.339% increase in carbon dioxide emission in these regions. Foreign direct investment is attracted by institutions' quality, which increases economic growth and affects environmental quality. Economic growth is boosted due to good institutional quality and causes environmental degradation. Institutional quality is helpful to environmental quality in

Latin America and the Caribbean. Carbon dioxide reduces by 0.372% due to a 1% increase in institutional quality in this region.

3.6 Conclusion

The present study examines the EKC hypothesis in six regions of the world: South Asia, the Middle East, and North Africa, Europe and Central Asia, Latin America and the Caribbean, East Asia and the Pacific, and Sub-Saharan Africa from 2000 to 2018.

The EKC hypothesis is confirmed in all regions except the Sub-Saharan African region in both spatial and non-spatial models. In a non-spatial model, trade openness is dangerous to the environment in East Asia, the Pacific, Latin America, and the Caribbean, but it causes more damage in East Asia and the Pacific region. Trade openness improves the environmental quality in the Middle East, North Africa, Europe, and Central Asia, but trade is more beneficial to Europe and Central Asia than to the Middle East and North Africa. While in a spatial model, trade openness harms the environment in Sub-Saharan Africa, East Asia and Pacific, Latin America, and the Caribbean region and is beneficial for Europe and Central Asia.

Carbon emissions increase due to foreign direct investment (FDI) in the Middle East, North Africa, East Asia and the Pacific, and Sub-Saharan Africa. The FDI has the most significant impact on carbon emissions in Sub-Saharan Africa, followed by East Asia and the Pacific, and the Middle East and North Africa in both non-spatial and spatial models. There is a positive impact of School enrollment on CO_2 emissions in Sub-Saharan Africa, the Middle East, and North Africa, but a negative effect on East Asia and the Pacific in both spatial and non-spatial models.

Financial development positively affects Europe, Central Asia, East Asia, and the Pacific. Financial development causes more carbon emissions in East Asia and the Pacific than in Europe and Central Asia in both spatial and non-spatial models. Financial development only improves the environmental quality in Latin America and the Caribbean in the non-spatial model.

Institutional quality increases the carbon emissions in the Middle East and North Africa, Europe and Central Asia, South Asia, East Asia, and the Pacific, but the most affected region is South Asia in spatial and non-spatial models. Institutional quality benefits the quality of the environment in Sub-Saharan Africa in the non-spatial model. While in a spatial model, institutional quality has a beneficial effect on the environment in Latin America and the Caribbean region.

Chapter 4

Non-Linear Effect of Trade Openness on Environmental Quality: A Panel Threshold Analysis

4.1 Introduction

Nowadays, trade is made more commonly and intensively between countries in this global economy. Trade is an important economic activity that is increasing with time. A sixteen-fold increase in annual trade volumes has occurred in the last fifty years. Through this increase in global trade, countries worldwide have profited from more industrial development, investment, income growth, and employment (Azhar *et al*., 2007).

Other benefits of trade are poverty reduction, improvement of the income distribution, increased capital mobility, the spread of agreements such as human rights and international environment and democracy, diffusion of technology and information, and increased and easy movement of goods and services. Theoretically, international trade boosts economic growth by enlarging markets and increasing resource allocation efficiency. Much attention has been given to the benefits of trade liberalization over the years, and the disadvantages of trade liberalization are not highlighted. The major drawback is an environmental problem (Azhar *et al*., 2007; Vishuphong, 2015).

Over the last four decades, climate change policy has been one of the most critical anxieties among environmentalists, economists, and policymakers to prevent global warnings. The debate on environmental outcomes of international trade in developed and developing countries opened in 1972 at the United Nations Stockholm Conference on Development and Environment. Gradually environmental aspects are introduced in international trade agreements, e.g., The North American Free Trade

Agreement (NAFTA), which confirms environmental awareness in this globalized world (Aller *et al*., 2015).

The trade openness policy is one of the well-known policies of economic development. In current years, the trade quality of the environment relationship has been a hotly disputed issue among opponents and supporters of trade openness. Trade is helpful to the environment because it is expected to increase the income level, and as a result, people demand environment-friendly goods. Under strict environmental laws, international trade encourages firms to adopt environment-friendly production techniques. This is called the gain-from-trade hypothesis. As opposed to this, the race to the bottom hypothesis is that the scale of economic activities and pollution increases with trade. Firms produce pollution-intensive goods if there is lax environmental regulation. Pollution-intensive industries shift to these countries as suggested by the pollution haven hypothesis (Ibrahim & Law, 2016).

Economic factors such as industries and consumers change their behaviors according to the requirement of institutions. Many types of institutions exist public, private, semi-public, public-private partnership, etc. The public sector includes government organizations, passing the regulative conditions for firms. They use command and control instruments according to which the firm operates. Economic instruments such as taxes and subsidies are also included in these institutions, and firms are encouraged to change their strategies to attain good environmental performance. Economic actors are forced by private sector requirements to operate in such a way as to gain legitimacy. Good governance and democracy have a positive influence on environmental performance. Good governance and level of democracy are related to economic growth or decline. Well-performing institutions like political stability reduce uncertainty and positively affect long-term economic development (Mavragani *et al.*, 2016).

Trade liberalization is objectionable if it increases economic growth without regard for environmental degradation and resource exhaustion. The emissions of gases increased due to a rise in industrial production. The emission of toxic chemicals and hazardous gases also increases due to trade openness because there is lax environmental regulation in developing countries. To expand the size of the economy, a country can involve in the production of dirty goods. Trade benefits the environment due to democracy, free factor mobility, and international standards. One of the components of environmental deprivation and natural resource depletion is inadequate governance. Due to the high degree of corruption, flexible environmental policies exist, and dirty industries can enter and pollute the economy (Zafar *et al.*, 2013).

The modern concept of sustainable development first appeared in 1987, warning about the harmful environment due to rapid economic growth and globalization. Sustainable development is to fulfill the present-day generation's needs without conceding the future generation's capability. It guarantees the balance between economic growth, environmental consequences, and social welfare.

The role of economics in the case of global environmental problems, e.g., global warming, ozone layer depletion, climate change, biodiversity losses, and acid rain, is that the causes of these problems and the development of different policies are examined thoroughly in it. These environmental problems pose severe dangers to future generations. Possible harmful effects on the environment are created due to increased economic openness. Trade is expanding in natural resources and dangerous products, which have added to the terror about the environment.

Many researchers have analyzed the influence of different policies on the quality of the environment due to global warming and environmental degradation. Many countries of the world are integrated through the process of globalization. They make free trade with each other. Free trade is beneficial as well as costly to different countries. This process of globalization has created complex problems such as migration and environmental degradation. Now a day‘s challenge is to explore models and techniques for trade's impact on the environment's quality.

Better institutional quality improves the environment if a trade harms the environment. In contrast, if the trade benefits environmental quality, then better institutional quality is further useful to the environment. So, the present study will try to answer the subsequent questions:

- What is the impact of trade on air pollution when institution quality is low or high?

The study will explore the effect of institutional quality on trade-environment relationships. The specific objectives of the current study are:

- to find the threshold of institutional quality in the trade-environment relationship

Developed countries have high institutional quality, which is transferred to developing countries through trade. Developed countries have stringent environmental regulations, and developing countries' environmental standards increase gradually. Our study will explore the threshold level of institution quality, after which trade positively affects the environment.

We favor the discontinuous approach in this essay because low institutional quality and high institutional quality have different effects on trade-environment relationships. IQ is different in developed and developing countries. IQ is high in developed countries. Environmental laws are Strick in developed countries. On the other hand, IQ is low in developing countries. Environmental laws are lax in developing countries.

This study is planned as follows. Section 4.2 is about the literature review. The methodology is discussed in section 4.3, and the results are given in section 4.4. In the end, section 4.5 concludes the study.

4.2 Literature Review

This section is about the literature review regarding the importance of institutional quality in a trade-environment relationship.

Different countries' studies find institutional quality's role in trade and environmental quality. This section will review some of these studies examining the role of institutional quality in a trade-environment relationship.

Most studies attain that institutional quality is beneficial to the quality of the environment. In the same vein by using time series data, Mavragani *et al.* (2016) examine the influence of institutional quality and openness of the economy on environmental performance. The study finds that openness of the economy and all indicators of institutional quality are useful for environmental performance.

In the case of Pakistan, Zafar *et al.* (2013) examine the impact of trade liberalization and corruption on the quality of the environment. Two environmental indicators used in this study are water and air pollution. The study finds that trade liberalization benefits the environment and that open economies are not much affected by corruption. EKC is also approved in Pakistan. The industrialization process negatively affects the environment. Education and law and order situations are beneficial to the environment.

By using the data from 1996 to 2018 and for Pakistan, Ahmed *et al.* (2020) find that financial development (FD) and institutional quality (IQ) have a significant long-run symmetric and asymmetric association with the degradation of the environment and environmental sustainability. A positive and adverse shock to FD substantially affects environmental degradation and sustainability. Though a positive and adverse shock to IQ has a more substantial impact on environmental degradation but a more negligible effect on environmental sustainability.

Institutional quality also has a beneficial effect on the quality of the environment in those studies which use panel data. Winslow (2005) examines the effect of democracy on environmental quality. Two measures of democracy Freedom house index and Polity III, are used, and environmental quality is measured by urban air pollution. The result of the study is that a negative link exists between democracy level and urban air pollution. A higher level of democracy is associated with low air pollution.

Bernauer and Koubi (2009) investigate the impact of political institutions on Environmental quality using data from 42 countries from 1971 to 1996. The result of the study is that degree of democracy positively affects air quality, and the presidential system is more beneficial to air quality than a parliamentary system.

Moreover, there is a positive link between the strength of labor unions and air quality and a negative link between green parties and air quality.

Using the data from 1993-2004, Tamazian and Rao (2010) analyze the relationship between economic growth, financial development, and institutional quality for 24 transition economies. The econometric technique used for this purpose is system GMM. Both institutional quality and financial development negatively impact CO_2 emissions. It indicates that CO_2 emissions declined by the improved institutional quality and financial development in transition economies.

