NEAR EAST UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

DEPARTMENT OF BANKING AND FINANCE

INFLUENCE OF ECONOMIC GROWTH, TECHNOLOGY, ENERGY, AND TAX REVENUE IN THE SWITZERLAND: EVIDENCE FROM ARDL MODEL

MSc. THESIS

MICHELLE PAIDAMOYO MASUNDA

NICOSIA

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APPROVAL

We certify that we have read the thesis submitted by **MICHELLE PAIDAMOYO MASUNDA** titled **"INFLUENCE OF ECONOMIC GROWTH, TECHNOLOGY, ENERGY, AND TAX REVENUE IN THE SWIZERLAND: EVIDENCE FROM ARDL MODEL"** and that in our combined opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Social Sciences.

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Declaration

I hereby declare that all information presented in this thesis, "**INFLUENCE OF ECONOMIC GROWTH, TECHNOLOGY, ENERGY, AND TAX REVENUE IN THE SWIZERLAND: EVIDENCE FROM ARDL MODEL"** was collected, analyzed, and presented in accordance with all academic rules and ethical guidelines of the Institute of Graduate School, Near East University. I further declare that, to the best of my abilities, any supplementary resources utilized in the preparation of this thesis are adequately cited, acknowledged, and referenced.

MICHELLE PAIDAMOYO MASUNDA

…..../……/2023

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MICHELLE PAIDAMOYO MASUNDA

Abstract

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Several factors have the potential to affect the quality of the environment. Since environment has the potential to have substantial consequences on habitats and the people who live in it, it is essential to have a good understanding of what causes the environmental damage and how their effects may be mitigated. Therefore, this research study employed Autoregressive Distributed Lag (ARDL) model on the data spanning from 1990 to 2020, in the case of the Switzerland to understand the effect of technological innovation, renewable energy, economic growth, trade, and tax revenue on the environmental quality. The outcomes of ARDL reveals that in long-run technological innovation, renewable energy, and tax revenue have positive influence on the environmental quality. However, economic growth and trade harms the Switzerland environment. Additionally, this research study reveals that in short run technological innovation and tax revenue plays major role to enhance the environmental quality, whereas, renewable energy and economic growth shows negative pattern. Based on the results, this research has recommended potential policy recommendations and suggestions to the policymakers, environmentalists, economists, and government authorities of Switzerland.

Keywords: Climate change, Autoregressive distributed lag (ARDL) model, Technology, Renewable energy, economic growth, Tax revenue, Switzerland

Özet

İSVİÇRE'DE EKONOMİK BÜYÜME, TEKNOLOJİ, ENERJİ VE VERGİ GELİRİNİN ETKİSİ: ARDL MODELİNDEN KANITLAR

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HAZİRAN 2023, Sayfa 81

Çeşitli faktörler çevrenin kalitesini etkileme potansiyeline sahiptir. Çevre, habitatlar ve içinde yaşayan insanlar üzerinde önemli sonuçlar doğurma potansiyeline sahip olduğundan, çevresel hasara neyin neden olduğunu ve etkilerinin nasıl azaltılabileceğini iyi anlamak önemlidir. Bu nedenle, bu araştırma çalışması, teknolojik yeniliğin, yenilenebilir enerjinin, ekonomik büyümenin, ticaretin ve vergi gelirinin çevre kalitesi üzerindeki etkisini anlamak için İsviçre ekonomisi söz konusu olduğunda, 1990'dan 2020'ye kadar uzanan veriler üzerinde Otoregresif Dağıtılmış Gecikme (ARDL) modelini kullanmıştır. ARDL'nin sonuçları, uzun vadeli teknolojik yeniliklerde, yenilenebilir enerjinin ve vergi gelirlerinin çevre kalitesi üzerinde olumlu bir etkiye sahip olduğunu ortaya koymaktadır. Bununla birlikte, ekonomik büyüme ve ticaret İsviçre ortamına zarar vermektedir. Ek olarak, bu araştırma çalışması, kısa vadede teknolojik yenilik ve vergi gelirinin çevre kalitesini artırmada önemli rol oynadığını, oysa yenilenebilir enerji ve ekonomik büyümenin olumsuz bir model gösterdiğini ortaya koymaktadır. Sonuçlara dayanarak, bu araştırma İsviçre'nin politika yapıcılarına, çevrecilerine, ekonomistlerine ve hükümet yetkililerine potansiyel politika önerileri ve önerileri önermiştir.

Anahtar Kelimeler: İklim değişikliği, Otoregresif dağıtılmış gecikme (ARDL) modeli, Teknoloji, Yenilenebilir enerji, ekonomik büyüme, Vergi gelirleri, İsviçre

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CHAPTER I
Introduction

1.1. Background of the study

Global warming and climate change are the result of human activity dating back to the Industrial Revolution. The global temperature has dramatically increased, glaciers have melted, there have been significant floods events, violent storms at sea, and food yields have decreased. A commonly accepted climate change policy is to increase the share of renewable energy (RNE). Without government and private support, the price of renewable energy projects is excessively high. A financial sector that is dynamic and efficient can provide adequate funding for RNE installations. Utilizing carbon-free products and procedures, green technological advances reduce greenhouse gas emissions. Green technology can aid in the production of RNE sources.

Human use of natural resources causes stress on ecosystems, which in turn contributes to modern concerns. This has prompted ecologists and economists all over the world to stress the importance of a worldwide movement toward environmental protection. As the number of direct and indirect human activities rises, so does concern about the environment's reactions to changes in population, energy use, economic growth, and other critical factors (Alola, 2019). To wit: (Emir & Bekun, 2019). Ecological accounting, in the form of the EF and the LCF, has been widely acknowledged as a complement to traditional accounting for ecological quality based on carbon emissions (mostly CO2). In lieu of releasing greenhouse gases, we do this instead. It is highly recommended that a “sustained effort be made toward reducing the pressure on the global ecological carrying capacity in light of the importance of the Intergovernmental Panel on Climate Change (IPCC) report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems" (IPCC, 2017). Governments, environmentalists, and policymakers continue to worry about the consequences because of the growth of major economies like the China's and other European nations' economies.

The ambition to attain ecological sustainability has resulted in the formation of several projects and aspects that have proven successful in generating carbon-free or ecosystem-beneficial growth. There are numerous potential environmental influences, but technology innovation is deemed important owing to three-fold reasons (Panait et al., 2022). To begin with, the growth theories place a strong emphasis on the role that technical advancement plays in overcoming development constraints. The roles that technology plays in addressing issues that are related to growth theory can be extrapolated from the challenges and difficulties that are brought to the ecosystem by population expansion. To achieve this goal, technological advancements make it possible for economic progress to occur with minimal to no impact on the environment. Recent decades have seen a huge increase in investment in creating novel technologies. In order to learn whether patents on environmental technologies affect CO2 emissions, energy supply, economic growth, and commercial freedom in Spanish, Empirical studies were conducted by Oyebanji et al. The nonlinear ARDL shows a long-term relationship between pollution outputs, patents protecting those outputs, economic expansion, and freer trade. Less frequent patenting of environmentally beneficial innovations results in increased pollution, while more frequent patenting of such innovations results in reduced emissions of greenhouse gases. When trade liberalization increases, environmental emissions rise, and when they decrease, emissions decrease. The study confirms that there are serious environmental costs associated with EG in Spain.

The importance of the link between tax income and environmental degradation has been highlighted by recent studies. Much research has investigated the negative and positive effects of tax revenue on ecological degeneration through several mechanisms. Given that the rate of environmental degradation is strongly influenced by government spending (Abbass et al., 2022). Spending on health and education has been hypothesized to put pressure on governments to invest in environmental protection through taxation. It is believed that consumption-driven expenditures lead to ecological degradation. Tax collection-a weapon of fiscal policy is important for preventing environmental degradation as it is for current account balance and EG. In addition to this, decreases in the budget deficit led to a rise in the rate of capital accumulation, as well as an increase in the demand for energy and overall economic activity. (Halkos & Paizanos, 2016) analyzed data from 1973 to 2013 and found that the adoption of expansionary fiscal expenditure can lower emissions of both types of pollution, whereas deficit financed tax cuts are associated with an increase in consumption-driven CO2 emissions. Their research was based on the findings that expansionary fiscal expenditure can lower emissions of both types of pollution. Using the G7 nations as a sample, time-varying methods were utilized to probe the connection amongst monetary policy and CO2 emissions from the years 1875 to 2016.

The authors presented evidence that there is a temporal causal link between variations in CO_2 emissions and changes in government spending. Except for Canada, the association between GDP and CO_2 levels has remained stable and unaltered over the course of time. In a similar vein, examined the connection between monetary policy and sectoral-based CO_2 emissions in BRI economies using data ranging from the years 2000 to 2018. According to the findings, there is a meaningful connection between variables such as GDP per capita, fiscal policy instruments, CO_2 emissions, and foreign direct investment in the transportation and electrical sectors. In addition, it has been demonstrated that increasing public spending is a more effective technique for cutting down on CO_2 emissions in the BRI region.

The effects of nuclear and renewable energy sources on economies were compared to the carbon dioxide emissions of the world's 10 top polluters by Dar et al. (2022). By using FMOLS and a heterogeneous panel causality modeling methodology, two panels examined GDP and CO_2 emissions separately from 1990 to 2014. It is also difficult to determine what role natural gas plays in explaining the slowing economy and the reduction in CO_2 emissions. Experiments showed that when the government backed nuclear power and manipulated RNEs, emissions went down, and GDP went up. Increased CO_2 emissions and EG are linked to natural gas use even soon. Al-mulali and Binti (2015) looked into the impacts of CO_2 emissions and RNE use on GDP and the development of the financial sector. Thirty countries in Sub-Saharan Africa had their economies examined for this research. All the way from 1980 to 2008, they are the years that were used in the panel study. The study showed that long-term energy consumption and growth were strongly associated. This was the finding of both empirical studies. Since immediate EC boosted EG and GDP, these countries may profit from increasing their energy productivity by adopting energy conservation efforts, limiting their energy consumption. This is because immediate energy consumption boosted economic growth. Empirical research was conducted using data for Greece from 1990 to 2019 to examine the consequences of production deregulation on the environment, considering trade liberalization, GDP growth, and the usage of renewable energy sources. Using non-linear ARDL methods, they analyzed these dynamics. The NARDL model identified a temporal correlation between variables. The NARDL limits test indicates that the carbon dioxide output and regressors are cointegrated, which is the main finding of the study.

1.2. Problem Statement

Concern for the world's ecosystem is high on the list of worries for those who work in environmental advocacy and conservation. Once limited to the environment, these problems have now spread to other areas, leading to environmental catastrophes including unusually severe weather and rising sea levels (Munir et al., 2020). The world's attention in the previous two decades has been focused on the stern problem of GHGs. The United governments is just one of many international bodies that has attempted to draft legally enforceable treaties between governments to mitigate climate change's worst impacts (Romero & Gramkow, 2021).

Recent years have been a flurry of research into what factors towards EF (Destek and Sinha 2020). However, focusing just on EF to gauge environmental sustainability ignores the supply side of the natural world. Therefore, a more accurate method is to do an analysis of EF and biocapacity simultaneously and make suggestions for achieving the SDGs. Considering both the supply and demand of nature, Shang et al. (2022) recently adopted the LCF, which claims that EF analysis alone is insufficient for environmental evaluation. The LCF, which can be computed as biocapacity/EF, is the most complete index of EQ available today (Pata 2021). A LCF larger than "1" suggests that biocapacity is greater than EF and that there are sufficient natural resources for environmental sustainability. A LCF below "1" indicates that a country's ability to maintain a healthy environment is threatened. The LCF literature is just getting started, but there are still many countries like Switzerland that haven't been studied.

In 2015, Switzerland became one of the countries to sign and later ratify the Paris Agreement. First and foremost, under the terms of the Paris Agreement, all nations are required to cut the amount of CO2 in the atmosphere. The primary overarching goals are to improve adaptability to climate change, make financial flows consistent with low-greenhouse gas development, and limit global warming to well below 2 degrees Celsius compared to the pre-industrial era. The maximum increase in temperature that is being targeted is 1.5 degrees Celsius. Switzerland is eager to contribute toward the accomplishment of these objectives. As was announced in 2019, the Federal Council is working toward the goal of reducing greenhouse gas emissions to the point where they are net zero by the year 2050. This indicates that by the year 2050, Switzerland should have eliminated the production of any greenhouse gas emissions altogether. As a result, Switzerland will decrease its use of fossil fuels to an absolute minimum, reduce its emissions of greenhouse gases to the greatest extent practicable, and offset any leftover emissions by the creation of negative emissions. Negative emissions technologies, also known as NET, are man-made or naturally occurring processes that permanently remove carbon dioxide from the atmosphere and store it somewhere. Moreover, Switzerland is dedicated to ensuring that national and international financial flows are compatible with environmental sustainability.