Using the data from 2004-2007, Goel *et al*. (2013) explore the effect of institutional quality (corruption and shadow economy) on pollution in MENA countries. The two-stage least squares (2SLS) method is used for estimation. The result is that more corruption and a more shadow economy negatively affect pollution. The emission level is underreported due to high corruption, and pollution is unrecorded due to an increase in the shadow economy.

Shahab and Nasersadrabadi (2014) examine the effect of trade openness on the quality of the environment in selected countries of the MENA groups from 1997 to 2007. The random effect model is utilized in this study. The study finds that trade and government investment positively affect CO_2 emissions while government size negatively affects CO_2 emissions.

Aller *et al*. (2015) examine trade's network or indirect effect on the environment. The 3SLS estimation technique is used in this study because the system of equations is estimated, and an intertemporal correlation exists between the error terms. Congestion externalities and market power are used to study the indirect effect of trade. Both effects have a detrimental impact on the quality of the environment in high-income countries and positively impact low-income countries. Technique effect or entrance of multinational companies negatively impacted low-income countries' environment. The composition effect has a harmful effect on the quality of the environment. The quality of institutions only improves the quality of the environment of developing countries.

Using a dynamic panel data model for sixty emerging and developing countries, Bernard and Mandal (2015) find the effect of trade openness on the quality of the environment. Data from 2002-2012 and the fixed-effect model and GMM estimation technique are used in this study. Environmental Performance Index (EPI) and CO_2 emissions pointers of environmental quality. The results of the fixed effect model indicate that trade openness improves the EPI while it increases CO_2 emissions. GMM is used when endogeneity is considered. The findings of GMM, when EPI is used as an environmental indicator, are that political factors are beneficial to the environment while population and income are harmful to the environment. Using CO_2 emissions as an environmental indicator, the GMM estimation results show that income, trade openness, population, and energy consumption harm the environment.

Using data from 1996 to 2010, Abid (2016) investigates the effect of economic, institutional, and financial development on CO_2 emissions in 25 Sub-Saharan African economies. Both static and dynamic panel data estimation techniques are used in this study. This study does not support the EKC hypothesis, and a monotonically increasing relation between income and carbon emission is found. Trade openness and institutional quality also affect environmental quality and economic growth. Economic development, Trade openness, the rule of law, and regulatory quality positively affect CO_2 emissions, while political instability, government effectiveness, control of corruption, and democracy have a negative effect on CO_2 emissions. The result shows that good governance positively affects environmental regulation and controls CO_2 emissions. Financial development has an insignificant effect on CO_2 emissions because of low financial development in these economies.

Abid (2017) examines the EKC hypothesis and the effect of institutional quality on environmental degradation in MEA (the Middle East & Africa) and EU (European Union) countries by taking the data from 1990-2011. GMM-system method is used in this study. The shape of EKC is monotonically increasing for both MEA and EU countries. Institutional quality negatively affects environmental degradation in the case of EU countries because of high institutional quality and the adoption of clean production techniques. However, it has an insignificant impact on environmental deprivation in the case of MEA countries due to low institutional quality.

Some studies find the beneficial effect of institutional quality in a trade-environment relationship. Similarly, Lutz (2012) examines the effect of political institutions on the trade-environment relationship using data from 1990 to 2008, for African countries. The study used two environmental indicators, CO_2 emissions and net forest depletion. The study finds that trade positively affects CO_2 emissions, and better political institutions further enhance this relationship. There is U shaped relationship between democracy and net forest depletion. EKC is found for CO_2 emissions but not for net forest depletion**.**

For 12 Asian developing countries, Umer *et al.* (2014) examine the effect of trade, public sector corruption, and environmental quality from 1995 to 2012. Pooled ordinary least squares (OLS), fixed effects, and random effect models are applied. The results show that trade and government effectiveness positively affect the environment, and trade openness generated by government efficiency benefits the environment.

Using the system GMM estimation technique, Ibrahim and Law (2016) examine the effect of institutional quality and trade on the quality of the environment in 40 Sub-Saharan African countries. They find that trade and institutional quality positively affect the environment, and institutional reforms benefit the environment. Trade is favorable to the quality of the environment in countries where institutional quality is high and damaging to countries with low institutional quality. Governments should take institutional reforms to get the beneficial environmental impact of trade. The study concludes that trade openness and sound quality of institutions are necessary for a better environment and growth.

Yasmeen *et al*. (2018) find the effect of trade institutions on the environment for 117 countries and five regions such as Europe, Sub-Saharan, Middle East, Asia and Pacific, North Africa and Latin America, and the Caribbean over the period 2002 to 2014. GMM is applied to obtain the desired results. The result is that trade is advantageous for the quality of the environment in whole sample countries. Institutions play an important role in shaping trade environment relationships. Scale effect rises the pollution, and the technique effect declines the pollution.

Using the data from 1984 to 2018, Hunjra et al. (2020) analyze the diminishing effect of financial development, institutional quality, and quality of environmental relationships in South Asian countries. The generalized least square (GLS) method is used to obtain empirical results. Financial development harms the environmental quality suggesting that financial development enhances industrial activity but does not improve technology. Foreign direct investment (FDI) is beneficial for the quality of the environment. Moreover, institutional quality reduces the harmful effect of economic growth, financial development, energy consumption, and foreign direct investment on environmental quality.

Some studies find that institutional quality moderates the harmful effect of different variables. In this way, Zakaria and Bibi (2019) investigate the effect of financial development and institution quality on the environment in South Asian countries from 1984 to 2015. The generalized least square (GLS) method is used to obtain empirical results. Financial development, energy consumption, trade openness, and economic growth deteriorate the environment. However, Institutional quality moderates the harmful effect of these variables on the environment.

Using the data from 2002 to 2014 and for 112 countries, Nguyen *et al*. (2021) find that financial development positively affects energy consumption. Institutional quality reduces the reverse harmful effects of financial development. As a result, financial development positively impacts the per capita energy use in the poor quality institutional framework and negatively affects the per capita energy use in the strong quality institutional framework. A two-step system GMM is employed in this research study.

Studies using the estimation technique of the panel threshold model are as follows. For example, Shao (2020) examines the consequence of marine patents and per capita gross ocean product (GOP) on marine pollution. The panel threshold model is used in this study. The result is that per capita GOP increases marine pollution, but this effect declines in different phases. Marine patent reduces marine pollution in the high-level phase because of technological innovation.

For 87 developing countries over the period 1984 to 2018, khan *et al.* (2020) find that economic freedom reduces the financial development in low-freedom regimes and enhances the financial development in high-freedom regimes by employing a panel threshold model. The threshold is found at the 4.282 value.

For 31 developing countries from 1970 to 2013, Aye and Edoja (2017) find that economic growth declines the carbon dioxide emission in the low-growth regimes and increases it in the high-growth regimes by using a panel threshold model. Financial development, population, and energy consumption also enhance carbon dioxide emissions.

Vishuphong (2015) studies the impact of trade reforms on the environment of Thailand by employing the Computable General Equilibrium (CGE) analysis. The result of the study is that trade reforms increase the GDP but decrease the environmental quality. A combined policy between trade reforms and lax environmental tax benefits both GDP and the environment. Trade reforms and strict environmental taxes have a helpful effect on the environment but have a harmful effect on GDP.

Hübler (2017) examines the relationship between inequality and emission using simultaneous-quantile regressions. The study finds that inequality reduces the per capita CO_2 emissions and energy intensities in pooled regression. FDI and trade rise CO_2 emissions and energy use.

Baek *et al*. (2009) analyze the link between trade, income, and environment for developed and developing countries using Johansen's maximum likelihood procedure. The result is that trade and income growth improve the quality of the environment in developed countries and worsen the environmental quality in developing countries. Causality runs from trade and income to the environment in the case of developed countries and from the environment to income and trade in developing countries. However, the causal relationship for China is the opposite.

Wu *et al*. (2012) explore the impact of the governance environment on trade flow. They obtain that rule-based countries trade greater than relation-based and family-based countries. Rule-based countries trade more with rule-based countries, and relation-based countries trade more with relation-based countries, but family-based countries trade less with family-based countries and with relation-based and rule-based countries.

Li *et al.* (2015) examined the effect of trade on-air visibility for 134 countries from 1961-2004. The result is that trade openness has an adverse effect on the quality of the environment both in developed and developing countries.

Cherniwchan (2017) examines the effect of NAFTA on the emission of particulate matter (PM_{10}) and SO_2 emissions from U.S. manufacturing plants. The study finds that trade liberalization has reduced the emission of SO_2 and particulate matter from affected plants. Two third of the reduction in pollution between 1994 and 1998 occurred due to trade liberalization. Reduction in emission intensity occurred due to within-plant changes, new technologies' adoption, and increased access to intermediate inputs.

Tamazian *et al*. (2009) analyzed the impact of financial and economic development on CO_2 emissions for BRIC countries from 1992-2004. Random effect specification is used as an estimation technique. The result is that both economic growth and financial development negatively affect CO_2 emissions because financial development attracts FDI and provides funds at a low cost to firms for technologically advanced products.

Using the data from 1965 to 2008, Shahbaz *et al.* (2013) examine the impact of financial development, coal consumption, economic growth, and trade on CO_2 emissions in South Africa. ARDL cointegration methodology is used in this study to obtain the long-run link among variables. The error correction method (ECM) finds a short-run link among variables. A long-run link among variables is found. Furthermore, financial development improves the environment quality. Economic growth and coal consumption increase CO_2 emissions, while trade openness negatively affects CO_2 emissions.

Using the data from 1970 to 2012, Ali and Abdullah (2015) explore the effect of financial development, trade, and economic growth on CO_2 emissions. The study employs the Vector Error Correction Model (VECM). The empirical findings are that financial sector development improves the environment. Trade openness reduces CO_2 emissions. It means the import of environment-friendly goods is encouraged.

Using the data from 1989 to 2011, Ziaei (2015) explores the effect of financial indicators shocks on CO_2 emissions and energy consumption for 12 East Asia and Oceania and 13 European countries. Panel Vector Auto Regression (PVAR) modeling is utilized to find this relationship. The result is an insignificant effect of carbon emission shock on the stock market and credit market in both European and East Asia and Oceania countries. Energy consumption has a more significant influence on the stock market in European countries than in East Asia and Oceania countries. Energy consumption is positively influenced by stock market shock in East Asia and Oceania countries.

Shahbaz *et al.* (2016) examine the effect of financial development on CO_2 emissions from 1985-2014 in Pakistan. The nonlinear ARDL approach is used to obtain empirical results. This research finds that financial development through the banking sector positively affects CO_2 emissions. Energy consumption and economic growth harm environmental quality.

Charfeddine and Khediri (2016) analyze the link between financial development and carbon emission in the case of the UAE over the period 1975 to 2011. The result of the study is that the link between financial development and carbon dioxide emission is inverted U-shaped. Electricity consumption, urbanization, and trade openness have a beneficial effect on environmental quality. The EKC hypothesis is also confirmed in this study.

In summary, low institutional quality is harmful to the quality of the environment. In contrast, high institutional quality benefits the quality of the environment because institutions work effectively in high institutional quality, and strict environmental laws and regulations are enforced, leading to low carbon dioxide emissions. Institutional quality has a beneficial effect on the trade-environment relationship. The study's objective is to determine the threshold level of institutional quality in a trade-environment relationship.

Table 4.1: Summary of Empirical results regarding the effect of institutional quality on the trade-environment relationship

Reference	Statement	Period of Analysis	Region of Analysis	Methodology	Empirical results	Conclusion
Impact of institutional quality on trade-environment Relationship						
Yasmeen et al. (2018)	The Effect of Trade Institutions on the Environment	2002 to 2014	117 countries	GMM first difference model	Trade: - 0.00097 Trade*Institutional quality: -0.0012	Trade is beneficial for the environment in whole sample countries. The institution plays important role in shaping trade environment relationships.
Abid (2017)	The effect of institutional quality on environmental degradation.	1990-2011	MEA (Middle East & Africa) and EU (European Union) countries	GMM-system method	Trade: -0.048 Control of corruption: -0.130 Regulatory quality: -0.117 Political instability: -0.115 Government effectiveness: -0.057	Institutional quality has a negative effect on environmental degradation in the case of EU countries and has an insignificant effect on environmental degradation in the case of MEA countries
Mavragani *et al.* (2016)	Effect of openness of the economy and institutional quality on environmental performance.	Selected years.	75 countries (All G20 and EU countries)	Principal component analysis as the extraction method, and Varimax with Kaiser normalization as the rotation method	Trade: 11.26 Control of corruption: 33.12 Government effectiveness: 26.38 Voice and accountability: 38.15	The openness of the economy and all indicators of institutional quality have a positive effect on environmental performance.
Abid (2016)	The effect of economic, institutional, and financial development on CO_2 emissions.	1996 to 2010	Sub-Saharan Africa economies	Static and dynamic panel data estimation technique	Trade: 0.001 Rule of law: 0.175 Regulatory quality: 0.175 Political instability: -0.042 Government effectiveness: -0.149	Trade openness, economic growth, rule of law, and regulatory quality have a positive effect on CO_2 emissions while political instability and government effectiveness have a negative effect on CO_2 emissions.
Ibrahim and law (2015)	Role of the institution in a trade-environment relationship.	2000-2010	40 Sub-Sahara African countries	System GMM estimation technique	Trade: 0.0333 Institutional quality: -0.0016 Trade × Institutional quality: -0.0019	Trade openness along with sound institutional quality is necessary for a better environment.

Umer *et al.* (2014)	The effect of trade, and public sector corruption on environment quality	1995-2012	12 Asian developing countries	Pooled ordinary least square (OLS), Fixed effect model (FEM), Random effect model (REM)	Trade: -0.593 Government effectiveness: -0.3039	Trade and government effectiveness have a positive effect on the environment and trade openness generated by government efficiency is beneficial to the environment.
Zafar *et al.* (2013)	Impact of trade liberalization and Corruption on the Environment in the Case of Pakistan	1980-2011	Pakistan	Autoregressive Distributed Lag Model (ARDL)	Trade: -3.020 Trade*Corruption: 1.185	Trade liberalization is beneficial to the environment and open economies are not much influenced by corruption.
Lutz (2012)	The effect of political institutions on the trade-environment relationship	1990 to 2008	African countries	Arellano–Bover system GMM (GMM-SYS) estimator	Trade: 0.008 Trade*Political institutions: -0.001	Trade has a negative effect on CO_2 emissions and better political institutions further enhance this relationship.
Tamazian and Rao (2010)	The relationship between economic growth, financial development, institutional quality, and environment.	1993-2004	24 transition economies	System GMM	Trade: 0.0042 Trade*Institutional quality: −0.0218	Trade has a positive effect on CO_2 emissions. Both financial development and institutional quality have a negative impact on CO_2 emissions.

Comparing the results presented in Table 4.1, it is found that trade openness is harmful to the quality of the environment in 24 transition economies, in Sub-Saharan African countries, and trade openness along with institutional quality is beneficial for the quality of the environment in these countries. In the case of 117 countries, trade openness has a beneficial effect on the quality of the environment and institutional quality further enhances this relationship.

Trade and all indicators of institutional quality boost the environmental quality in MEA (Middle East & Africa) and EU (European Union) countries and 75 countries (All G20 and EU countries) while trade and some indicators of institutional quality are detrimental to the environmental quality and some indicators of institutional quality are advantageous to the environment in Sub-Saharan Africa economies.

4.3 Methodology

4.3.1 Theoretical Framework of the non-linear effect of trade openness on environmental quality

This study aims to find the non-linear effect of trade openness on the quality of the environment by using institutional quality as a threshold variable. High institutional quality emphasizes strict environmental regulation. Then the trade will improve environmental quality because environmentally friendly and energy-efficient goods are imported and exported. On the other hand, lax environmental regulation is emphasized by low institutional quality then the trade is harmful to environmental quality.

4.3.2 Empirical Methodology

4.3.2.1 Model Specification for the importance of institutional quality in trade-environment relation

Threshold describes the nonlinear link between dependent and independent variables. The effect of an independent variable on the dependent variable is different before and after the threshold. Before the threshold, there is one set of coefficients, another set of coefficients between the first and second threshold, and so on.

To consider the different effects of trade openness on carbon emission in the ‗low institutional quality and ‗high institutional-quality regimes, we can depend on the threshold regression applied by Hansen (2000).

$$CO_{it} = \beta_{10} + \beta_{11} TRD_{it} + e_{it} \qquad if\ IQ_{it} < \gamma \qquad (4.1)$$

$$CO_{it} = \beta_{20} + \beta_{21} TRD_{it} + e_{it} \qquad if\ IQ_{it} \geq \gamma \qquad (4.2)$$

Where, IQ_{it} is the threshold variable and γ is the unknown threshold value. TRD_{it} is trade openness and is an explanatory variable. It is expected that β_{11} is positive when ($IQ_{it} < \gamma,$ low institutional quality) and β_{21} is negative when $IQ_{it} \geq \gamma,$ high institutional quality.

Poor institutional quality leads to lax environmental regulations, and strict environmental regulations are implemented due to the high quality of an institution. The scale of production increases due to trade. As a result, emission increases in countries with lax environmental regulations. Technological improvement occurs due to international trade, and environment-friendly goods are produced, especially in countries with strict environmental regulations. It means trade, along with good governance, is beneficial to environmental quality.

In the threshold regression model, the variables' linkages (magnitude, sign, and significances) differ in separate regimes. Threshold regression models are a type of regime-switching model where the slope parameters differ following a regime-switching mechanism, and it depends upon the threshold variable. Threshold regression models are written as follows:

$$CO_{it} = \alpha + \beta_0 TRD_{it} + \beta_1 TRD_{it} f(q_{it}; \gamma) + \epsilon_{it} \qquad (4.3)$$

Where CO_{it} is the dependent variable, TRD_{it} is the independent variable, $\beta_0\ and\ \beta_1$ are coefficient, transition function is $f(q_{it}; \gamma)$, vector of the parameter is $\gamma,$ and the threshold variable is q_{it}. If the transition function is defined as a binary function, then it can be written as:

$$f(q_{it};\gamma) = \begin{cases} 1 & if\ q_{it} \geq c \\ 0 & if\ q_{it} < c \end{cases} \quad (4.4)$$

Model is then simply defined as

$$CO_{it} = \alpha + \beta_0 TRD_{it} + \beta_1 TRD_{it} I_{(q_{it} \geq c)} + \epsilon_{it} \quad (4.5)$$

Where $I(.)$ is stated as the indicator function and the location parameter is c. If the transition function is described as a binary function, then for the slope parameter, there is a regime-switching mechanism that is dependent upon the location parameter and slope variable

$$CO_{it} = \begin{cases} \alpha + (\beta_0 + \beta_1) TRD_{it} + \epsilon_{it} & if q_{it} \geq c \\ \alpha + \beta_0 TRD_{it} + \epsilon_{it} & if\ q_{it} < c \end{cases} \quad (4.6)$$

There are two regimes in this case for slope parameters which are β_0 and $\beta_0 + \beta_1$. The transition function is generally verified as follows:

$$0 \geq f(q_{it};\gamma) \leq 1 \quad (4.7)$$

But sometimes, it takes the form

$$\lim_{q_{it} \to +\infty} f(q_{it};\gamma) = 1 \qquad \lim_{q_{it} \to -\infty} f(q_{it};\gamma) = 0$$

(4.8)

4.3.2.2 Panel Threshold Model:

An analyst develops the threshold model for the non-dynamic panel model with individual-specific fixed effects. The least-square method estimates the thresholds and fixed effect transformation is used for slope regression.