Switzerland believes that fossil fuels will dominate the energy market for a long time to come. Realizing that fossil fuels are a major source of pollution, Switzerland has begun investing heavily in renewable and nuclear energy (RNE) and energy infrastructure (Paramati et al. 2022). The share of RNE sources in the OECD countries' overall energy mix hit a record 11% in 2018, up from 6% in 1990 (Mujtaba et al. 2022). However, in OECD countries like Switzerland, where industrial sectors dominate the main economic activities and consume the largest share of fossil fuels, fossil fuel use appears to be the primary driver of economic development. There is a negative impact on Switzerland's ability to maintain environmental sustainability since more than 80% of its energy comes from fossil fuels. Approximately 35% of global CO2 emissions from energy use are attributable to OECD countries, according to a study published by the OECD in 2021. Researching the impact of RNE sources, technological innovation (TI), EG, tax income, and trade on Switzerland's LCF is crucial considering the country's high levels of environmental pollution and usage of fossil fuels.

Many studies have been done to try to figure out the effect that a variety of variables has on carbon emissions (Yuping et al., 2021). Carbon emission is only responsible for a large part of GHGs, which is insufficient to explain and evaluate the overall deterioration of the environment (Akinsola, 2022). However, several researchers Kirikkaleli (2021) have claimed EF is a more thorough measurement for the deterioration of the environment. Nonetheless, to account for EFs, two metrics are required: EFs and biocapacity. This assessment considers a variety of different components of the ecosystem. EFs consider the demand side of nature, whereas biocapacity considers the supply side. There have been a lot of studies that have looked at how different factors affect an EF Kirikkaleli et al. (2021) but most of them have forgotten to look at the supply side (biocapacity). Because of this, there is a pressing requirement to design an evaluation that is more appropriate and dependable for determining the quality of the environment. According to Fareed et al. (2021), the LCF is supposed to reflect a country's ability to maintain its population in compliance with the modern lifestyles that they lead. The LCF can be calculated by dividing the supply side, which is referred to as the biocapacity, by the demand side, which is referred to as the EF. When the load capacity is less than 1, the status of the ecosystem is unsustainable, and when the load capacity is greater than 1, the state of the ecosystem is sustainable. As a direct consequence of this, the threshold for sustainable development is equal to one. The argument that was presented before is based on the notion that LCF is a more thorough assessment than carbon emissions and the EF. Considering this, the goal of this present study is to investigate the effect of non-RNE, TI, EG, tax revenue, and trade on LCFs in the context of Switzerland.

1.3. Purpose of the study

Human activities, such as industrial development, carbon emissions, GHGs, and natural calamities such as downpours, hurricanes, famines, rising temperatures, and spirits, are the main factors contributing to ecological decline in the contemporary world. The demand for necessities such as food, clothing, and shelter increases proportionally to a society's population. RNE eradicates the problem of GHGs and the reduction of certain methods of air pollution, the increase of energy diversification, and the reduction of reliance on smuggled petroleum. RNE preserves natural resources.

Utilization of RNE sources benefits society, industry, and the environment. Switching to RNE is one of the most effective methods to reduce the planet's impact. Producing electricity from renewable sources has fewer negative environmental effects. RNE sources can generate electricity without emitting CO2, carbon dioxide is the primary greenhouse gas that has caused our planet to warm and demands thinking about how unsustainable development contributes to poverty. Therefore, UNEP (2012) suggests including disaster risk reduction and resilience building in all sustainable goal-setting initiatives. To resolve environmental issues and accomplish ecological goals in Switzerland, this academic study examines the impact of TI, RNE, EG, tax revenue, and trade on LCF.

1.4. Research Questions

1. What is the impact of TI on LCF?
2. What is the impact of RNE on LCF?

3. What is the impact of EG on LCF?
4. What is the impact of tax revenue on LCF?
5. What is the impact of trade affects LCF?

1.5. Statement of Hypotheses

Following hypotheses are proposed based on the discussion: improving TI, increasing RNE use, expanding EG, appropriately investing tax revenue and sustainable trade can improve LCF.

H1: TI has a significant influence on LCF.
H2: EG has a significant impact on LCF.
H3: RNE has a significant influence on LCF.
H4: LCF is significantly influenced by tax revenue.
H5: Trade has a significant impact on LCF.

1.6. Significance of the study

It is widely held that industrialization, increased economic activity, the use of non-RNE resources, and intensive commerce are major contributors to the degradation of ecosystems in many countries. Economic growth is a long-term answer to environmental deterioration in nations with high and upper middle incomes, but the converse is true in countries with poor and lower middle incomes. In addition, studies show that individuals from all walks of life understand that their energy choices influence the environment. What impact rising consumption of EG and RNE has on Switzerland's efforts to deregulate the environment. No studies have been done before this on the effects of RNE, TI, EG, tax revenue, or trade on LCF in Switzerland, until now. This study adds to the growing body of evidence connecting EG with an increased reliance on RNE sources. The results would provide interesting insights for all Swiss citizens. Economic expansion and the absorption of RNE sources into LCFs are both affected by the knowledge they give.

1.7. Scope of The Study

The erudite work explores the effect of RNE, TI, EG, tax revenue, trade on LCF in the context of Switzerland. This investigation is poised to investigate the relationship between RNE and LCF since it is important to examine this connection in developed country such as Switzerland. Moreover, Switzerland occupies first slot on TI index for the 12th consecutive year. Therefore, it is pertinent to check the influence of TI on LCF in Switzerland and would provide novel insights in this regard. Lastly, the nexus among EG, RNE and LCF is also necessary to comprehend comprehensively in the perspective of Switzerland. Thus, the impact of RNE, TI, EG, tax revenue, trade on LCF in the context of Switzerland has never been investigated. Thus, there is an opportunity to address this literature gap which will provide several policy implications for practitioners and academics.

1.8. Contribution of Study:

This research thesis contributes the existing body of Knowledge in four folds: First this is the first study to investigate the role of green energy, green technology, and tax review in the contest of Switzerland. Before this study, none of them have considered the tax review effect on the environment of the Switzerland (Yuping et al., 2021). Secondly, Investigation into the impact that a wide range of factors may have on carbon emissions has taken up a large amount of time and effort in recent years (Yuping et al., 2021). The release of carbon is only responsible for a major portion of greenhouse gases (GHGs), which is inadequate to explain and assess the total degradation of the environment (Akinsola et al., 2022). On the other hand, a number of studies Kirikkaleli et al. (2021) have asserted that EF is a more comprehensive assessment for the degradation of the environment. However, in order to properly account for EFs, two metrics—namely, EFs and biocapacity—are necessary. During this analysis, a wide range of the ecosystem's constituent parts were taken into consideration. EFs consider the demand side of nature, whereas biocapacity considers the supply side. Numerous studies have been done to inquire into the various ways in which various circumstances influence an EF. Kirikkaleli et al. (2021), however, most of them have neglected to investigate the supply side (biocapacity). Because of this, there is an immediate need to devise an assessment that is more suited to the circumstances and more reliable to ascertain the state of the environment. According to Fareed et al. (2021), the LCF is believed to reflect a country's capacity to keep its population conforming to the contemporary lifestyles that its citizens lead. You may determine the LCF by dividing the supply side, which is referred to as the biocapacity, by the demand side, which is referred to as the EF. This will result in the calculation. The condition of the ecosystem is deemed to be unsustainable when the load capacity is less than 1, and it is in a sustainable state when the load capacity is more than 1. As a direct consequence of this, the threshold for sustainable development is equal to one.

The argument that was presented before is based on the notion that the LCF is a more thorough assessment than carbon emissions and the EF. Third, we have used ARDL econometric model, which is lasted updated and flexible to use with small data set and produce long and short run estimations. Finally, the results of this these will provide direction to the Switzerland to prepare the right policies to enhance the quality of environment.

1.9. Definition of the variables

GDP is a way to measure how many things and services a country makes in total. As a broad measure of overall domestic production, it may be able to show how well an economy is doing. Trade is when people in an economic system voluntarily exchange goods or services with each other. Since neither party is forced to do business with the other, a transaction will not happen unless both parties think it will help them. This is because neither side has to do business with the other.

A technological innovation is the introduction of a new or improved product or process with technological qualities that are different from those of technologies that have been used before. Technical product innovations include newly released new products and processes that are already in use. For a product or process to be innovative, these perks don't have to be new from the point of view of other companies or the market.

Environmental degradation is when the state of the environment gets worse because of things like the number of contaminants in the environment and other things, like bad land use and natural disasters.

Tax revenue is the sum of all revenues collected from various types of taxation, including but not limited to taxes on income and profits, social security contributions, taxes imposed on goods and services, payroll taxes, and taxes on the ownership and transfer of property, among others. The percentage of a country's gross domestic product (GDP) that is made up of total tax revenue shows how much money the government gets from its people through taxes. With this measure, you can figure out how much control the government has over the economy's resources. You can figure out how high the tax burden is by figuring out how much of GDP total tax receipts make up. This statistic relates to the entire government (at all levels) and is expressed in millions of US dollars and as a percentage of the total GDP.

1.10. Limitations of the study

Journals, books, and magazines that provide relevant data or information are sometimes only available for purchase online, making it difficult for researchers to compile a targeted literature review. The study has limitations in that its huge sample size means that it focuses on a time period that may not be relevant or that has low predictive power. Due to its reliance on archival materials and earlier studies, this line of inquiry has been underrepresented throughout Europe, and Switzerland in particular. As a result, there is a paucity of studies that address the topic of LCF in Switzerland as it relates to EG, RNE, TI, tax income, and trade. There haven't been enough studies done to draw any firm conclusions about the effects of EG, RNE, TI, tax revenue, or trade. Consequently, the results of this study may not be generalizable to all Swiss authorities, which is a major restriction. The following is the order in which the research was conducted: In the first chapter, we present an overview of the literature review that informed this investigation. It also includes information about the study's design and organization, as well as its aims, significance, research questions, and scope. In Chapter 2, we describe the literature review's fluid sequence, focusing on prior studies that have examined the effects of RNE, the EG, TI, tax revenue, and trade on LCF in Switzerland and elsewhere. In this section, we'll examine the disconnect between our findings and those of the literature at large. The third part focuses on the evidence and numbers used to analyze the LCF's connection to RNE, the EG, TI, tax income, and trade. The research objective or model specification, as well as the sample design, statistical methods, and econometric analysis employed in this study, are all covered here for full context. Here, we'll take a closer look at what all that data and those conclusions mean. During the policymaking process in Europe, these will be useful tools for decision-makers to have on hand. All citations cited throughout our research will be listed in the final chapter, which will also serve as a summary of our prior work. In this section, you'll find a complete bibliographic citation list, as well as brief biographies of each person listed in the study.

1.11. Organization of the study

The subsequent chapters will use the format described in the following paragraphs. In Chapter 2, we evaluate the latest literature review on the given variables. The third chapter presents the research methodology. Then evidence that goes along with it are both presented in Chapter 4. Following the presentation of the empirical findings of the study, the concluding chapter (Chapter 5) offers some suggestions for future policy.

CHAPTER II
Literature Review

2.1 Theoretical Framework: Environmental Kuznets Curve (EKC)

Researchers, academics, and policymakers are paying more and more attention to the problem of how to achieve rapid and steady economic growth without putting the environment at risk. The EKC hypothesis is a thought that most people agree links damage to the environment to economic activity. The EKC hypothesis says more economic action is bad for the environment. Grossman and Krueger (1991) found that as income levels rise, so does the quality of the surroundings. However, this change is only temporary. The EKC hypothesis says that the link between rising income and rising pollution is like Kuznets' (1955) pattern of rising income and rising income inequality. This is because there is no pollution level that works for everyone. The EKC says that a country's greenhouse gas emissions, like carbon dioxide, are strongest when its economy is weak and get lower as its economy grows. (Antonakakisa, Chatziantoniou, and Filis, 2017) say that pollution will rise until a certain level of income is reached (the "turning point"), and then it will start to go down once the economy has settled. Because of this, the link between the economy and CO2 emissions looks like an upside-down U. There have been three lines of study published in academic journals about the link between a growing economy and more pollution. In the first part of the investigation, the EKC theory is tested by looking at how economic growth and pollution are related. We claim that augmented energy consumption follows increased economic growth and improved energy efficiency. Finally, the two halves of the concept are fused into a whole. The third section employs a multivariate method to examine the connection between energy use, GDP growth, and CO2 emissions. There is evidence for all three parts of this theory from reliable sources. The first section is the most engaging since it examines the connection between CO2 pollution and economic growth to disprove the EKC theory. Experts who are studying the link between growing economies and more pollution on the ground think that the link between the two will eventually become negative as countries get better and invest in infrastructure and technology that use less energy. Tamarit and Esteve published their findings in 2012.