This model is used to find the threshold of a variable whose presence at some level improves the effect of another variable. For example, trade, along with good governance, improves environmental quality. In this study threshold of institutional quality is estimated. The purpose is that trade benefits the environment at what level of institutional quality? The equation of the panel threshold model is as follows:

$$CO_{it} = \mu_{it} + \beta_1 TRD_{it} I(q_{it} \leq \gamma) + \beta_2 TRD_{it} I(q_{it} > \gamma) + {}_1X_{it} + e_{it} \quad (4.9)$$

$$CO_{it} = \mu_{it} + \beta_1 TRD_{it} I(q_{it} \leq \gamma) + e_{it} \qquad \text{where } (q_{it} \leq \gamma) \quad (4.10)$$

$$CO_{it} = \mu_{it} + \beta_2 TRD_{it} I(q_{it} > \gamma) + e_{it} \qquad \text{where } (q_{it} > \gamma) \quad (4.11)$$

if $\beta_1 = \beta_2$ then equation 4.9 becomes

$$CO_{it} = \mu_{it} + \beta_1 TRD_{it} I(\gamma) + e_{it} \quad (4.12)$$

Whereas “TRD” is the trade variable regressing in this study, and “q” is the threshold variable. $(q_{it} \leq \gamma)$ and $(q_{it} > \gamma)$ are two regimes. These regimes are compared on the core of slope parameters β_1 and β_2 in this analysis of threshold. X is another control variable. The threshold variable and regressor are not time-dependent in the non-dynamic panel threshold model. The model about error term assumes that it is identically distributed and independent with zero mean and has finite variance.

The computation of βs takes place through ordinary least squares because the sum of the residual square is minimized by OLS, as recommended by Hassen (1999). In equation 4.9, the threshold variable is q, and the regressor is the trade openness. If there is a single threshold, then the hypothesis for this will be that $\beta_1 = \beta_2$. If the null hypothesis is accepted, there is no threshold, and the model becomes linear. A standard test can be used to test the null hypothesis. If the sum of squared is noted as SSR_0 of the linear model, the likelihood ratio test is written as:

$$F_1 = \frac{SSR_0 - SSR_1(\hat{\gamma})}{\hat{\sigma}^2} \quad (4.13)$$

Where convergent estimates of σ^2 is denoted by $\hat{\sigma}^2$. The major problem is that the threshold parameter is not identified under the null. Therefore, the asymptotic distribution of the F_1 become nonstandard and does not signify Chi-squared distribution. So, one solution to this problem is to use the bootstrap procedure. Original data is resampled in the bootstrap procedure to generate many data sets. The bootstrap procedure's advantage is that different estimators' confidence intervals and standard errors are computed, and more precise results are provided.

There are different steps in the bootstrap procedure. In repetitive bootstrap, the value of the threshold and regressor variables is assumed to be fixed in the first step. Regression residual is used to create a bootstrap sample, and the model is computed by it, and the value of the bootstrap is calculated by the likelihood ratio method. LASSO is used for model selection, and model 34 is selected with minimum BIC values. All those variables are retained in the Lasso regression used in this study.

4.4 Results and Interpretation

4.4.1 Non-linear effect of trade openness on environmental quality (overall data)

This study aims to find the non-linear relationship between trade openness and environmental quality by using one threshold variable (i.e., institutional quality). Threshold values and F-statistics are presented in Table 4.2. When institutional quality is taken as a threshold variable, the point estimate of one threshold for institutional quality is 0.434. The P-value associated with F-statistic is significant at the 1% level and shows that one threshold exists in the relationship between trade openness and the quality of the environment. Then trade is decomposed into scale effect, technique effect, and composition effect. No threshold exists between scale effect and environmental quality when institutional quality is considered a threshold variable. Similarly, when institutional quality is taken as a threshold variable, no threshold is found between technique effect, environmental quality, composition effect, and environmental quality.

Table 4.2: Threshold effect test for environmental pollution (CO_2)

Regime dependent variable	Threshold variable	Threshold effect	F-statistics	P-value	Threshold values
TRD	IQ	Single Threshold	82.350***	0.007	0.434
lnGDP	IQ	No threshold	27.980	0.493	0.114
lnGDPS	IQ	No threshold	28.820	0.433	0.114
lnKLR	IQ	No threshold	36.240	0.273	0.430

Source: Author's calculations. (P < 0.10, ** P < 0.05, *** P < 0.01)*

In this table, GDP shows the scale effect. GDPS represents the technique effect and KLR indicates the composition effect. No threshold is found for these variables.

Table 4.3 indicates the result of the panel threshold model. In column 1, with institutional quality as the threshold variable, one threshold splits institutional quality into two phases: low institutional quality (below 0.4337) and high institutional quality regime (above 0.4337). Trade openness enhances carbon dioxide emission in low institutional quality regimes, reducing carbon dioxide emission in high institutional quality regimes. Pollution-intensive products are produced and exported in the case of lax environmental regulations. With strict environmental regulations, green and energy-efficient technologies are adopted, and less pollution-intensive products are imported. These results correspond to the findings of (Ibrahim & Law, 2016). Scale effect, technique effect, and composition effect do not improve the environmental quality when interacting with institutional quality.

Scale effect positively affects carbon dioxide emissions in columns 1, 3, and 4. The reason is that industrial activities increase as the economy develops. The use of vehicles, appliances, and electric devices rises with income increases and leads to more carbon dioxide emissions. The technique effect improves the environmental quality in columns 1, 2, and 4. Environmentally friendly technology is imported due to trade openness which has an advantageous effect on the environment. The composition effect deteriorates the environmental quality in columns 1, 2, and 3. Because of trade openness, dirty industries are shifted from developed to developing countries. Foreign direct investment positively affects carbon dioxide emission, which verifies the pollution heaven hypothesis in columns 1, 2, 3, and 4. Due to lax environmental regulations in developing countries, polluting industries are attracted by FDI. Education enhances carbon dioxide emissions in columns 1, 2, 3, and 4. Personal skills increase due to education and earnings also increase. An increase in purchasing power and consumption causes environmental degradation.

Institutional quality increases the carbon dioxide emissions in columns 1, 2, 3, and 4. This result is in line with (Abid, 2016). Low institutional quality leads to weak environmental regulation and does not restrict the production companies from using green and energy-efficient technology. Financial development harms environmental quality in columns 1, 2, 3, and 4. It suggests that financial development is used to increase industrial activities rather than improve technology, which aligns with Hunjra *et al.* (2020). Moreover, well-off financial intermediation provides loans to consumers to purchase luxurious goods such as cars, refrigerators, and washing machines that emit carbon dioxide and other dangerous gases.

Table 4.3: Panel threshold regression result

Variables	(1)		(2)		(3)		(4)	
lnGDP	3.507***	(18.89)			3.52***	(18.79)	3.618***	(19.28)
lnGDPS	-0.171***	(-16.94)	-0.175***	(-17.09)			-0.179***	(-17.55)
lnKLR	0.103***	(3.92)	0.133***	(5.03)	0.134***	(5.05)		
TRD			-0.035	(-1.64)	-0.035	(-1.62)	-0.030	(-1.41)
FDI	0.085***	(3.94)	0.092***	(4.23)	0.092***	(4.22)	0.091***	(4.19)
EDU	0.378***	(6.69)	0.365***	(6.39)	0.365***	(6.39)	0.390***	(6.81)
IQ	0.727***	(6.92)	0.345***	(3.30)	0.342***	(3.26)	0.678***	(6.24)
IFD	0.519***	(6.48)	0.535***	(6.60)	0.536***	(6.61)	0.519***	(6.42)
$TRD * I(IQ \leq 0.434)$	0.092***	(3.66)						
$TRD * I(IQ > 0.434)$	-0.099***	(-4.36)						
$lnGDP * I(IQ \leq 0.114)$			3.496***	(18.57)				
$lnGDP * I(IQ > 0.114)$			3.523***	(18.75)				
$lnGDPS * I(IQ \leq 0.114)$					-0.179***	(-17.48)		
$lnGDPS * I(IQ > 0.114)$					-0.175***	(-17.13)		
$lnKLR * I(IQ \leq 0.430)$							0.114***	(4.27)
$lnKLR * I(IQ > 0.430)$							0.146***	(5.52)
Constant	-17.40***	(-20.05)	-16.961***	(-19.28)	-16.98***	(-19.31)	-17.667***	(-20.07)
R-squared	0.7603		0.7560		0.7557		0.7578	
Observations	2261		2261		2261		2261	
Countries	119		119		119		119	
Threshold variables	**IQ**		**IQ**		**IQ**		**IQ**	

Source: Author's work. Values presented in parentheses are t-values, (P<0.10, ** P<0.05, *** P<0.01)*

4.4.2 Non-linear effect of trade openness on environmental quality (developing countries)

Table 4.4 shows threshold values and F-statistics. The P-value associated with F-statistic is significant at the 10% level and shows that one threshold exists in the link between trade openness and environment quality when institutional quality is taken as a threshold variable. The point estimate of one threshold for institutional quality is 0.241. The lower regime represents the value of institutional quality below the threshold, and the upper regime shows the value of institutional quality above the threshold parameter.

Table 4.4: Threshold effect test for developing countries using environmental pollution (CO_2)

Regime dependent variable	Threshold variable	Threshold effect	F-statistics	P-value	Threshold values
TRD	IQ	Single Threshold	36.41*	0.09	0.2401
lnGDP	IQ	Single Threshold	37.320*	0.057	0.089
lnGDPS	IQ	Single Threshold	38.80*	0.0767	0.0887
lnKLR	IQ	No threshold	30.250	0.233	0.089

Source: Author's work. (P<0.10, ** P<0.05, *** P<0.01)*

One threshold is estimated between the sale effect and carbon dioxide emission, technique effect, and carbon dioxide emission when institutional quality is taken as the threshold variable because the P-value associated with F-statistic is significant at the 10% level. No threshold has existed between the composition effect and carbon dioxide emission.

Table 4.5 shows the panel threshold model's result in developing countries' cases. In columns 1, 2, and 3, with institutional quality as the threshold variable, one threshold split institutional quality into two phases, low-level institutional quality, and high-level institutional quality.

Table 4.5: Panel threshold regression result for developing countries

Variables	(1)		(2)		(3)		(4)	
lnGDP	2.504***	(4.87)			2.357***	(4.58)	2.329***	(4.49)
lnGDPS	-0.117***	(-3.76)	-0.107***	(-3.44)			-0.107***	(-3.42)
lnKLR	0.177***	(4.26)	0.205***	(4.89)	0.204***	(4.87)		
TRD			0.205***	(4.17)	0.207***	(4.22)	0.216***	(4.38)
FDI	0.244**	(1.66)	0.284**	(1.93)	0.282**	(1.92)	0.285*	(1.93)
EDU	0.453***	(4.78)	0.520***	(5.51)	0.519***	(5.50)	0.513***	(5.40)
IQ	0.237	(1.19)	0.237	(1.19)	0.230	(1.16)	0.298	(1.50)
IFD	1.005***	(4.54)	1.134***	(5.11)	1.133**	(5.12)	1.101***	(4.95)
$TRD * I(IQ \leq 0.24)$	0.129*	(2.41)						
$TRD * I(IQ > 0.24)$	0.345***	(6.92)						
$lnGDP * I(IQ \leq 0.089)$			2.257***	(4.36)				
$lnGDP * I(IQ > 0.089)$			2.319***	(4.49)				
$lnGDPS * I(IQ \leq 0.089)$					-0.118***	(-3.79)		
$lnGDPS * I(IQ > 0.089)$					-0.109***	(-3.52)		
$lnKLR * I(IQ \leq 0..089)$							0.288***	(6.03)
$lnKLR * I(IQ > 0.089)$							0.196***	(4.65)
Constant	-13.523***	(-6.28)	-12.580***	(-5.80)	-12.745***	(-5.89)	-12.721***	(-5.84)
Observations	741		741		741		741	
R-squared	0.7293		0.7208		0.7209		0.7228	
Number of countries	39		39		39		39	
Threshold variables	**IQ**		**IQ**		**IQ**		**IQ**	

Source: Author's work. Values presented in parentheses are t-values, (P<0.10, ** P<0.05, *** P<0.01)*

In column 1, Trade openness positively affects environmental quality below and after the threshold in developing countries. Scale effect increases carbon dioxide emission before and after the threshold in column 2. The reason is that low institutional quality leads to environmental degradation. The technique effect improves the environmental quality before and after the threshold in column 3.

Scale effect positively impacts carbon dioxide emission in columns 1, 3, and 4. Trade openness and investment bring about more industrialization and worsen the pollution level. Market size upsurges due to trade openness. Firms are a sight on economies of scale due to significant market sizes. The technique effect decreases carbon dioxide emission in columns 1, 2, and 4. Energy-efficient technology is imported because of trade openness. Environmental quality improves due to the increased manufacturing of environmentally friendly goods. The composition effect raises carbon dioxide emissions in columns 1, 2, and 3.

The trade effect positively affects carbon dioxide emission because the scale effect dominates the technique and composition effect. Foreign direct investment and primary school enrolment worsen the environmental quality: institutional quality positively but insignificant effect carbon dioxide emissions. There is a positive and significant link between financial development and air pollution.

4.4.3 Non-linear effect of trade openness on environmental quality (Developed countries)

Table 4.6 shows threshold values and F-statistics. The P-value associated with F-statistic is significant at a 5% level, which shows that one threshold exists between composition effect and environmental quality when institutional quality is taken as the threshold variable. No threshold has existed between trade openness and quality of the environment, scale effect and environmental quality, and technique effect and environmental quality.

Table 4.6: Threshold effect test for developed countries using environmental pollution (CO_2)

Regime dependent variable	Threshold variable	Threshold effect	F-statistics	P-value	Threshold values
TRD	IQ	No Threshold	38.770	0.217	0.306
lnGDP	IQ	No Threshold	35.030	0.260	0.306
lnGDPS	IQ	No Threshold	32.730	0.337	0.306
lnKLR	IQ	Single Threshold	61.530**	0.017	0.306

Source: Author's work. (P<0.10, ** P<0.05, *** P<0.01)*

Table 4.7 shows the panel threshold model's result in developed countries' cases. Trade openness declines carbon dioxide emissions in developed countries when institutional quality is considered a threshold variable (column 1). Scale effect increases carbon dioxide emission (column 2). Technique effect negatively affects carbon dioxide emission (column 3). The composition effect improves environmental quality before and after the threshold (column 4).

Scale effect increases carbon dioxide emission in columns 1, 3, and 4 in developing countries. The technique effect lessens carbon dioxide emission in columns 1, 2, and 4. The composition effect improves environmental quality in columns 1, 2, and 3. Competition is created among domestic producers, who choose energy-efficient techniques to minimize the cost of production.

Trade openness negatively affects carbon dioxide emission in columns 2, 3, and 4. The reason is that the technique effect dominates the scale effect. FDI worsen the environmental quality in column 1, 2, 3, and 4. IQ and IFD boost carbon dioxide emissions in columns 1, 2, 3, and 4.

Table 4.7: Panel threshold regression result for developed countries

Variables	(1)		(2)		(3)		(4)	
lnGDP	3.199***	(10.50)			3.143***	(10.32)	3.394***	(11.130)
lnGDPS	-0.146***	(-9.33)	-0.145***	(-9.25)			-0.155***	(-9.93)
lnKLR	-0.138***	(-3.84)	-0.139***	(-3.86)	-0.137***	(-3.81)		
TRD			-0.223***	(-10.67)	-0.222***	(-10.65)	-0.228***	(-11.01)
FDI	0.068***	(3.92)	0.069***	(4.00)	0.069***	(4.00)	0.066***	(3.88)
EDU	0.065	(0.93)	0.054	(0.77)	0.054	(0.770)	0.070	(1.00)
IQ	0.360***	(3.31)	0.389***	(3.53)	0.385***	(3.49)	0.385***	(3.58)
IFD	0.346***	(4.77)	0.352***	(4.84)	0.355***	(4.89)	0.323***	(4.47)
$TRD * I(IQ \leq 0.0.306)$	-0.061*	(-1.83)						
$TRD * I(IQ > 0.0.306)$	-0.231***	(-11.04)						
$lnGDP * I(IQ \leq 0.306)$			3.185***	(10.44)				
$lnGDP * I(IQ > 0.306)$			3.170***	(10.40)				
$lnGDPS * I(IQ \leq 0.306)$					-0.142***	(-9.09)		
$lnGDPS * I(IQ > 0.306)$					-0.143***	(-9.18)		
$lnKLR * I(IQ \leq 0.306)$							-0.207***	(-5.61)
$lnKLR * I(IQ > 0.306)$							-0.140***	(-3.93)
Constant	-16.177***	(-10.74)	-16.013***	(-10.64)	-15.863***	(-10.54)	-17.209***	(-11.40)
Observations	1520		1520		1520		1520	
R-squared	0.2689		0.2684		0.2681		0.2697	
Number of countries	80		80		80		80	
Threshold variables	**IQ**		**IQ**		**IQ**		**IQ**	

Source: Author's work. Values presented in parentheses are t-values, (P<0.10, ** P<0.05, *** P<0.01*

Trade openness positively affects carbon dioxide emissions before and after the threshold in developing countries while it negatively affects carbon dioxide emissions before and after the threshold in developed countries. The reason is that institutional quality is low and environmental regulation is lax in developing countries. So, polluted goods are imported and produced in developing countries. Institutional quality is high and environmental regulation is strict in developed countries. That‘s why clean products are imported and produced by these countries.

The composition effect is increasing carbon dioxide emission before and after the threshold in developing countries while it decreases carbon dioxide emission before and after the threshold in developed countries. The reason is that developing countries move towards heavy industries and they care little about pollution, while in developed countries, specialization takes place in light manufacturing industries and services.

4.5 Conclusion

This study investigates the non-linear relationship between trade and the environment using the data from 2000 to 2018 for the whole world. The non-dynamic panel threshold model is used to find out the empirical results. Trade increases carbon dioxide emissions before the threshold and reduces carbon dioxide emissions after the threshold when institutional quality is taken as a threshold variable. Scale effect positively impacts carbon dioxide emission. Technique effect reduces carbon dioxide emission. The composition effect increases carbon dioxide emissions.

When institutional quality is considered a threshold variable in developing countries, trade openness increases carbon dioxide emissions before and after the threshold. The scale effect worsens the environmental quality before and after the threshold. The technique effectively reduces carbon dioxide emissions before and after the threshold. The composition effect deteriorates the environmental quality.

When institutional quality is considered a threshold variable in developed countries, trade openness diminishes carbon dioxide emissions. Scale effect rises carbon dioxide emission. Technique effect reduces carbon dioxide emission. The composition effect improves the environmental quality before and after the threshold.

Chapter 5

Conclusion and Policy Implications

The previous three chapters are about different determinants of environmental quality. The second chapter decomposes trade openness into scale, technique, and composition effects. The scale effect raises CO_2 emissions, implying that the environment deteriorates due to economic development in the present environmental policies, but the environment improves in the long run due to the technique effect. Trade liberalizations increase CO_2 emissions. The energy effect deteriorates the environmental quality. The reason is that most energy demands are fulfilled by fossils fuel in the present situation.

Such policies should be adopted which encourage new and updated technological progress. So clean production along with economic growth should be achieved. Imports and the production of dirty products should be discouraged, which deteriorates environmental quality. There is a need to support renewable energy resources to clean the environment. Environmentally friendly and efficient technologies such as low-energy cars, and electrical appliances are used in daily life to reduce the use of energy which is a major cause of pollution.

Scale effect and composition effect increase carbon dioxide emission while technique effect reduces carbon dioxide emission in developing countries. Developing countries should adopt clean and environmentally friendly techniques of production. Environmental laws should be strict in these countries to import only modern and energy-efficient technologies. To make the environment clean, International cooperation is required to share clean technology. Environmental legislation should be incorporated by the government into a trade agreement to promote clean industries and a less polluted economy.