Sharma (2011) found out, for a world panel of 69 countries, what factors caused CO2 emissions to go up or down from 1985 to 2005. Increasing GDP per capita also helps reduce carbon dioxide emissions across the board in terms of household income. Also, in all four panels, statistics have shown that the level of opening to trade has almost no effect on carbon dioxide emissions. Also, you can only see the bad effects of urbanization in the world panel. The results show that urbanization doesn't make a big difference in the amount of CO_2 that the income panels release. Lastly, it was found that the overall amount of electricity used, and the amount of primary energy used per person have a positive effect on CO_2 emissions in all three income groups. These last two types of energy were also statistically significant in the high-income groups. The results of the world panel are unclear because the total amount of primary energy used per person has only a small effect on CO_2 emissions, and the amount of electricity used per person has only a small effect in the other direction. Historians say that as industrialization moves forward, even in the most primitive stages of society, the number of resources used and foods grown gets more intense. Because CO_2 emissions are linked to making trash, both the use of up resources and the making of trash are speeding up. As a country develops, it shifts its focus to the service industry, which uses less carbon because it uses more modern technology.

According to recent research by Jiang et al. (2018), in this study, they tested the pollution refuge theory by collecting data from 150 different Chinese cities in 2014 to see if it was true. They ran a regression analysis with FDI factors along with things like GDP per capita, academic benefits to business, population density, people's capacity to concentrate. The logical next step is to look at the results. Moran's I was examined first, and it was discovered that the AQI values in 150 cities were positively connected with one another in space. The time-tested statistical technique of OLS regression was employed to answer the second category of questions. The results did not support the hypothesis and finally, the total impacts of our explanatory variables were calculated using geographical econometrics, in particular the spatial Durbin model. GDPPC appears to have a good direct effect but a negligible indirect effect, according to the data. Negative values can be assigned to both FDI from abroad and population size.

Menegaki (2011) used a random effect model to look at the connection between RNE and EG in Europe. His results backed the neutrality hypothesis. Long-term research shows a link between the unemployment rate, the amount of carbon dioxide made, the amount of RNE used, and the GDP. It's important to remember that a 1% rise in GHGs emissions has a bigger good effect on GDP than a 1% rise in RNE sources. This is because engaging in RNE is expensive, which makes it less competitive as an EG engine. Neither the long-term nor the short-term Granger association between EG use and RNE consumption is confirmed by the panel error correction model, lending credence to the neutrality hypothesis. This data demonstrates that the RNE market is relatively little to Europe's GDP. Previous research was helpful since it used bivariate models to account for CO2 emissions while disregarding a few other factors. To account for additional potential factors influencing CO2 emissions, multivariate models have recently superseded bivariate ones in studies. To illustrate a nation's global impact, we measured its "environmental footprint" (EF). Researchers analyzed the monetary systems of 93 nations and classified them into four groups based on their income levels. The research objectives were accomplished with a comparative panel model with EF serving as the dependent variable for each country. To see the full scope of an issue's global impact, an EF is an invaluable resource. However, the EKC hypothesis is applicable to rich economies and nations. This is due to the immaturity of the economies of low- and middle-income countries. As a result, environmental degradation usually accelerates alongside economic expansion. The U-shaped link between environmental damage and income is generally positive until a country achieves a certain level of economic growth, at which point the association turns negative. Until energy-efficient, energy-saving, and RNE-boosting technologies become widely available and affordable, low-income countries will be unable to reap the benefits of the relationship's structure. Therefore, this study's high- and upper-middle-income countries are the strongest candidates for the EKC theory's validity. The findings also indicate that the consumption of energy is a major contributor to the deteriorating state of the environment across all socioeconomic classes. Urbanization and trade liberalization, both of which have positive benefits on environmental footprints, exacerbate environmental harm in low-, middle-, and high-income countries. This link makes logical given the large variety of environmental problems that urbanization may bring. Since low-income countries' financial development lags that of upper-middle-income and high-income nations, EG has little bearing on their EF. As economies in middle- and high-income countries improve, their environmental footprints (EFs) shrink. When compared to the industrial industry, the financial sector is more environmentally friendly and makes more efficient use of resources. The U-shaped relationship between EG and EF is demonstrated by their research, with the EKC reaping the greatest benefits in high- and middle-income countries and suffering the least in low-income countries.

Salahuddin et al. (2018) examined the connections between energy use, GDP, FDI, and overall CO2 emissions from 1980 to 2013. The study was carried out from 1980 to 2013. The ARDL models' findings show that Kuwait's EG, CO2 emissions, direct investment, and energy consumption are all statistically significant and positively associated over the short and long terms. Less evidence, however, points to a connection between CO2 emissions and EG having any significant effects now or in the foreseeable future. Results from applying the DOLS estimate approach to examine the variables' long-term dependability of link were equivalent. The outcomes were the same as a result of this. The FDI, growing energy consumption, and Gross Domestic Product are all significant Granger causes of carbon dioxide emissions, according to the VECM Granger causality test. Rising financial development and rising economic activity also have a shaky, unidirectional causal link. Additionally, there is a causal link that runs in both directions between growing economic activity and increased power usage. As the population of the globe continues to grow rapidly, the ecosystem will become even more destroyed. It puts everything that gives this world value in danger of being extinct. Making the transition to RNE sources and safeguarding the country's energy supply in this way can aid in ensuring sustainable growth and halting further environmental degradation. In this context, Shittu et al. (2021) did this research to ascertain the reasons behind the environmental deterioration occurring in resource-rich Asian countries, covering numerous explanatory variables, one of which is energy security. This has been done using a variety of estimate techniques, such as aggregated OLS, fixed effect, variable instrumental approach, and random effect. They found a negative link between the rent paid for intrinsic capital and EF after examining the relevant criteria. The rent from natural resources does indeed have the impact of lowering the EF by 0.037%, according to our Driscoll-Kraay and IV-2SLS standard errors. This precise finding came about as a result of the data analysis. They also found a link between energy security and environmental degradation, as well as recommendations for countries to improve energy security. Our results show a non-linear relationship between EG and EF, which defies the predictions of the EKC hypothesis. Additionally, it has been discovered that while growing the population affects environmental sustainability, increasing the EF increases the ecological fitness index. To reduce the detrimental impact of ecological deterioration on the standard of life of the general population, for instance, the earnings from the extraction of natural resources must be used to fund productive projects. Rents necessitate the ecologically sustainable management of our resources in order to lessen the damage they do to the integrity of the environment. Therefore, high rates of extraction are required for replenishable resources to keep supplies stable. Nonrenewable resources may possibly provide rents from these resources are reinvested in other sectors in accordance with the Hartwick-Solow rule. By analyzing the dynamic panel threshold estimator, Sirag et al. (2018) put the EKC hypothesis to the test. How much energy is consumed and how much money is made are the metrics by which GDP and CO2 pollution are evaluated. In addition, the economic levels of the countries are used to standardize the data and reduce the impact of diversity. They employ generalized method of moments (GMM) estimation of the conventional EKC model with GDP and its quadratic form as explanatory factors to evaluate the performance of the dynamic panel threshold. The dynamic panel threshold demonstrates the non-linear relationship between GDP and energy consumption.

2.2 The Pollution Haven Hypothesis (PHH)

Ecological contamination has received a lot of attention from scientists and politicians in recent years. One explanation for this is that environmental factors significantly influence both human health and economic development. Therefore, it is crucial to investigate the root of the problem. However, the spatial constraints at play in this context have received scant attention in recent studies on the consequences of FDI on environmental harm. This study reveals intriguing links between FDI and pollution in Pakistan. The total scale impact technique demonstrates that physical capital stock and personnel have a sizable and beneficial effect on GDP, while pollution has a sizable and detrimental effect. FDI has a significant negative impact on both carbon dioxide emissions and recyclable waste. The length of roads and the amount of capital assets have a correlation with CO2 emissions, while GDP per capita has the reverse relationship. By demonstrating a positive correlation between Pakistan's pollution levels and its FDI, this study contributes to the pollution haven idea. Foreign direct investment (FDI) is beneficial for countries in many ways. These benefits include the dissemination of technological knowledge and information, the acceleration of technological advancement, and the improvement of managerial skills. However, the negative environmental impacts of FDI are being exacerbated by climate change. Different schools of thought exist amongst experts concerning the relationship between carbon pollution and FDI. Some academics found a positive correlation between the two, while others found a negative one.

Shao (2018) analyzed the effect of FDI on carbon emissions in 188 countries between 1990 and 2013. The dynamic panel data approach is used to examine the indigeneity issue up front, which strengthens the credibility of the final findings. The research concludes that FDI has a sizable and negative impact on a country's carbon dioxide emissions. Foreign direct investment (FDI) is found to have a positive influence on carbon intensity even after controlling for factors including the usage of fossil fuels, the size of the manufacturing sector, the number of people living in cities, and the degree to which trade is liberalized. Both increased fossil fuel consumption and rapid industrial expansion contribute to rising atmospheric CO_2 levels. However, the expansion of urban areas and the ease of international trade both have a negative correlation with carbon intensity.

Nasir et al. (2019) examined the effects of the improved economy of the ASEAN, improved banking, and increased FDI on the region's natural resources. The research in this paper employs a number of quantitative panel analysis techniques, including FMOLS and DOLS, to examine data collected between 1982 and 2014. In this paper, we show that CO_2 emissions are statistically connected to these variables. The quantity of equities traded on the stock market is one such indicator, as is the ratio of bank loans to deposits. The only indicator of financial expansion that did not show a significant correlation with CO_2 emissions was international debt. This made sense conceptually and rationally. This meant that the long-term impact of environmental harm was greater due to domestic credit creation. The research also showed that when economies in ASEAN countries develop and get more FDI, environmental impact increases. Therefore, the increasing FDI and rapid EG that have occurred over the past several decades and will continue to occur are detrimental to the environment. The Pollution Heaven Hypothesis (PHH) is supported by a large body of evidence. More evidence of the EKC can be found in the economy of ASEAN countries now that the negative impact of the quadratic term for GDO has been established. However, the lack of statistical significance suggests that unrestrained economic expansion will not contribute to environmental protection. Credit, such as bank credit, is produced by the banking sector in ASEAN countries at a higher rate than deposits, according to studies. It appears that this is detrimental to the local ecosystem. This makes perfect sense, given that the primary function of the banking credit system is to facilitate the acquisition of loans by sectors that are not environmentally friendly yet consume substantial quantities of "energy."

Waqih et al. (2019) investigated the impact of FDI on ecological devastation. However, the FMOLS long-run data cannot be relied upon if the ARDL assumptions are used for the FDI criterion. Cross-sectional, longitudinal, and temporal analyses of ARDL data may yet provide evidence of PHH. All of the countries represented on the panel are developing nations with lax environmental regulations, as seen by these findings. This might be used to entice wealthy individuals and organizations to invest in these countries, which would help their economies expand. These investors will bring the shady practices of their home nations with them when they arrive. The presence of the EKC can be demonstrated by both the long- and short-term ARDL figures. The FMOLS soundness assessment verifies the validity of these findings. This implies that the energy consumption of EG will increase in tandem with its performance. This demonstrates that conventional energy sources such as thermal energy are the only ones capable of satisfying this demand immediately. In the next years, renewable, non-emitting energy (RNE) sources including solar, nuclear, wind, and hydropower can help mitigate this effect by fueling the global economy's expansion. Reliable, low-cost energy sources could help the area save money while also reducing carbon emissions.

Liu et al. (2018) claim to have employed local and global spatial autocorrelation measures and the spatial panel regression approach to determine the spatial clustering of FDI and environmental pollution, and the effect of FDI on environmental pollution. They concluded that FDI has varying impacts on various pollutants. Garbage ash and dust pollution went down, but sulfur dioxide and wastewater pollution went up, according to the study's authors. The evidence supports both the Pollution Halo and Pollution Heaven ideas. The calculated data suggest a reverse U-shaped association between economic growth and environmental degradation. This lends credence to the EKC theory. There was no statistically significant increase or decrease in levels of smoke, dirt, or waste produced by the factory. However, it was shown that the industrial layout significantly affected the airborne concentrations of sulfur dioxide. Sulfur dioxide is not a waste, but ashes, dust, and water all are. There was a statistically significant and adverse trend in people's environmental consciousness. This signifies that people identified unmet requirements for protecting the environment. The amount of dust and soot in waste was demonstrated to have no statistical influence on the amount of money spent on research and technology in both the SLM and SEM models. Spatial regression analysis reveals that FDI affects the major environmental pollutants in distinct ways. The utilization of policy variables, strong governance, and technological innovation all work together to help FDI lower emissions of carbon dioxide. Hao and Liu (2015) examine the impact of these confounding variables on the correlation between carbon dioxide emissions and foreign direct investment. The research employs six metrics of governmental effectiveness and four measurements of carbon dioxide emissions. Haug and Ucal's 2019 research examines the effects of FDI and international commerce on CO2 emissions in Turkey. Among its successful applications are those just stated. Researchers examine both linear and non-linear ARDL models and show that exports, imports, and FDI all have significant, albeit unequal, effects on CO2 emissions per person. All CO2 measurements established through empirical study indicated asymmetric effects, with the exception of the industrial, construction, and transportation sectors. They discovered that if all other variables remain constant, Turkey is now over an environmental Kuznets curve's tipping point. Since then, both long-term and short-term CO2 emissions per person in Turkey have decreased while real net GDP per person has increased in Turkey. The environmental Kuznets principle also held true for CO2 intensity, a measure of energy efficiency. Since the 1990s, a decline in real net GDP has been accompanied by a rise in CO2 emissions per unit of energy produced, whereas a rise in real net GDP has been accompanied by a decrease in CO2 emissions. Long-term effects of FDI, exports, and imports on CO2 emissions per person are statistically significant; FDI's influence is nearly statistically significant. However, factors influencing CO2 intensity are unrelated to those influencing GDP per capita. Financial growth and urban expansion are two examples. Long-term consequences vary depending on the sector, as shown by the structural breakdown of CO2 emissions by sector in terms of their share of overall CO2 emissions. To comprehend how international trade, immigration, and urbanization impact CO2 emissions from power and heating plants, a world economic analysis is required. The same holds true for commercial enterprises, public sector positions, and private residences. The only notable outlier is growth, which has no bearing on the numbers. Conversely, construction and manufacturing emissions are only correlated with GDP and GDP per capita. No matter what factors are considered, the transportation sector will continue to be a major source of pollution. Using the Pollution Halo Hypothesis (PHH) and Pollution Halo Value (PHV), we quantified the environmental impact of FDI. Proponents and detractors of FDI both claim that it has negative or positive effects on ecological systems. One of the contributors is Shahbaz (2018).

The connections between conservational smog, tourism, FDI, economic growth, and RNE consumption were analyzed by Bildirici and Gokmenoglu (2020). Using a dataset covering the years 1975-2017, researchers applied co-integration processes such the PARDL, trivariate causality tests, and Johansen, Kao in an effort to incorporate data from Syria, Nigeria, Somalia, Afghanistan, the Philippines, Thailand, Pakistan, Iraq, and Yemen. Terrorist acts, which are broadly defined in this article as any act that generates uncertainty and fear around the world, are shown to have far-reaching effects on environmental pollution in addition to their political, social, and economic effects. CO2 emissions rose for many reasons, including terrorism, robust economic expansion, and foreign direct investment. Terrorism is also a major contributor to greenhouse gas emissions, and the energy demands of modern terrorists are constantly growing as they make use of ever more sophisticated technologies. Every country in the world is affected by global issues like terrorism and pollution. The fight against terrorism cannot be won by any single country acting alone; rather, international cooperation is required. Foreign direct investment (FDI) that is skewed toward carbon intensive businesses is a major contributor to global warming. The public's lack of awareness about the risks posed by polluting businesses, the absence of regulatory restrictions, and the inaction of lawmakers have all contributed to a steady rise in emissions. Foreign direct investment, ecological gradients, energy consumption, and terrorist acts all contribute to a worsening global environmental crisis.

Energy consumption, carbon dioxide emissions, and GDP growth in Pakistan were among the topics studied by Fan and Hao (2020). Johansen-Juselius co-integration and error-correction models, which are bivariate, were used for the analysis. The ARDL-bound testing method was used to verify the accuracy of the co-integration results. The implications of our research for public policy are extensive. First, the long-term and short-term causality between EG and energy consumption suggests that maintaining a healthy energy supply is essential to generating high rates of economic growth over the long-term. Since Pakistan is already experiencing significant energy/electricity shortages, the government there should make developing the country's natural resources a top priority. There is a clear causal relationship between energy shortage and economic development. Second, more energy consumption is associated with higher CO_2 emissions in the economy; this suggests that a growing economy's need for energy is ultimately detrimental to the natural world. Therefore, the government should prioritize increasing energy supply through increasing the amount of RNE used in the economy. Long-term economic expansion and increasing CO_2 emissions generate a positive feedback loop. This suggests that more economic growth could reduce growth quality by jeopardizing efforts to enhance the environment.

The goal of the research by Demissew et al. (2020) was to put the EKC theory to the test in 12 East African countries using the PMG estimation method from 1990 to 2013. The model used a square of GDP per capita, globalization, FDI, political issues, and population density to determine the impact of CO_2 emissions on countries in Eastern Africa. While Kuznets hypothesized an inverted U-shaped link between long-term CO_2 emissions and EG, the data show a bell-shaped association instead. This suggests that after GDP per capita reaches 128.95 USD, the correlation between CO_2 emissions and GDP per capita becomes positive, whereas it was negative before this point. However, the opposite (an inverted U) occurs soon. The tipping point in per capita GDP in the short term is about $677.35. By enforcing regulations like environmental protection legislation, updating existing sectors, and embracing new technologies that minimize pollution over time, Eastern African countries can make their economic growth more efficient at cutting CO_2 emissions.

Omri and Bel Hadj (2020) discussed how poor nations might reduce their CO_2 emissions with the support of excellent government and TI. Major challenges confronting the global economy today include climate change, globalization, air pollution, and openness to foreign direct investment and commerce. This has led to the impact of FDI on rising CO_2 emissions being recognized as a global issue. Our empirical research provides important insights into the role that technological advancement and effective government can play in lowering CO_2 emissions in low-income regions of the world. They find, first, that foreign direct investment (FDI) is positively correlated with several measures of carbon emissions, while most characteristics of government exert a negative influence on these measures. They see a positive correlation between the decline in CO_2 emissions and the improvement in government quality brought about by FDI. To mitigate the beneficial effects of FDI on carbon emissions in developing nations, governments should encourage the entry of FDI and high-tech fields into the environment while also imposing a variety of environmental regulations. Second, there is a negative correlation between technical development and carbon emission indicators, as well as between carbon emission indicators and the dynamics of FDI and economic expansion. High-tech, environmentally friendly areas that disseminate knowledge about cleaner technology throughout regions, sectors, and the entire country should be a priority for emerging nations seeking foreign direct investment. This will help developing countries mitigate the negative consequences of FDI from more developed nations. The systems that regulate absorptive capacity need to be enlarged for this process to be more effective.Wang (2021) examined the effects of monetary expansion, the Human Capital Index, the use of RNEs, and globalization on EF and Carbon footprint during a twenty year period. Specifically, he used data from Brazil, Russia, India, and China. Increasing EF and carbon footprint are two major ways in which economic growth exacerbates environmental degradation. Major globalization and RNE usage, on the other hand, exacerbate environmental deterioration by decreasing EF and carbon footprint. Therefore, the EF and carbon footprints of the BRICS countries need to be reduced, and the BRICS nations as a whole should focus more on RNE consumption and globalization. To make the most of their resources, they should also invest in educational programs, R&D, and projects including RNE. There are two camps when discussing the effects of foreign direct investment on the environment of the host country: advocates and opponents. There are those who believe FDI is beneficial to the host country's ecosystem (Liang, 2011). While foreign direct investment (FDI) might hasten economic progress, it can also damage the ecology of the host country, argue Tang and Tan (2015). Similarly, Kivyiro and Arminen (2014) discover that in Sub-Saharan Africa, CO2 emissions, EG, energy use, and FDI all trend in the same direction. According to the research of Omri et al. (2014), there is a reciprocal relationship between carbon dioxide emissions and both FDI and EG flows. This demonstrates how FDI can reduce the wealth of the receiving country.

2.3 The nexus between TI and LCF

Policymakers and academics are beginning to recognize the value of TI (TEI) in reducing environmental deterioration as the rate of innovation increases (Agyekum et al., 2022; Du et al., 2022). Extensive study of TEI has taken place in recent years.

As a result, several scientists have investigated TEI's effects on the natural world. Among these analyses, efficiency, R&D activity, and patenting activity are three key indications for evaluating TEI. Destek and Manga (2021), among others, found that TEI helps lower EF (EF) in major developing nations. Meanwhile, they investigate the link between TEI and CO2 emissions and find that the latter are indeed increased. Similar findings were found by Adebayo and Kirikkaleli (2021) who studied the effect of TEI on CO2 emissions in Japan. According to the study results, TEI causes a rise in Japan's emission rates. Adeshola et al. (2022) concluded that TEI had a positive influence on CO2 emissions using Portugal as an example. Furthermore, Su et al. (2021) used annual data from 1990-2018 to examine the connection between TEC and CO2 emissions in Brazil. The empirical research using ADRL showed that TEI is associated with the rise in CO2 emissions.

Fareed et al. (2022) found that the growth in CO2 emissions and EF (EF) can be linked to the increase in TEI in their investigation of the connection between TEI and CO2 emissions in NICs between 1995 and 2018. Researchers in South Korea have found that TEI has a negative effect on CO2 emissions. Akadiri et al. (2022) found in NICS that TEI is inversely related to CO2 emissions. In addition, Xie et al. (2022) used the ARDL method to study CO2 emission factors in China. Using data collected between 1985 and 2019, the team concluded that TEI and CO2 emissions interact negatively. Xu L. et al. (2022) looked into how TEC could help reduce emissions in Turkey. According to the findings, the growth of the TEI is to credit for Turkey's falling emission levels. Using data from 1995-2019, Sharif et al. (2022) also looked at the TEI-emissions nexus in the G7 economies. Emissions reductions thanks to TEI were shown to be significant when the CS-ARDL method was applied.

The underlying links between TI and environmental quality have been the subject of numerous previous research. Kihombo et al. (2021) looked at studies that correlated TI and EF from 1990 to 2017. They validated the hypothesis that technological development dampens EF in WAME economies. The effects of TI on the EF in Brazil, India, China, and South Africa were studied by Yang et al. (2021) between 1990 and 2016. They claimed that environmental damage would be mitigated as technology advanced. The impact of TI on Pakistan's EF from 1992-2018 was also analyzed by Kirikkaleli (2021), who concluded that TI is beneficial to the EF. Destek and Manga (2021) investigated the effect of technological advancement on energy efficiency (EF) and carbon emissions in major emerging markets between 1995 and

2016. The team determined that TI mitigates carbon emissions without impacting ecosystem functioning.

Ali et al. (2019) and others have investigated a number of factors that have the potential to degrade environmental quality, highlighting the need of environmental preservation in modern times. Rapid urbanization and the accompanying increase in industrialization have been major contributors to climate change and other environmental problems around the world. Europe is among the developed world and has an extraordinarily high pace of industrialization. The rate and magnitude of CO2 emissions in Europe will increase as the continent becomes more industrialized. They also find that urbanization and CO2 emissions have a short-term, unidirectional causal relationship. These results lend credence to the argument that Switzerland's growing industrial footprint is having an adverse effect on the environment.

In addition, Ahmad et al. (2020) analyzed the impact of technological advancement on 22 different economies' efforts to create a sustainable environment from 1984 to 2016. Their research proved that new technologies have a positive effect on the environment. On the other hand, Usman and Hammar (2021) analyzed how technological progress affected the APECC EF. According to the data, EF rises as technology develops. Between 1996 and 2017, the consumption-based carbon emissions of the G-7 economies were reduced due to TI, as determined by Wahab et al. (2021). But Su et al. (2021) found that, between 1990 and 2018, TI actually increased Brazil's carbon emissions. In addition, Adebayo and Kirikaleli (2021) demonstrated that Japan's rising technological prowess increases carbon emissions.

Using data provided by WAME, Kihombo et al. (2021) discovered that TEI reduces EF. Recent research by Zhang W. et al. (2022) shows that TEI harms EF in the BRICS countries. They used information collected from 1990 through 2018. In addition, Destek and Manga (2021) noted that sizable developing market economies benefit from TEI's ability to lower EF. Meanwhile, they conducted an analysis of TEI's impact on CO2 emissions and found that TEI actually causes an increase in CO2 emissions in these countries. Using panel data from 1990 to 2018, Rout et al. (2022) analyzed the connection between TEI and EF in BRICS. Using PMADRL, an empirical analysis method, it was found that there is a negative correlation between TEI and EF. And in the context of Bangladesh, Gupta et al. (2022) discovered that TEI reduces EF. Xu Y. et al. (2022) investigated the connection between TEI and EF in China between 1990 and 2027 and discovered that the reduction in EF is associated with the rise in TEI. Similar findings were found by Suki et al. (2022), who investigated the effect of TEI on EF in Malaysia. According to the findings, TEI has a negative impact on a country's EF.