In the third chapter, the EKC hypothesis is existed in all regions (East Asia and the Pacific, the Middle East and North Africa, Europe and Central Asia, South Asia, Latin America, and the Caribbean) but is not found in Sub-Saharan Africa. Moreover, trade has a detrimental effect on Latin America, the Caribbean, East Asia, and the Pacific. FDI increases carbon dioxide emissions in Sub-Saharan Africa, East Asia, the Pacific and the Middle East, and North Africa. Education deteriorates the environmental quality in the Middle East, North Africa, and Sub-Saharan Africa. Financial development improves environmental quality in Latin America and the Caribbean. Institutional quality reduces carbon dioxide emission in Sub-Saharan Africa.

The EKC hypothesis in these regions implies that clean and dirty production occurs at the initial stages of their growth. But after reaching a certain level of development, people of these countries may demand a clean environment, and their governments may impose stricter environmental regulations for more immaculate production. These actions can help to improve the quality of the environment. There is no N-Shaped relation found in these regions. So, these regions should continuously improve their efficiency so that the environmental quality does not deteriorate with further production. To make the environment cleaner, such environmental regulations should be implemented that reduce greenhouse gas emissions. Green energy sources, for instance, wind and solar should be encouraged, and the use of Biodiesel fuel and green investment should be supported.

The EKC does not exist in the Sub-Saharan African region. This means economic growth does not influence carbon emissions in the present situation. So, environmental regulations should be implemented and further developed to prevent air pollution from rising in the future.

Environmental panic should be considered while formulating trade policies in East Asia, the Pacific, Latin America, and the Caribbean. FDI should be environmentally friendly in the Middle East, North Africa, East Asia, the Pacific, and Sub-Saharan Africa. The education system should be improved, and environmental awareness should be induced in Sub-Saharan Africa, the Middle East, and North Africa. Financial development should encourage the purchase of energy-efficient products to keep the environment green and clean in East Asia, the Pacific, Europe, and Central Asia. Institutional quality should be further improved in East Asia and the Pacific, Europe and Central Asia, South Asia, the Middle East, and North Africa.

The last chapter analyses the non-linear effect of trade on environmental quality by using institutional quality as a threshold variable. Trade openness deteriorates the environment in low institutional quality and is favorable to the environment when institutional quality is high. The results are different for developed and developing countries. The trade effect and scale effect deteriorate the environmental quality before and after the threshold, while the technique effect is beneficial for environmental quality before and after the threshold in developing countries. Alternatively, the composition effect negatively impacts carbon dioxide emission in developed countries before and after the threshold.

There is a need for institutional reforms along with trade-led growth in developing countries that improves the quality of the environment and encourages innovations. Developing countries should adopt cleaner technologies to reduce emissions. Scale effect deteriorates the quality of the environment because there is a large share of dirty goods production in GDP. So, developing countries need to modify their composition effect to get the benefit of trade-led growth.

For the whole world, the beneficial effect of trade on the environment is strengthened if institutional reforms are taking place along with trade-led growth policies. Better institutional quality in a country can bring more trade, a better quality of the environment, and growth as well. There is a need for high institutional quality and promoting trade policies for economic development. So strict environmental regulations are implemented, and environmentally friendly technology is adopted. Production process and industrialization are done by considering environmental regulations.

Using the spatial econometric approach, the effect of trade openness on environmental quality is found for the whole world. The effect of trade openness on environmental quality can be found in low, middle, and high-income countries using the same econometric approach. This study finds the non-linear effect of trade openness on environmental quality for the whole world. This work can be extended to different world regions and low, middle, and high-income countries.

References

Abid, M. (2016). Impact of economic, financial, and institutional factors on CO_2 emissions: Evidence from Sub-Saharan Africa economies, *Utilities Policy*, 41, 1-10.

Abid, M. (2017). Does economic, financial and institutional developments matter for environmental quality? A comparative analysis of EU and MEA countries, *Journal of Environmental Management*, 188, 183-194.

Ahmed, K., & Long, W. (2012). Environmental Kuznets curve and Pakistan: An empirical analysis. *Procedia Economics and Finance*, *1*, 4-13.

Ahmed, F., Kousar, S., Pervaiz, A., & Ramos-Requena, J. P. (2020). Financial development, institutional quality, and environmental degradation nexus: New evidence from asymmetric ARDL co-integration approach. *Sustainability*, *12*(18), 7812.

Ali, W., & Abdullah, A. (2015). The long-run relationship between economic growth, financial development, trade openness and CO_2 emission in Malaysia, *2015 International Symposium on Technology Management and Emerging Technologies (ISTMET), August 25 - 27, 2015*, Langkawi, Kedah, Malaysia

Aller, C., Ductor, L., & Herrerias, M. J. (2015). The world trade network and the environment, *Energy Economics*, 52, 55-68.

Al-Mulali, U., & Sheau-Ting, L. (2014). Econometric analysis of trade, exports, imports, energy consumption and CO_2 emission in six regions. *Renewable and Sustainable Energy Reviews*, *33*, 484-498.

Al-Mulali, U., Tang, C. F., & Ozturk, I. (2015). Estimating the environment Kuznets curve hypothesis: Evidence from Latin America and the Caribbean countries. *Renewable and Sustainable Energy Reviews*, *50*, 918-924.

Anastacio, J. A. R. (2017). Economic growth, CO_2 emissions and electric consumption: Is there an environmental Kuznets curve? An empirical study for North American countries. *International Journal of Energy Economics and Policy*, *7*(2), 65-71.

Andreoni, J., & Levinson, A. (2001). The simple analytics of the environmental Kuznets curve. *Journal of Public Economics*, *80*(2), 269-286.

Ansari, M. A., & Khan, N. A. (2021). Decomposing the trade-environment nexus for high income, upper and lower middle-income countries: What do the composition, scale, and technique effect indicate? *Ecological Indicators*, *121*, 107-122.

Antweiler, W., Copeland, B. R., & Taylor, M. S., (2001). Is free trade good for the environment? *American Economic Review,* 91(4), 877–908.

Apergis, N., & Ozturk, I. (2015). Testing environmental Kuznets curve hypothesis in Asian countries. *Ecological Indicators*, *52*, 16-22.

Atici, C. (2012). Carbon emissions, trade liberalization, and the Japan–ASEAN interaction: A group-wise examination. *Journal of the Japanese and International Economies*, *26*(1), 167-178.

Ayeche, M. B., Barhoumi, M., & Hammas, M. A. (2016). Causal linkage between economic growth, financial development, trade openness and CO_2 emissions in European countries. *American Journal of Environmental Engineering*, 6(4), 110-122.

Aye, G. C., & Edoja, P. E. (2017). Effect of economic growth on CO_2 emission in developing countries: Evidence from a dynamic panel threshold model. *Cogent Economics & Finance*, *5*(1), 1379239.

Azhar, U., Khalil, S., & Ahmed, M. H. (2007). Environmental effects of trade liberalisation: a case study of Pakistan. *The Pakistan Development Review*, 46(4), 645-655.

Balaguer, J., & Cantavella, M. (2018). The role of education in the Environmental Kuznets Curve. Evidence from Australian data. *Energy Economics*, *70*, 289-296.

Baek, J., Cho, Y., & Koo, W. W. (2009). The environmental consequences of globalization: A country-specific time-series analysis. *Ecological Economics*, *68*(8-9), 2255-2264.

Beck, T. (2002). Financial development and international trade: Is there a link? *Journal of International Economics*, *57*(1), 107-131.

Bekmez, S., & Ozsoy, F. N. (2016). The relation between environmental pollution and trade: a panel data analysis. *Journal of Agriculture and Environment for International Development (JAEID)*, *110*(1), 57-72.

Bernard, J., & Mandal, S. K. (2015). The impact of trade openness on environmental quality: an empirical analysis of emerging and developing economies. *WIT Transactions on Ecology and the Environment*, *203*, 195-208.

Bernauer, T., & Koubi, V. (2009). Effects of political institutions on air quality. *Ecological Economics*, *68*(5), 1355-1365.

Bommer, R., & Schulze, G. G. (1999). Environmental improvement with trade liberalization. *European Journal of Political Economy*, *15*(4), 639-661.

Borhan, H., Ahmed, E. M., & Hitam, M. (2012). The impact of CO_2 on economic growth in ASEAN 8. *Procedia-Social and Behavioral Sciences*, *35*, 389-397.

Boulatoff, C., & Jenkins, M. (2010). Long-term nexus between openness, income, and environmental quality. *International Advances in Economic Research*, *16*(4), 410-418.

Charfeddine, L., & Khediri, K. B. (2016). Financial development and environmental quality in UAE: Cointegration with structural breaks. *Renewable and Sustainable Energy Reviews*, *55*, 1322-1335.

Chebbi, H. E., Olarreaga, M., & Zitouna, H. (2011). Trade openness and CO_2 emissions in Tunisia. *Middle East Development Journal*, *3*(01), 29-53.

Chen, F., Jiang, G., & Kitila, G. M. (2021). Trade Openness and CO_2 Emissions: The Heterogeneous and Mediating Effects for the Belt and Road Countries. *Sustainability*, *13*(4), 1958.

Chen, Y., Wang, Z., & Zhong, Z. (2019). CO_2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China. *Renewable Energy*, *131*, 208-216.

Cherniwchan, J., (2017). Trade liberalization and the environment: Evidence from NAFTA and U.S. manufacturing", *Journal of International Economics*, 105, 130–149.

Cho, C. H., Chu, Y. P., & Yang, H. Y. (2014). An environment Kuznets curve for GHG emissions: A panel cointegration analysis. *Energy Sources, Part B: Economics, Planning, and Policy*, *9*(2), 120-129.

Cole, M. A. (2004). Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages. *Ecological Economics*, *48*(1), 71-81.

Cole, M. A., & Elliott, R. J. (2003). Determining the trade–environment composition effect: the role of capital, labor and environmental regulations. *Journal of Environmental Economics and Management*, *46*(3), 363-383.

Constantinescu, C. (2014). Valuing interdependence of education, trade and the environment for the achievement of sustainable development, *Procedia - Social and Behavioral Sciences*, 116, 3340–3344.

Dasgupta, S., Laplante, B., Wang, H., & Wheeler, D. (2002). Confronting the environmental Kuznets curve. *Journal of economic perspectives*, *16*(1), 147-168.