The impact of TEI on EF in BRI was studied by Yasmeen et al. (2021). The results showed that TEI had a negative effect on EF. Chu (2022) found that, for OECD countries, TEI had a negative impact on EF. In addition, Sherif et al. (2022) used the panel dataset from 1992 to 2015 to investigate the TEC-EF nexus in the Next-11 countries. Using the FMOLS and DOLS methodologies, empirical research found that TEI reduces EF. However, Kirikkaleli et al. (2022) used panel data from 1990-2017 to examine the TEI-EF association in BRICS and discovered that TEI is relevant to the rise in EF.

2.4 The interrelationship among EG, RNE, and LCF

In environmental research, the connection between EG, RNE, and CO2 emissions has been a point of contention for decades. By reducing levels of carbon dioxide in the atmosphere, green energy has the potential to significantly improve environmental sustainability in the context of global warming. This has led to a plethora of empirical studies exploring the factors that contribute to ecological sustainability. Researchers Saboori et al. (2012) found that GDP negatively affects CO2 levels in the region of sub-Saharan Africa. Kivyiro and Arminen (2014) used the ARDL technique to show that CO2 and EG are positively correlated in the economies of sub-Saharan Africa. A positive correlation between CO2 and China's EG was shown by Hao et al. (2019). Income rise, as found by Kartal et al. (2022), is correlated with increased CO2 emissions in Finland. Several methods based on time series analysis confirmed the correlation between income and CO2 emissions in Chile (Kirikkaleli et al., 2022). Nurgazina et al. (2022) found that when incomes rose in China, so did levels of carbon dioxide. Increasing EG in South Africa improved environmental quality, as demonstrated by Samour et al. (2022). Income boosts the G7 countries' CO2 emissions and carbon footprint, as indicated by Shahzad et al. (2023). While Yang et al. (2021) found that more wealth was associated with greater EF, Wang et al. (2022) shown that EG had a positive impact on CO2 in OECD countries. Income and EF are positively correlated in OECD countries, as found by Hassan et al., Rafque et al., and Sun et al. (2022).

Several empirical studies conclude that traditional energy sources like oil and gas negatively affect environmental sustainability (Ahmed et al. 2022; Fakher et al. While fossil fuels have a negative impact on the environment, renewable energy sources (RNEs) like solar power have been shown to have a favorable effect. To assess the link between RNE and CO2 levels, Sharif et al. (2019) studied 74 nations. The numbers show a positive relationship between RNE and CO2. Khan et al. (2019) argue that RNE is the fundamental factor that allows many Asian economies to be environmentally sustainable. The RNE had a significant positive and helpful effect on Turkey, as stated by Sharif et al. (2020). Based on their analysis, Anwar et al. (2022) found that RNE improves the long-term environmental viability of 15 Asian economies. Ali et al.'s (2022) study finds that the RNE has a negative impact on CO2 levels in China. Amin et al. (2022) found that an increase in RNE aided in environmental sustainability in 187 nations. Recently, using bootstrap Fourier Granger causality, Kartal et al. (2023) discovered that RNE improves the LCF in the USA. Research (in the USA) led them to this conclusion. Adebayo and Samour's (2023) study, which relied on the panel ARDL methodology, found that RNE positively affected LCF in the BRICS countries. According to Wang et al. (2023), the RNE lowers the EF in six of the ASEAN countries.

The significance of strong institutions to the GDP and carbon emissions of the three countries is highlighted by the time series analysis. Both South Korea and Thailand's economic growth rates are significantly affected by factors such as energy consumption and the degree of market freedom. However, research shows that when trade restrictions are eased, Indonesia's GDP increases. Statistical methods were used to uncover each of these associations. Long-term causal linkages between CO2 emissions and GDP growth were also indicated, as were short-term causal relationships between GDP growth and energy usage.

Hassan et al. (2020) analyzed the relationship between structural changes brought on by rising economic growth and improved institutional standards and the levels of carbon dioxide emissions and energy consumption. Granger causality is employed to probe the links between phenomena, and ARDL modeling is utilized to examine both the immediate and distant future. The results of the study show that high-quality institutions have a significant impact on cutting down on carbon dioxide emissions. Further evidence for the existence of the EKC for CO2 emissions comes from data demonstrating that EG induces a decrease in CO2 emissions over time. The primary purpose of the research was to analyze the function of the institution; fresh information about Pakistan was gathered as a result. Pakistan's institutional strength is a crucial factor in influencing the shape of the inverted U-shaped link between GDP and pollution there. Human energy use is a major contributor to carbon dioxide emissions, which are unfortunately unavoidable in the modern world. In the short run, the relationship between institutional quality and CO2 emissions is unidirectional, but in the long run, the relationship between these two variables is causal.

Few empirical studies have examined the effect of EG and RNE on LCF, despite the fact that many have been undertaken to examine the connection between EG, RNE, CO2 emissions, and EF. The LCF is used in the process of assessing environmental sustainability due to its exhaustiveness and comprehensiveness. Pata (2021) analyzed data from the United States and Japan to find out how RNE influences LCF there. In this article, the authors provided evidence that RNE improves LCF. According to Pata and Isik (2021), EG helps lower the rate of LCF in China. A rise in LCF in Indonesia is attributable, in part, to RNE, as discovered by Fareed et al. (2021). Based on their research, Pata and Samour (2022) concluded that there was no statistically significant relationship between REC and LCF in France. The effects of EG on LCF in South Africa are studied by Awosusi and coworkers (2022). The results suggest that EG has an effect that is detrimental to efforts to increase environmental adaptation. The causes of LCF in India were investigated by Akadiri et al. (2022). The authors discovered that LCF has a significant positive impact in South Africa, while EG has a significant negative connection with LCF. Furthermore, the authors showed that EG is correlated negatively with LCF. For South Korea and G7 countries, respectively, researchers Dogan and Pata (2022) and Pata and Kartal (2022) discovered a non-linear U-shaped link between the LCF and EG. Pata and Balsalobre-Lorente (2022) used a dynamic ARDL model to show that income negatively affected LCF in Turkey. A favorable link was discovered between RNE and LCF in a research of RNE, health spending, and LCF across ASEAN countries conducted by Shang et al. (2022). Using ARDL testing, Xu et al. (2022) showed that EG and RNE negatively affect LCF. Pata et al. (2023) found that using biomass increased LCF while using EG decreased ecological quality in the United States. Pata and Tanriover (2023) contended that EG did not affect LCF in the top 10 most visited tourist locations.

2.5 The connection between tax revenue and LCF

The income policy of the government is the tool available to fiscal planners for halting environmental degradation. Many groups and academics around the world have called for tax reform as a means of bringing economic policy in line with environmental goals. Fiscal instruments might include the imposition of additional taxes, the creation of tax incentives, the rewriting of current tax legislation, the fight against tax havens, and the cancellation of international debts. In addition, we think taxes are the most effective tool available right now. Since the Paris agreement in 2015, people have been trying to slow the rise of greenhouse gas emissions by paying a tax on carbon. These actions are presently being taken.

As one of the most popular approaches to combating climate change and other environmental disruptions, the carbon tax is the focus of this subsection. Ecological taxes have its theoretical roots in work done by Pigou (1920); these taxes, which are based on the principle that the "polluter pays," are also known as Pigouvian taxes. However, these levies can be seen as a tool to correct market imperfections.Despite the fact that there are many kinds of environmental levies, we have focused mostly on carbon taxes. Carbon taxes are intended to reduce carbon dioxide emissions, which are generally agreed upon as the principal cause of climate change and global warming (Balsalobre-Lorente et al. 2021). Ecological fees are also the most economically viable means of achieving this goal. Carbon taxes are neutral despite having many positive effects on finances and no negative consequences on the economy. Several theoretical and empirical considerations (Dogan et al. 2022; Ashiabor et al. 2011) suggest that environmental taxes may worsen the current state of the tax system in the economy. Carbon taxes, like other indirect taxes, may have a disproportionately negative impact on low-income groups. On the plus side, it may help the government bring in revenue, reduce the tax burden on employees, lessen inequality, internalize negative externalities, and cut down on the consumption of energy and natural resources. Internalizing external costs is another possible advantage. Possible advantages include taking responsibility for previously externalized costs and harms (Dogan et al., 2022). Carbon taxes are collected by a wide range of national and regional governments, and their amount is determined by dividing emissions by energy use.

After analyzing the variables that affected BRICS states' EF on a yearly basis between 1992 and 2016, Danish et al. (2020) published their findings. The primary focus of the study is an examination of the study's methodology. To take into consideration cross-sectional dependence, the method begins with a search for global correlations and then employs a panel unit root test of the second generation. When non-stationary variables are present, cross-sectional dependence must be managed in the same way as for controlling for co-integration connections. After a co-integration relationship has been established, the study uses FMOLS and DOLS estimators to compute the long-run co-integration parameters. Finally, data from the five BRICS nations point to a U-shaped link between ECF and income that is flipped upside down. Rent from intrinsic capital, expansion of RNEs, and growing urbanization all contribute to a decrease in ECF. In order to assess the strength of the link between the variables under study, the empirical application concludes with a heterogeneous panel causality test. This supports the conclusion that there is a causal relationship between real income and ECF, operating in both directions. The ECF causes a granger effect that can be reversed in terms of environmental abundance. There is also supporting evidence for the hypothesis that urbanization, real income, and RNE use all contribute to one another in a positive feedback loop. However, the correlation between natural resource abundance and material prosperity only works in one direction. The availability of raw materials is the driving force behind RNE.

Carbon emissions taxes have been discussed, formulated, and enacted on a global scale. Carbon taxes have been used by many nations and local governments in the United States for more than 25 years to combat climate change and reduce carbon emissions, with tax rates ranging from less than $1 per ton of CO2 emissions in Poland to as much as $139 per ton in Sweden. According to one study (Metcalf, 2019), Poland has one of the world's lowest carbon tariffs. Twenty-seven nations and/or regions will have carbon taxes in place by the year 2020. However, a carbon price in Switzerland may have strong economic, administrative, and efficiency arguments in its favor (Mildenberger et al., 2022).

A carbon tax has the potential to promote EG through increased job creation, decreased deficit spending, and improved environmental well-being, according to research on carbon taxes that has been done on both existing (Metcalf, 2019) and theoretical (Alexander and Backus, 2007) taxes. This is in addition to the emissions reductions that the tax has brought about. A carbon pricing in Switzerland, according to Carattini et al. (2018), would increase economic efficiency, enhance environmental outcomes, and make it easier to cut other tax subsidies and expenditure initiatives. Eliminating a number of other expenditure programs and tax subsidy schemes would have this effect. A renewable energy standard like Switzerland's Renewable Portfolio Standards has a higher overall cost per ton of CO2 emissions reduced than a carbon tax. These regulations are preferable to a carbon price in that they require a specific proportion of newly generated electricity to come from sources that emit no emissions (Baranzini & Carattini, 2017).

2.6 The linkage between trade and LCF

The increase in EG is a direct result of trade, which promotes the investigation of comparative advantages in the transfer of resources between nations. It can have beneficial or harmful effects on the ecosystem, depending on how it gets there (Essandoh et al., 2020). The relaxed environmental regulations that tend to entice polluting enterprises are largely to blame for this unwanted outcome. On the other hand, trade may entice businesses to establish operations in countries where their presence will lead to cleaner manufacturing and, consequently, a better environment (Sarkodie and Strezov 2019). Furthermore, international ties between governments and multi-national corporations have allowed for certain technical innovation to disseminate into underdeveloped countries, which has fostered clean environment in some fashion. According to Rennings (2000), an environmental innovation is the creation of new or altered processes, methods, or systems that aid the environment and promote environmental sustainability. The organization also holds the view that greener technologies can help mitigate environmental threats including pollution and resource depletion. Pressure from environmentalists, governments, organizations, and civil society, say Dangelico and Pujari (2010), compels nations and corporations to test their sustainability, which in turn motivates them to develop creative solutions. A study conducted by Long et al. (2017) concluded that environmental innovation fosters environmental contamination since it drives sustainable development toward cleaner manufacturing. (Palmer et al., 1995) stress the significance of the company's strategy in this context. Support for environmental management methods, according to the conformists, will only lead to higher costs and less business profits. From the perspective of green growth, spending money on environmental management now can save money later in the form of lower operating costs and higher profits. The earlier a company or country incorporates innovation into production and environmental management, the greater the potential advantages and the better the reputation the organization or country will have.

By breaking down trade into its component parts, Salman et al. (2019) found that exporting contributes to rising CO_2 emissions in some Asian nations. Scale, composition, and approach are the three dimensions into which the effects of widened market access can be partitioned. The scale effect, in general, shows how an increase in trade volume impacts production, energy use, and subsequent CO_2 emissions. Composition is the phase where the recipients of any traded goods or resources are determined. Trade liberalization often leads to cleaner environments because of the technique effect. This is due to the fact that manufacturing efficiency, technological innovation, and reduced energy use are all outcomes of international trade. The environment may be impacted in two ways if trade was more open. Polluting industries often lead to higher CO_2 emissions after relocating to places with less stringent environmental regulations, a phenomenon known as the pollute haven hypothesis (PHH). Consider the fact that PHH is among the top five emitters in developing countries like China. Liu et al. (2018) validate PHH in various Chinese cities by an examination of the spatial impact of FDI on pollution. This was done to ensure the accuracy of their research.

There have been structural shifts in the receptivity of economies, cultures, and ecosystems to external influences like industrialization, the Flow of Capital Overseas, and economic growth, according to Munir and Ameer (2020). The primary goal of this research is to examine the complex interplay between outside capital flows, environmental governance, and urbanization in Pakistan's rapid and gradual degradation of its natural environment. In this study, we utilize the non-linear ARDL model to analyze annual time-series data from Pakistan between 1975 and 2016 and evaluate long- and short-term correlations. Long-term connections among foreign direct investment, endogenous growth, and innovation in Pakistan are taught using the NARDL model. Long-term, increased FDI has a large and beneficial effect on CO_2 emissions, while decreased FDI has a small and negative effect. These 2009 observations provide credence to Acharyya's theory. Pakistan's EG will have a favorable effect on the country's CO_2 emissions in the long run, while a fall will have an adverse effect. Both he and Richard (2009) came to the same conclusion. The decline in carbon dioxide emissions that comes with increased industrialization is small but noticeable. To a similar extent, industrialization reduces carbon dioxide emissions. According to this research, growing FDI, high consumer spending, and urbanization are all contributing to Pakistan's environmental degradation. Based on the results of a Granger causality test, we know that the sum of the components associated with industrialization and investment leads to amplified CO2emissions, whereas the sum of the components associated with EG leads to decreased emissions.

Moreover, the level of pollution can be affected by trade. For example, Wang et al. (2021) examined the impact that globalization of trade has on emissions by using ASEAN countries and a dataset that covered the years 1985 to 2017. Their study focused on the relationship between globalization of trade and emissions. An expansion in global commerce is associated with a lower level of CO_2 emissions in the ASEAN nations. In addition, the GMM approach used in the study that Guo et al. (2021) did on the relationship between trade and emissions in the nations that are now responsible for the greatest CO_2 emissions indicated that trade lowers CO_2 levels. In a manner that is quite analogous, Xu et al. (2020) explored the trade and CO_2 nexus in China by using 116 economies as a case study and making use of a dataset that encompassed the years 1986 to 2014. They did this by adopting a methodology that is referred to as "case study method." The panel method is used by the researchers, and the data showed that increased trade is the source of an increase in CO_2 levels. In addition, Dauda et al. (2021) evaluated the trade openness-emissions nexus for several African states by employing a dataset that included data from the years 1990 all the way through 2016. According to the findings of their analysis, increased commercial activity has a negative impact on environmental quality. This conclusion lends credence to the pollution haven idea. The dataset included information from 1990 all the way up until 2016. In a study with a similar aim, Essandoh et al. (2020) discovered that the effect of trade on CO_2 was negative for industrialized nations but had a positive effect for rising nations in 52 different countries between 1991 and 2014.

Several studies, including Ahmed et al. (2020) and Wang et al. (2022) consider trade as an explanatory variable when analyzing the environment of G-7 countries. They came to this conclusion because increased international trade activity, particularly regarding export, causes an increase in EF due to the increased consumption of energy and natural resources during the production stage. Because of this, they concluded that trade openness has a negative effect on the deterioration of the environment. As a result, it is anticipated that a rise in the degree to which trade is opened will have a depressing effect (that is, a lowering) on the LCF of Switzerland. There are still many unanswered questions regarding the impact that trade policy has on climate change mitigation. It is difficult to create a consensus on the determinants of climate change across because of the complexity of these aspects. This difficulty is related to the fact that different countries have distinct economic structures and diverse regulations governing the environment. The empirical findings offered in this study can be valuable in the process of formulating policies connected to climate change. According to the indications provided by the motivations, the objective of this study is to investigate, using contemporary econometric methods, the dynamic impact that trade policy has on the LCF in Switzerland. Because Switzerland is currently struggling to deal with challenges related to an ecological deficit, the research investigated the possibility of using LCF as an alternative to regular CO2.

CHAPTER III

Methodology:

3.1 Data

This study investigates the link between technological innovation, renewable energy, economic growth, trade, government tax revenue, and load capacity factor (proxy of environmental quality) in the case of Switzerland for the time period 1990 to 2019. Based on this the basic model is developed as under:

$$LCF_{it} = \xi_0 + \xi_1 TI_{it} + \xi_2 RNE_{it} + \xi_3 EG_{it} + \xi_4 TR_{it} + \xi_5 TXR_{it} + \upsilon_{it} \tag{1}$$

In eq. 1, LCF denotes load capacity factor. It is measured as biocapacity divided by ecological footprint and is used as proxy for the environmental quality. TI is the technological innovation. It measured as to number of patents, national and international. These patents are used to develop the environment related technologies. RNE refers to renewable energy and measured as "Renewable energy consumption (% of total final energy consumption)". It is a clean and environmentally friendly energy source, used as alternative to dirty energy sources such as fossil fuels. It is derived from replenishable sources such as "the Sun (solar energy), wind (wind power), rivers (hydroelectric power), hot springs (geothermal energy), tides (tidal power), and biomass (biofuels)." EG denotes the economic growth, measured as Gross Domestic Product GDP per capita (constant 2015 US$). TR denotes trade, measured as Trade (% of GDP). TXR refers the tax revenue. T denotes the time period ranging from 1990 to 2019. ξ_0 denotes intercept and $\xi_1 to\ \xi_5$ denotes the coefficients for the study variables. Finally, υ_{it} represents the error term. The Table. 1 presents the summary of the data.

Variable	Abbreviation	Measurement Unit	Source
Load Capacity Factor	LCF	Biocapacity divided by ecological Footprint	Calculation
Technological Innovation	TI	Total number of patients (Domestic and International)	WB
Renewable Energy	RNE	Renewable energy consumption (% of total final energy consumption)	WB
Economic Growth	EG	GDP per capita (constant 2015 US$)	WB
Trade	TRD	Trade (% of GDP)	WB
Tax Revenue	FDI	Foreign direct investment, net inflows (% of GDP)	WB

Table 1 Description of the data.

Note: WB stands for World Bank.

Data Source: World Bank (https://databank.worldbank.org/source/world-development-indicators)

3.2 Model Estimation

3.2.1 Unit Root test

Unit root estimator investigates the stationary of the data. To do so this research study employs the Augmented Dickey fuller test (ADF), developed by David Dickey and Wayne Fuller in 1979, and Phillips–Perron test (PP) developed by Phillips and Pierre Perron in (1988). The ADF test consider the following equations:

Without intercept and trend:

$$\Delta Y_t = \alpha_1 Y_{t-1} + \sum \gamma_j \, p_{j=1} \Delta Y_{t-j} + \epsilon_t$$

(2)

With Constant:

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum \gamma_j \, p_{j=1} \Delta Y_{t-j} + \epsilon_t$$

(3)

With constant and trend:

$$\Delta Y_t = \alpha_0 + \beta_t + \alpha_1 Y_{t-1} + \sum \gamma_j \, p_{j=1} \Delta Y_{t-j} + \epsilon_t$$

(4)

Where Y_t denotes the variable of study. Δ denotes the difference operator, ϵ_t denotes the error term, and Y_{t-j} represents the lagged values of the dependent variable, which is included in the model as a regressor. Moreover, the study employs Phillips and Perron test by testing the following equations:

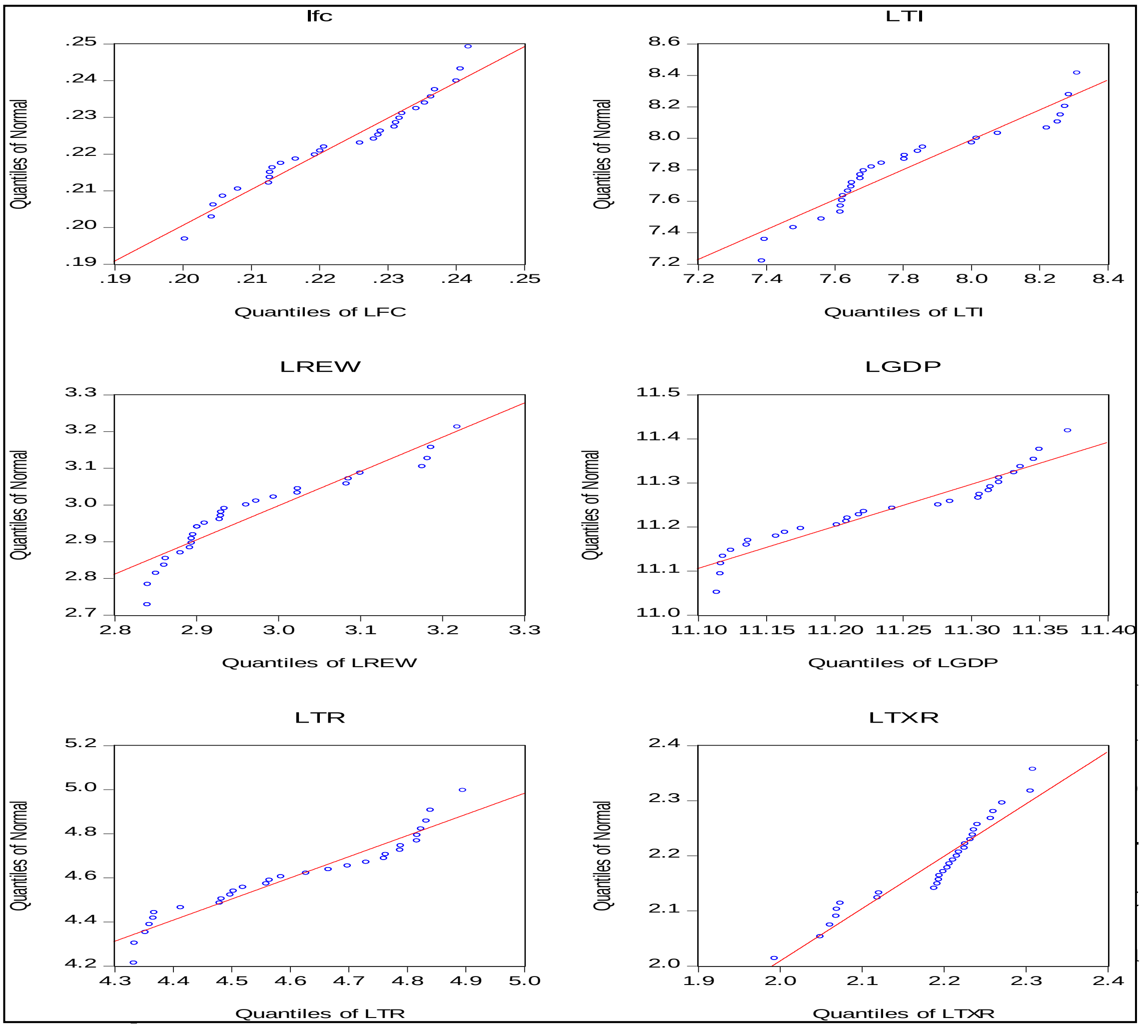
$$\Delta Y_t = \beta_0 + \gamma Y_{t-1} + \epsilon_t$$

(5)

$$\Delta Y_t = \beta_0 + \gamma Y_{t-1} + \beta_{1t} + \epsilon_t$$

(6)

All of the variables are discussed up top. In addition, the alternative hypothesis in these two-unit root tests is > 0, while the null hypothesis is = 0. If the variable stabilizes, the null hypothesis may be rejected; otherwise, the variable has a unit root problem, and the null hypothesis cannot be rejected. Elliott, Rothenberg, and Stock (ERS) created the Augmented Ducky Fuller GLS Test (ADF-GLS) in 1992 as a variation of the Augmented Dickey-Fuller test (ADF) to verify the reliability of the results.