Dean, J. M. (2002). Does trade liberalization harm the environment? A new test. *Canadian Journal of Economics/Revue Canadienne D'économique*, *35*(4), 819-842.

Dinda, S. (2005). A theoretical basis for the environmental Kuznets curve. *Ecological Economics*, *53*(3), 403-413.

Dinda, S. (2006). *Globalization and Environment: Can Pollution Haven Hypothesis alone explain the impact of Globalization on Environment?* MPRA Paper No. 50590.

Dong, K., Sun, R., Jiang, H., & Zeng, X. (2018). CO_2 emissions, economic growth, and the environmental Kuznets curve in China: What roles can nuclear energy and renewable energy play? *Journal of Cleaner Production*, *196*, 51-63.

Dou, Y., Zhao, J., Malik, M. N., & Dong, K. (2021). Assessing the impact of trade openness on CO_2 emissions: evidence from China-Japan-ROK FTA countries. *Journal of Environmental Management*, *296*, 113241.

Duy, L. N. (2010). The impact of trade liberalization on the environment in some East Asian countries: An empirical study. *22nd CEA Annual Conference at Oxford University.*

El-Alaoui, A. (2015). What is the relationship between environmental quality, economic growth and free trade? *International Journal of Social Sciences and Education Research*, *3*(1), 124-144.

Elmarzougui, E., Larue, B., & Tamini, L. D. (2016). Trade Openness, Domestic and Foreign Investments, and the Environment. *Modern Economy*, *7*(5), 591-605.

Energy Information Administration. (2004). *International Energy Annual 2002*.

Ertugrul, H. M., Cetin, M., Seker, F., & Dogan, E. (2016). The impact of trade openness on global carbon dioxide emissions: evidence from the top ten emitters among developing countries. *Ecological Indicators*, *67*, 543-555.

Frankel, J. (2008). *Environmental Effects of International Trade*, Sweden's Globalisation Council, Expert report no. 31.

Gale, L. R., & Mendez, J. A. (1998). The empirical relationship between trade, growth and the environment. *International Review of Economics & Finance*, *7*(1), 53-61.

Goel, R.K., Herrala, R., & Mazhar, U. (2013). Institutional quality and environmental pollution: MENA countries versus the rest of the world, *Economic Systems*, 37, 508-521.

Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement. (No. w3914). *National Bureau of Economic Research*.

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The Quarterly Journal of Economics*, *110*(2), 353-377.

Hakimi, A., & Hamdi, H. (2016). Trade liberalization, FDI inflows, environmental quality and economic growth: a comparative analysis between Tunisia and Morocco. *Renewable and Sustainable Energy Reviews*, *58*, 1445-1456.

Harbaugh, W. T., Levinson, A., & Wilson, D. M. (2002). Reexamining the empirical evidence for an environmental Kuznets curve. *Review of Economics and Statistics*, *84*(3), 541-551.

Holtz-Eakin, D., & Selden, T. M. (1995). Stoking the fires? CO_2 emissions and economic growth. *Journal of Public Economics,* 57, 85-101.

Hossain, M. S. (2011). Panel estimation for CO_2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. *Energy Policy*, *39*(11), 6991-6999.

Hosseini, H. M., & Kaneko, S. (2013). Can environmental quality spread through institutions? *Energy Policy*, 56, 312-321.

Hunjra, A. I., Tayachi, T., Chani, M. I., Verhoeven, P., & Mehmood, A. (2020). The moderating effect of institutional quality on the financial development and environmental quality nexus. *Sustainability*, *12*(9), 3805.

Hübler, M. (2017). The inequality-emissions nexus in the context of trade and development: A quantile regression approach, *Ecological Economics*, 134,174-185.

Ibrahim, M. H. & Law, S. H. (2016). Institutional quality and CO_2 emission–trade relations: evidence from Sub-Saharan Africa, *South African Journal of Economics,* 84(2), 323-340.

International Energy Agency (2014). *Capturing the Multiple Benefits of Energy Efficiency: Roundtable on Industrial Productivity and Competitiveness* (Discussion Paper). Paris: International Energy Agency.

IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Jabeen, A. (2015). Is trade liberalization, economic growth, energy consumption good for the environment? *Romanian Journal of Fiscal Policy (RJFP)*, *6*(2), 1-13.

Jalil, A., & Mahmud, S. F. (2009). Environment Kuznets curve for CO_2 emissions: A cointegration analysis for China. *Energy Policy*, *37*(12), 5167-5172.

Jankiewicz, M., & Szulc, E. (2021). Analysis of Spatial Effects in the Relationship between CO_2 Emissions and Renewable Energy Consumption in the Context of Economic Growth. *Energies*, *14*(18), 5829.

Jobert, T., Karanfil, F., & Tykhonenko, A. (2015), Trade and Environment: Further Empirical Evidence from Heterogeneous Panels Using Aggregate Data, GREDEG WP No. 2015-31.

Kang, Y. Q., Zhao, T., & Yang, Y. Y. (2016). Environmental Kuznets curve for CO_2 emissions in China: A spatial panel data approach. *Ecological Indicators*, *63*, 231-239.

Khan, H., Weili, L., Khan, I., & Khamphengxay, S. (2021). Renewable Energy Consumption, Trade Openness, and Environmental Degradation: A Panel Data Analysis of Developing and Developed Countries. *Mathematical Problems in Engineering*, *2021*, 1-13.

Khan, M. A., Islam, M. A., & Akbar, U. (2021). Do economic freedom matters for finance in developing economies: A panel threshold analysis. *Applied Economics Letters*, *28*(10), 840-843.

Kim, D. H., Suen, Y. B., & Lin, S. C. (2019). Carbon dioxide emissions and trade: Evidence from disaggregated trade data. *Energy Economics*, *78*, 13-28.

Kirikkaleli, D., & Kalmaz, D. B. (2020). Testing the moderating role of urbanization on the environmental Kuznets curve: empirical evidence from an emerging market. *Environmental Science and Pollution Research*, *27*(30), 38169-38180.

Le, T. H., Chang, Y., & Park, D. (2016). Trade openness and environmental quality: International evidence. *Energy Policy*, *92*, 45-55.

Lee, C. C., Chiu, Y. B., & Sun, C. H. (2010). The environmental Kuznets curve hypothesis for water pollution: Do regions matter? *Energy Policy*, *38*(1), 12-23.

Li, S., Zhang, J. & Ma, Y. (2015). Financial development, environmental quality and economic growth, *Sustainability*, *7*, 9395-9416.

Li, Z., Xu, N. & Yuan, J. (2015). New evidence on trade-environment linkage via air visibility, *Economics Letters*, 128, 72-74.

Li, W., Qiao, Y., Li, X., & Wang, Y. (2022). Energy consumption, pollution haven hypothesis, and environmental Kuznets curve: examining the environment–economy link in belt and road initiative countries. *Energy*, *239*, 122559.

Li, B., & Haneklaus, N. (2022). Reducing CO_2 emissions in G7 countries: The role of clean energy consumption, trade openness and urbanization. *Energy Reports*, *8*, 704-713.

Lin, F. (2017). Trade openness and air pollution: City-level empirical evidence from China. *China Economic Review*, *45*, 78-88.

Ling, C. H., Ahmed, K., Muhamad, R. B., & Shahbaz, M. (2015). Decomposing the trade-environment nexus for Malaysia: what do the technique, scale, composition, and comparative advantage effect indicate? *Environmental Science and Pollution Research*, *22*(24), 20131-20142.

Liu, X. (2021). The impact of renewable energy, trade, economic growth on CO_2 emissions in China. *International Journal of Environmental Studies*, *78*(4), 588-607.

Loibikiene, G. & Butkus, M. (2019). Scale, Composition and Technique effect through which economic growth, foreign direct investment, urbanization and trade affect greenhouse gas emissions. *Renewable Energy*, 132, 1310-1322.

Löschel, A., Rexhäuser, S., & Schymura, M. (2013). Trade and the environment: An application of the WIOD database. *Chinese Journal of Population Resources and Environment*, *11*(1), 51-61.

Lutz, M. B. (2012). Trade and environmental quality in African countries: do institutions matter? *International Centre for Economic Research*, Working Paper No. 14/2012

Majeed, M. T., & Mazhar, M. (2021). An empirical analysis of output volatility and environmental degradation: A spatial panel data approach. *Environmental and Sustainability Indicators*, *10*, 100104.

Managi, S. (2012). *Trade, Economic Growth and Environment*, IDE discussion paper no. 342.

Mavragani, A., Nikolaou, I. E., & Tsagarakis, K. P. (2016). Open economy, institutional quality, and environmental performance: A Macroeconomic Approach. *Sustainability*, *8*(7), 601.

Mehrara, M. (2014). The Relationship between GDP, Globalization and Environment. *International Journal of Applied Economic Studies*. 2(3), 1-6.

Mousavi, S. K. (2015). The effect of trade liberalization on the quality of the environment in both developed and developing countries. *Indian Journal of Fundamental and Applied Life Sciences, 5,* 2894-2902.

Nasir, M., & Rehman, F. U., (2011). Environmental Kuznets curve for carbon emissions in Pakistan: An empirical investigation. *Energy Policy*, 39(3), 1857-1864.

Nguyen, V. T. (2020). The role of foreign direct investment and trade on environmental quality in Vietnam. *The Journal of Asian Finance, Economics, and Business*, *7*(3), 289-294.

Nguyen, C. P., Schinckus, C., Su, T. D., & Chong, F. H. L. (2021). The energy consumption: the global contributions from financial development and institutions. *Environmental Science and Pollution Research*, 1-20.

OECD (1999). *Environmental Data Compendium 1999*, OECD, Paris.

Oh, J. & Yun, C. (2014). Environment Kuznets Curve revisited with special reference to Eastern Europe and Central Asia, *International Area Studies Review*, 17, 359-374.

Omri, A., Daly, S., Rault, C., & Chaibi, A. (2015). Financial development, environmental quality, trade and economic growth: What causes what in MENA countries, *Energy Economics*, 48, 242-252.