3.2.3 Autoregressive Distributed Lag (ARDL) Model

For the purpose of estimating the economic model, this research utilized the autoregressive distributed lag (ARDL) technique. This methodology has recently come into widespread use as a model for time series data. Competing time series models, such as the Johansen co-integration technique, were considered, but ultimately, we decided to go with this one instead. To begin, this model is suitable for time series data in which there are few observations, and there is no impact on the precision or validity of the 56 derived coefficients because of this model's use. Second, to evaluate both the short-run and the long-run effects, this model requires only a single equation. Other types of co-integration models, such as the Johansen co-integration technique, need the development of two separate models to function properly. Finally, and perhaps most crucially, the ARDL model does not demand that time series data be integrated in the same order; rather, it can be utilized integrated of I (0) and I (1) or mixed integrated (Pesaran et al., 2001). This is because the ARDL model does not require that the order in which the time series data are integrated is the same. Using equation 1 as a starting point, the estimating equation for the ARDL Model can be written as follows:

$$\begin{aligned}\Delta lnLCF_t = \theta_0 &+ \sum_{i=1}^{q} \rho_1 \Delta lnLCF_{t-j} + \sum_{i=1}^{f} \rho_2 \Delta lnTI_{t-j} + \sum_{i=1}^{f} \rho_3 \Delta lnRNE_{t-j} \\ &+ \sum_{i=1}^{f} \rho_4 \Delta lnEG_{t-j} + \sum_{i=1}^{f} \rho_5 \Delta lnTR_{t-j} + \sum_{i=1}^{f} \rho_6 \Delta lnTXR_{t-j} \\ &+ \pi_1 lnLCF_{2t-j} + \pi_2 lnTI_{t-1} + \pi_3 lnRNE_{t-1} + \pi_4 lnEG_{t-1} \\ &+ \gamma_5 lnTR_{t-1} + \gamma_6 lnTXR_{t-1} + \omega ECT_{t-1} + \in_{it}\end{aligned}$$

(7)

3.3.4 Granger casualty Test

Given that co-integration tests seek the long-run equilibrium, the ARDL model was also used in this work to perform a granger causality test to investigate the direction and causal relationship between the variables of interest. Granger causality, on the other hand, is more concerned with near-term predictability (Ogutu, 2014). According to Granger (1969), a time series variable is a "Granger cause" if it passes the Granger causality test. The formulas from

$$\boldsymbol{\Delta lnLCF_t} = \alpha + \sum_{\boldsymbol{i=1}}^{\boldsymbol{p-1}} \boldsymbol{\varsigma_i \Delta lnLCF_{t-i}} + \sum_{j=1}^{q-1} \omega_j \Delta lnTI_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnRNE_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnEG_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnTR_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnTXR_{t-n} + \lambda_1 ECT_{t-1} + \epsilon_{1t}$$

(8)

$$\boldsymbol{\Delta lnTI_t} = \alpha + \sum_{i=1}^{p-1} \varsigma_i \Delta lnLCF_{t-i} + \sum_{\boldsymbol{j=1}}^{\boldsymbol{q-1}} \boldsymbol{\omega_j \Delta lnTI_{t-j}} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnRNE_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnEG_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnTR_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnTXR_{t-n} + \lambda_2 ECT_{t-1} + \epsilon_{1t}$$

(9)

$$\boldsymbol{\Delta lnRNE_t} = \alpha + \sum_{i=1}^{p-1} \varsigma_i \Delta lnLCF_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnTI_{t-j} + \sum_{\boldsymbol{m=1}}^{\boldsymbol{q-1}} \boldsymbol{\vartheta_m \Delta lnRNE_{t-m}} + \sum_{l=1}^{q-1} \Theta_l \Delta lnEG_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnTR_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnTXR_{t-n} + \lambda_3 ECT_{t-1} + \epsilon_{1t}$$

(10)

$$\Delta \boldsymbol{lnEG_t} = \alpha + \sum_{i=1}^{p-1} \varsigma_i \Delta lnLCF_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnTI_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnRNE_{t-m} + \sum_{\boldsymbol{l=1}}^{\boldsymbol{q-1}} \boldsymbol{\Theta}_l \Delta \boldsymbol{lnEG_{t-l}} + \sum_{r=1}^{q-1} \xi_r \Delta lnTR_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnTXR_{t-n} + \lambda_4 ECT_{t-1} + \epsilon_{1t}$$

(11)

$$\Delta \boldsymbol{lnTR_t} = \alpha + \sum_{i=1}^{p-1} \varsigma_i \Delta lnLCF_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnTI_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnRNE_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnEG_{t-l} + \sum_{\boldsymbol{r=1}}^{\boldsymbol{q-1}} \boldsymbol{\xi_r} \Delta \boldsymbol{lnTR_{t-r}} + \sum_{n=1}^{q-1} \pi_n \Delta lnTXR_{t-n} + \lambda_5 ECT_{t-1} + \epsilon_{1t}$$

(12)

$$\Delta \boldsymbol{lnTXR_t} = \alpha + \sum_{i=1}^{p-1} \varsigma_i \Delta lnLCF_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnTI_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnRNE_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnEG_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnTR_{t-r} + \sum_{\boldsymbol{n=1}}^{\boldsymbol{q-1}} \boldsymbol{\pi_n} \Delta \boldsymbol{lnTXR_{t-n}} + \lambda_6 ECT_{t-1} + \epsilon_{1t}$$

(13)

3.2.5 Model's Stability Test and Diagnostics

The Breusch-Godfrey serial correlation test, the Breusch-Pagan-Godfrey heteroscedasticity test, and the Jarque-Bera normality test are used in this study to assess the model's validity, robustness, and reliability. A successful modeling procedure requires the execution of several diagnostic and stability tests. Furthermore, the model's reliability may be established in great part by the numerous experiments presented in this paper. Quantifying data association is crucial. This can be done by comparing the residual values to the expected values and showing their relative values. Alternatively, use a drawing. If the probability value and estimated F-statistics disagree, the null hypothesis is rejected. Finally, the Cusum and Cusum Square test are used to confirm the model file

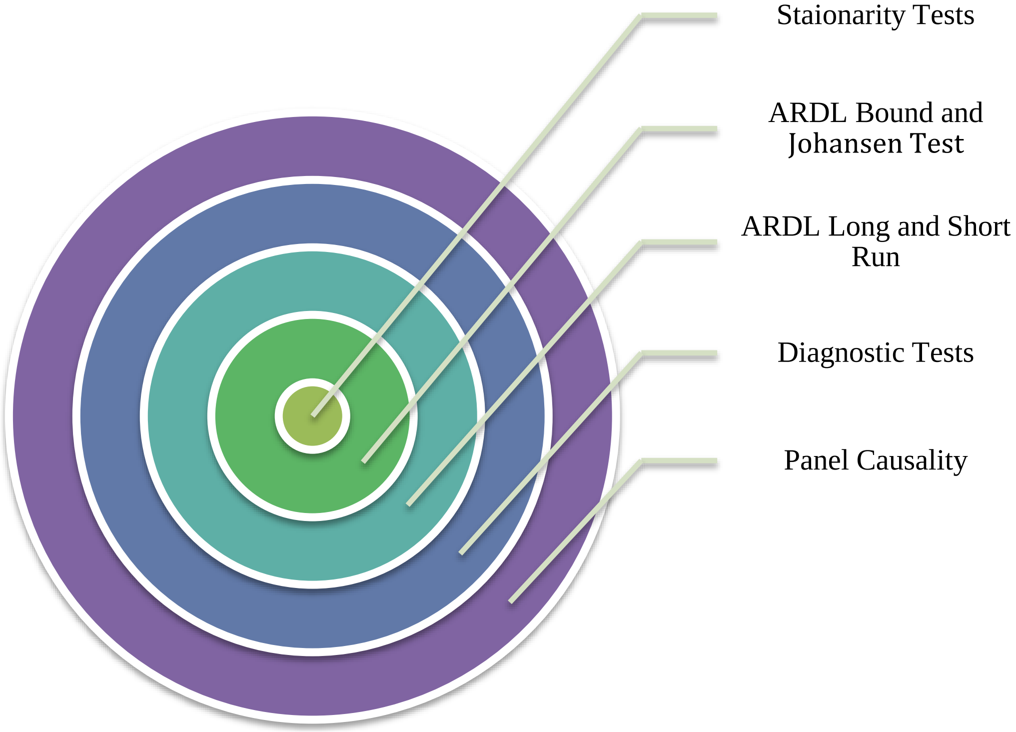


Figure 2 Flow of Analysis

CHAPTER IV
Results and Discussion

4.1 Descriptive Statistics

Table 2. shows the descriptive statistics of the LCF, TI, RNE, EG, TR, and TXR variables of study. The Mean of LCF, TI, RNE, EG, TR and TXR mean is 0.223, 7.819, 2.971, 11.236, 4.606, 2.186 and median is 0.226, 7.708, 2.930, 11.221, 4.584, 2.207 respectively. The Skewness for all variables is not zero and kurtosis is in between is less than 3. Moreover, the Jarque-Bera test null hypothesis of the normal distribution is rejected at a 1% significance level, indicating the series are not normally distributed. Therefore, we have used the ARDL econometric model to solve this problem of normal distribution.

Table 2 Descriptive Statistics

Variables	LCF	LTI	LRNE	LEG	LTR	LTXR
Mean	0.223	7.819	2.971	11.236	4.606	2.186
Median	0.226	7.708	2.930	11.221	4.584	2.207
Maximum	0.242	8.311	3.218	11.371	4.896	2.309
Minimum	0.200	7.387	2.840	11.114	4.333	1.993
Std. Dev.	0.012	0.282	0.115	0.087	0.185	0.081
Skewness	-0.196	0.506	0.876	-0.060	-0.069	-0.742
Kurtosis	1.795	2.055	2.508	1.516	1.578	2.642
Jarque-Bera	1.942	2.318	4.000	2.677	2.465	2.813
Probability	0.379	0.314	0.135	0.262	0.292	0.245
Sum	6.469	226.745	86.151	325.832	133.567	63.381
Observations	29	29	29	29	29	29

Source: Authors estimations

Note: LCF= load Capacity Factor, LTI = Logarithm of technological innovation, LRNE= Logarithm of renewable energy. LEG= Logarithm of economic growth, LTR = Logarithm of trade, LTXR = Logarithm of tax revenue.

4.2 Unit Root test results

To investigate the behavior of time series, this research employed the ADF, PP and AD-GLS unit root test. The results are presented in Table 3. The outcomes of the ADF, PP and AD-GLS estimators reveal that LCF, TI, RNE, EG, TR and TXR are not stationary at the level, however, all these variables are stationary at first difference.

Table 3 Unit Root Test

Variables	ADF Unit Root Test		PP Unit Root Test		AD-GLS Unit Root Test	
	Level	1st difference	Level	1st difference	Level	1st difference
LCF	-1.830	-6.638***	-1.986	-6.661***	-1.739	-1.869*
TI	-1.223	-7.149***	-1.223	-7.139***	-0.576	-7.264***
GDP	0.367	-4.130***	0.367	-4.095***	-0.153	-3.392***
TXR	-1.216	-9.782***	-1.520	-9.122***	-1.031	-2.606**
REW	1.145	-6.890***	0.543	-6.843***	0.290	-6.972***
TR	-0.599	-5.355***	-0.599	-5.712***	-0.332	-4.854***

Source: Authors Estimations

Note: ***, **, * denotes significance level at 1%, 5%, and 10% respectively.

4.3 The Cointegration estimation

This research investigated the existence of long-term association among the variables of the study. To do so this research thesis employed two econometric techniques namely, ARDL Bound test and Johansen Cointegration test. The outcomes of ARDL Bound Test and Johansen cointegration test are presented in Table 4 and Table 4 respectively. The outcomes of ARDL Bound test presents the F-statistic value (13.378), significant at 1% significance level. The test estimations of ARDL bound test rejects the null hypothesis of no long-term relationship among the variables. Hence, results suggest the existence of long-term association. Moreover, to check the robustness of results obtained by ARDL Bound test, this research employed the Johansen cointegration test. The outcomes of the Johansen cointegration test revealed existence of log term association among the variables for at most 1. Based on this the we employed ARDL model for the long and short run estimations.