Ozatac, N., Gokmenoglu, K. K., & Taspinar, N. (2017). Testing the EKC hypothesis by considering trade openness, urbanization, and financial development: the case of Turkey. *Environmental Science and Pollution Research*, 24(20), 16690-16701.

Özokcu, S., & Özdemir, Ö. (2017). Economic growth, energy, and environmental Kuznets curve. *Renewable and Sustainable Energy Reviews*, *72*, 639-647.

Palamalai, S., Ravindra, I. S., & Prakasam, K. (2015). Relationship between energy consumption, CO_2 emissions, economic growth and trade in India. *Journal of Economic & Financial Studies*, 3(2), 1-17.

Panayotou, T. (1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development. (No. 238). *International Labour Organization*.

Pata, U. K. (2018). The influence of coal and noncarbohydrate energy consumption on CO_2 emissions: Revisiting the environmental Kuznets curve hypothesis for Turkey. *Energy*, *160*, 1115-1123.

Perroni, C., & Wigle, R. M. (1994). International trade and environmental quality: how important are the linkages? *Canadian Journal of Economics*, 27 (3), 551-567.

Pethig, R. (1976). Pollution, welfare, and environmental policy in the theory of comparative advantage. *Journal of Environmental Economics and Management, 2*(3), 160-169.

Rabbi, F., Akbar, D., & Kabir, S. Z. (2015). Environment Kuznets curve for carbon emissions: A cointegration analysis for Bangladesh. *International Journal of Energy Economics and Policy*, *5*(1), 45-53.

Rahman, M. M., & Vu, X. B. (2020). The nexus between renewable energy, economic growth, trade, urbanisation and environmental quality: a comparative study for Australia and Canada. *Renewable Energy*, *155*, 617-627.

Rahman, M. M., & Alam, K. (2022). CO_2 Emissions in Asia–Pacific Region: Do Energy Use, Economic Growth, Financial Development, and International Trade Have Detrimental Effects? *Sustainability*, *14*(9), 5420.

Ren, S., Yuan, B., Ma, X., & Chen, X. (2014). International trade, FDI (foreign direct investment) and embodied CO_2 emissions: A case study of China's industrial sectors. *China Economic Review*, *28*, 123-134.

Saboori, B., Sulaiman, J., & Mohd, S. (2016). Environmental Kuznets curve and energy consumption in Malaysia: A cointegration approach. *Energy Sources, Part B: Economics, Planning, and Policy*, *11*(9), 861-867.

Samreen, I., & Majeed, M. T. (2020). Spatial econometric model of the spillover effects of financial development on carbon emissions: A global analysis. *Pakistan Journal of Commerce and Social Sciences (PJCSS)*, *14*(2), 569-202.

Sarkodie, S. A., & Strezov, V. (2019). Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. *Science of the Total Environment*, *646*, 862-871.

Selden, T. M., & Song, D. (1994). Environmental quality and development: is there a Kuznets curve for air pollution emissions? *Journal of Environmental Economics and Management*, *27*(2), 147-162.

Shafik, N., & Bandyopadhyay, S. (1992). Economic growth and environmental quality: time-series and cross-country evidence (904). *World Bank Publications*.

Shahab, M. R. & Nasersadrabadi, S. M. (2014). The study of the effects of economic openness on environmental quality in selected countries, *Indian Journal of Scientific Research,* 1(1), 375-379.

Shahbaz, M., Lean, H. H., & Shabbir, M. S. (2012). Environmental Kuznets curve hypothesis in Pakistan: Cointegration and Granger causality. *Renewable and Sustainable Energy Reviews*, *16*(5), 2947-2953.

Shahbaz, M., Mallick, H., Mahalik, M. K., & Loganathan, N. (2015). Does globalization impede environmental quality in India? *Ecological Indicators*, *52*, 379-393.

Shahbaz, M., Ozturk, I., Afza, T., & Ali, A. (2013). Revisiting the environmental Kuznets curve in a global economy. *Renewable and Sustainable Energy Reviews*, *25*, 494-502.

Shahbaz, M., Shahzad, S. J. H., Ahmad, N., & Alam, S. (2016). Financial development and environmental quality: The way forward. *Energy Policy*, *98*, 353-364.

Shao, Q. (2020). Nonlinear effects of marine economic growth and technological innovation on marine pollution: panel threshold analysis for China's 11 coastal regions. *Marine Policy*, *121*, 104110.

Siebert, H. (1977). Environmental quality and the gains from trade. *Kyklos*, *30*(4), 657-673.

Tamazian, A., & Rao, B. (2010). Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies, *Energy Economics,* 32, 137–145.

Tamazian, A., Chousa, J. P. & Vadlamannati, K. C. (2009). Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries, *Energy Policy*, 37, 246-253.

Tang, D., Li, S., Yang, Y., & Gu, L. (2020). Regional difference in spatial effects: A theoretical and empirical study on the environmental effects of FDI and corruption in China. *Discrete Dynamics in Nature and Society*, 2020. 1-12.

Tayebi, S. K., & Younespour, S. (2012). The effect of trade openness on environmental quality: evidence from Iran's trade relations with the selected countries of the different blocks. *Iranian Economic Review*, 16(32), 19-40.

Umer, F., Khoso, M., & Alam, S. (2014). Trade openness, public sector corruption, and environment: a panel data analysis for Asian developing countries, *Journal of Business & Economic Policy,* 1(2), 39-51.

Vishuphong, P., (2015). Rethinking the relationship between international trade and environment: Thailand as a case study, *Forum of International Development Studies*. 45 (4), 63-80.

Wang, Q., Wang, X., & Li, R. (2022). Does urbanization redefine the environmental Kuznets curve? An empirical analysis of 134 Countries. *Sustainable Cities and Society*, *76*, 103382.

Winslow, M. (2005). Is democracy good for the environment? *Journal of Environmental Planning and Management*, 48(5), 771–783.

Wu, J., Li, S. & Samsell, D. (2012). Why some countries trade more, some trade less, some trade almost nothing: The effect of the governance environment on trade flows, *International Business Review*, 21, 225–238.

Yang, W. P., Yang, Y., & Xu, J. (2008). The impact of foreign trade and FDI on environmental pollution. *China-USA Business Review*, *7*(12), 1-11

Yasmeen, R., Li, Y., Hafeez, M., & Ahmad, H. (2018). The trade-environment nexus in light of governance: a global potential. *Environmental Science and Pollution Research*, *25*(34), 34360-34379.

Zafar, F., Anwar, S., Hussain, Z., & Ahmad, N. (2013). Impact of trade liberalization and corruption on environmental degradation in Pakistan. *Journal of Finance and Economics*, *1*(4), 84-89.

Zafar, M. W., Saleem, M. M., Destek, M. A., & Caglar, A. E. (2022). The dynamic linkage between remittances, export diversification, education, renewable energy consumption, economic growth, and CO_2 emissions in top remittance-receiving countries. *Sustainable Development*, *30*(1), 165-175.

Zakaria, M., & Bibi, S. (2019). Financial development and environment in South Asia: the role of institutional quality. *Environmental Science and Pollution Research*, *26*(8), 7926-7937.

Zambrano-Monserrate, A., & Ruano, M. A. (2018). Testing environmental Kuznets curve hypothesis in Peru: The role of renewable electricity, petroleum and dry natural gas. *Renewable and Sustainable Energy Reviews*, *82*, 4170-4178.

Zhang, J., Zhang, K., & Zhao, F. (2020). Spatial effects of economic growth, energy consumption and environmental pollution in the provinces of China—An empirical study of a spatial econometrics model. *Sustainable Development*, *28*(4), 868-879.

Ziaei, S. M. (2015). Effects of financial development indicators on energy consumption and CO_2 emission of European, East Asian and Oceania countries, *Renewable and Sustainable Energy Reviews*, 42, 752–759.

Zuo, H., Ai, D., & Lin, Y. (2017). Foreign trade and pollution: the case of South China water quality. In *IOP Conference Series: Earth and Environmental Science*, 52(1), 1-7, IOP Publishing.

Appendix-A: List of countries in six regions of the world

Name of the Region	Region Code	Number of Countries	Name of Countries
Latin America and the Caribbean	1	21	Argentina, Brazil, Bolivia, Canada, Chile, Costa Rica, Colombia, El Salvador, Dominican Republic, Ecuador, Guatemala, Jamaica, Honduras, Mexico, Peru, Paraguay, Panama, Suriname, Uruguay, United States, Venezuela, RB
Europe and Central Asia	2	44	Albania, Austria, Armenia, Azerbaijan, Belarus, Bulgaria, Cyprus, Belgium, Croatia, Denmark, Czech Republic, Estonia, France, Finland, Germany, Georgia, Greece, Hungary, Ireland, Iceland, Italy, Kyrgyz Republic, Kazakhstan, Luxembourg, Latvia, Lithuania, Moldova, Norway, Netherlands, Portugal, Poland, Russian Federation, Romania, Slovak Republic, Serbia, Spain, Slovenia, Switzerland, Sweden, Turkey, Tajikistan, Ukraine, Uzbekistan, United Kingdom.
East Asia and the Pacific	3	14	Australia, Brunei Darussalam, China, Cambodia, Indonesia, Japan, Korea, rep., Mongolia, Malaysia, Myanmar, New Zealand, Philippines, Thailand, Vietnam
The Middle East and North Africa	4	16	Algeria, Egypt, Arab Rep., Bahrain, Israel, Jordan, Iran, Islamic Rep., Lebanon, Kuwait, Morocco, Malta, Oman, Qatar, Tunisia, Saudi Arabia, United Arab Emirates, Yemen, rep.
South Asia	5	5	Bangladesh, India, Nepal, Pakistan, Sri Lanka
Sub-Saharan Africa	6	22	Angola, Botswana, Benin, Congo, Cote d'Ivoire, Cameroon, Dem. Rep., Congo, Rep., Ethiopia, Ghana, Kenya, Mozambique, Mauritius, Niger, Namibia, Nigeria, South Africa, Senegal, Sudan, Togo, Tanzania, Uganda, Zambia