Table 4 ARDL Bound Test

Test Statistic	Value	Sig.	I(0)	I(1)
F-statistic	13.37843	10%	2.26	3.35
k	5	5%	2.62	3.79
		2.50%	2.96	4.18
		1%	3.41	4.68

Source: Authors Estimations

Table 5 Johansen Cointegration test

No. of CE(s)	Eigenvalue	Trace-Statistic	Critical Value	P-Value
None *	0.803186	117.7788	95.75366	0.0007
At most 1 *	0.739312	73.89043	69.81889	0.0228
At most 2	0.441012	37.59082	47.85613	0.3202
At most 3	0.400893	21.88688	29.79707	0.3048
At most 4	0.253546	8.054364	15.49471	0.4596
At most 5	0.005871	0.158975	3.841466	0.6901

Source: Authors Estimations

4.4 ARDL long term estimations

Table 6 shows positive coefficient (0.035) of $\ln\mathrm{TI}(-2)$ with LCF at 5% significance level. 1% increase in the $\ln\mathrm{TI}(-2)$ boosts the environmental quality by 0.035% in long run in the context of Switzerland. This proposes the direct impact of $\ln\mathrm{TI}(-2)$ on the environmental quality. The results of this study are in line with Suki et al., (2022), who produced the negative link among TI, CO_2, and EF. They witnessed that the innovation in environmental technology produce more opportunities to develop the new innovative methods of producing renewable sources which are ecofriendly. Similar results have been witnessed by Muhammad Usman et al., (2022) in Pakistan, M. K. Khan et al., (2022) in Canada, and Haldar & Sethi, (2022) in 16 emerging countries. To this end the results emanate that the country has the potential to enhance and put more focus on the environmental technology to enhance the environmental quality. To do so, the country is doing its best such as the Switzerland Institutional Performance Index ranks second in the world, and the country leads the region and the globe in innovation outputs[1] such as "Switzerland federal technology institute ETH Zurich came forth in Europe[2]". Moreover, the Switzerland economy primary focus on the science and technology and government, private sectors, and environmental stakeholders are strongly promoting it. It is the prime sources of making Switzerland economy as the green and clean economy of the world at the very top of the list in terms of innovation around the world (Global Innovation Index Report, 2022). To this end, it is to conclude that in Switzerland economy is environmental technological innovation is the top tear to reduce the environmental hazards and helps to create clean atmosphere.

Moreover, the outcomes of ARDL estimator in the long run, show positive coefficient (0.090) of lnRNE with LCF at 1% significance level. In the context of Switzerland, a 1% rise in the lnRNE improves the environmental quality over time by 0.090%. This suggests that lnRNE directly affects the state of the environment. The outcomes are linked with Akam et al., (2021) in HIPC, and M. Ali & Seraj, (2022), in top ten FF and REC consuming nations. Similarly, Joof et al., (2023) while investigating the renewable energy impact on ecological footprint, witnessed the indirect association. They found that increase in the RNE increases the EF, hence, harming the environmental quality. Renewable energies lessen the adverse effects that human activities have on the environment and are seen as a useful instrument for achieving long-term economic development that is both sustainable and compatible with environmental preservation. In addition, renewables sources like wind, solar, and biofuel are the paths to clearing the ecosystem and particularly, to accomplish the objective defined in Sustainable development goals (SDG's) by the year 2030. To meet the desired objective under SDG's, recently, Switzerland is mainly focusing on the renewable energy sector. The Switzerland is transition process to transit fossil fuel and dirty sources of energy to renewable sources such as generating electricity and district heating system. However, since many decades ago, hydroelectric power has been Switzerland's most important source of renewable energy. This source is mostly used for the generation of electricity. Moreover, "New" sources of renewable energy such as "ambient heating, biomass, wind, and most particularly solar energy" have

[1] https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2022-en-main-report-global-innovation-index-2022-15th-edition.pdf
[2] https://www.Switzerlandinfo.ch/eng/business/global-ranking_five-reasons-why-switzerland-s-top-in-innovation/42375380

witnessed a substantial increase in recent years owing to scaled-up efforts that have been taken to encourage their use in country. Hence, country uses 25% renewable energy share out of total energy consumption[3]. This has been witnessed that renewable energy sources use in the country has been increase throughout the years such as since 1990 it has been rising at the 10% however, it remained stable in 2006 and again in 2020 it went to 27%. The country is consuming the renewable energy above the average of EU (19%) consumption but still below the Sweden and Finland 60%, and 44% respectively. Therefore, it can be suggested to the government, stakeholder, and other authorities of the country to invest capital in the renewable energy alternatives in the future and meet the total requirement of energy through the renewable energy sources rather than fossil fuels and dirty energy sources.

Furthermore, the results of the ARDL estimator in the long run reveal a negative coefficient (-0.074) of lnEG with LCF, although it is negligible. In the context of Switzerland, a 1% rise in the lnEG hampers the environmental quality over time by 0.074%, but association is not significant. This suggests that lnEG affects the state of the environment insignificantly negatively and demonstrates that the economic expansion that results from an increase in GDP has a negative impact on the environment in Switzerland by leading to an upsurge in the LCF. The outcomes are linked with Ramzan et al., (2023) who employed “non-parametric causality-in-quantiles algorithms” in the case of US. They found that economic growth has a negative impact on the environment. It hampers the environment as the US boosts the economy. Similar results have been obtained by Akam et al., (2021) and M. Ali & Seraj, (2022) in the case of “Heavily indebted poor country” (HIPC) and “top ten fossil fuel consuming and top ten renewable energy consuming countries”, respectively. Therefore, the results advocate that economic growth in the Switzerland help the each unit of the business and economic sector. So, it contributes to an increase in both industrial output and commercial operations, but at the cost of quality of environment. Putting otherwise, the expansion of economic activity will, over the course of time, result in a higher level of environmental deterioration.

In addition, the findings reveal a negative coefficient (-0.085) of lnTR with LCF being significant at the 1% level. This produce that a 1% rise in the lnTR the environmental

[3] https://www.eda.admin.ch/aboutswitzerland/en/home/wirtschaft/energie/die-erneuerbaren-energien.html

quality of the Switzerland will be hampered by 0.085%. The findings witnessed that environmental quality of the country is worsened if trade growth incurred in the long run. The outcomes are integrated with Ramzan et al., (2023) in HIPC, M. Ali & Seraj, 2022, in top ten FF and REC consuming nations, and Muhammad et al., (2020) "across 65 belt and road initiative countries". So, the expansion of commercial operations encourages economic development and industrial activity, both of which contributed to a rise in ecological contamination. Therefore, the Switzerland economy, economists, and policymakers must consider the component of environment degradation while forming the strategies to boost the economic activities and growth.

Finally, ARDL findings produce the positive coefficient (0.233) of TXR with LCF, at 1% significance level. It witnessed that a 1% increase in TXR increase environmental quality by 0.223%. Therefore, it is concluded that collection of tax revenue by the government produce an opportunity to invest in clean and green environment. The results are in line with Akam et al., (2021) who witnessed the similar results in the case of Pakistan. Similar, outcome have been obtained by Ramzan et al., (2023) studied the government tax revenue and EFP in US economy. So, it can be inferred that Switzerland's tax income (Income) is sufficient to pay an adequate amount of environmentally friendly and clean projects that help to the reduction of environmental dangers. This also indicates that the tax collecting mechanism in the nation is robust enough and well-implemented enough to collect the revenues and to deploy adequate resources in incentivizing the adoption of sustainable energy for the purpose of environmental preservation in Switzerland.

Table 6 ARDL long-run estimation

Variables	Coefficient	Std. Error	t-Statistic	P-Value
$\ln\mathrm{TI}(-2)$	0.035**	0.016	2.230	0.048
lnRNE	0.090***	0.025	3.573	0.004
lnEG	-0.074	0.061	-1.213	0.251
lnTR	-0.085***	0.018	-4.804	0.001
lnTXR	0.233***	0.050	4.687	0.001

Source: Authors estimations

$\ln\mathrm{TI}(-2)$ stands for the logarithm of the lag of technological innovation, lnRNE = refers to logarithm of renewable energy, lnEG stands for the logarithm of economic growth, lnTR presents the logarithm of trade, and lnTXR denotes the logarithm of the tax revenue.

4.5 ARDL Short run estimations

Table 7 displays the ARDL estimator's short-term performance. The results show that at the 1% level of significance, the coefficients of ln(-2)TI (0.019) and ln(-2)TXR (0.042) are both positive and significant with LCF. This indicates that in the short-term context of Switzerland, the lag of technical innovation and current tax revenue collection are the major essential source to reduce environmental degradation and enhance the quality index of environment. Both (Akam et al., 202; Ramzan et al., 2023) and (Akam et al., 202) agree with the findings. The lnRNE is negative (-0.031), although this is not a major concern in the near term. This finding shows that, soon, renewable energy won't be enough to solve the environmental crisis. Ramzan et al., (2023) corroborate the findings; they found a similar correlation while studying the economy of the United States. Thus, Switzerland's usage of renewable energy is insufficient to significantly aid in the conservation of natural resources and the mitigation of environmental degradation.

Moreover, ΔlnEG have negative coefficient (-0.130) with LCF, significant at 5% significance level. The outcomes of this research are in line with previous literature such as (Liang & Yang, 2019; Ozcan et al., 2020; Shauku Kihombo et al., 2022; Shafique et al., 2021)) in "China, OECD Economies, West Asian and the Middle East (WAME) nations, and 10 Asian economies". To this end, the government, environmentalist, policymakers, economists, and environmentalists should take into consideration environmental factors, affecting the environment quality positively and negatively in short term, while formulating and implementing the projects, polices, and related initiatives in the short run.

Table 7 ARDL short-run estimation

Variables	Coefficient	Std. Error	t-Statistic	P-Value
C	0.377***	0.035	10.784	0.000
$\Delta \ln TI(-2)$	0.019**	0.006	3.053	0.011
$\Delta \ln RNE$	-0.031	0.019	-1.605	0.137
$\Delta \ln EG$	-0.130**	0.046	-2.837	0.016
$\Delta \ln TXR$	0.042**	0.020	2.166	0.053
$ECT(-1)$	-0.972***	0.090	-10.805	0.000

$\ln TI(-2)$ stands for the logarithm of the lag of technological innovation, lnRNE = refers to logarithm of renewable energy, lnEG stands for the logarithm of economic growth, lnTR presents the logarithm of trade, and lnTXR denotes the logarithm of the tax revenue.

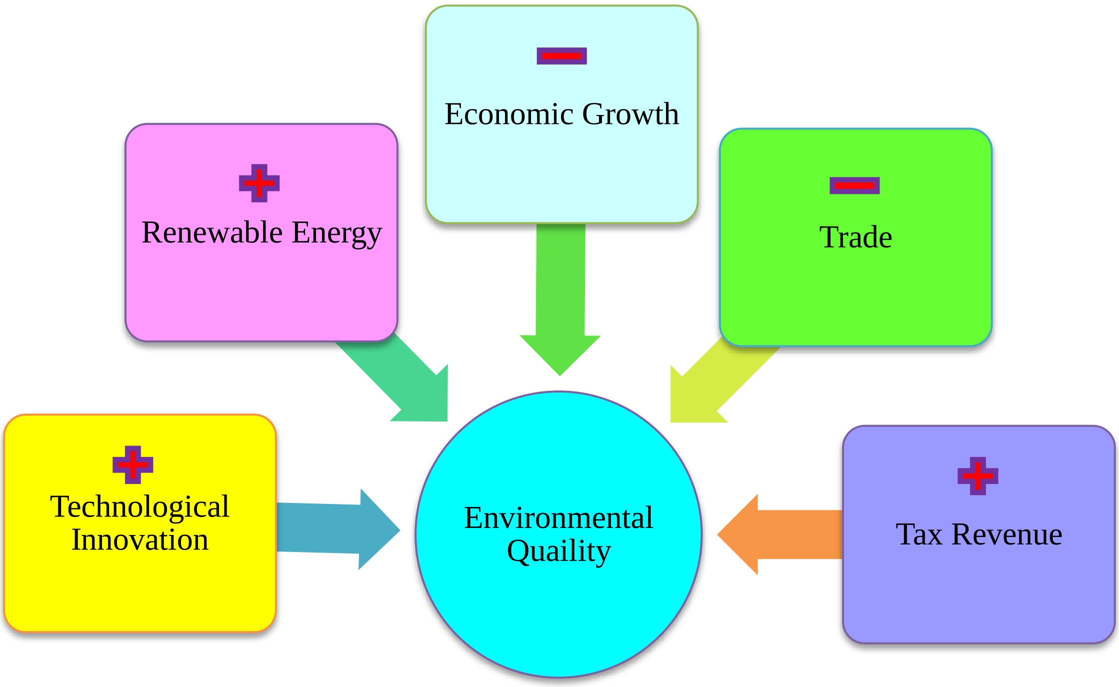


Figure 3 Graphical long-term results

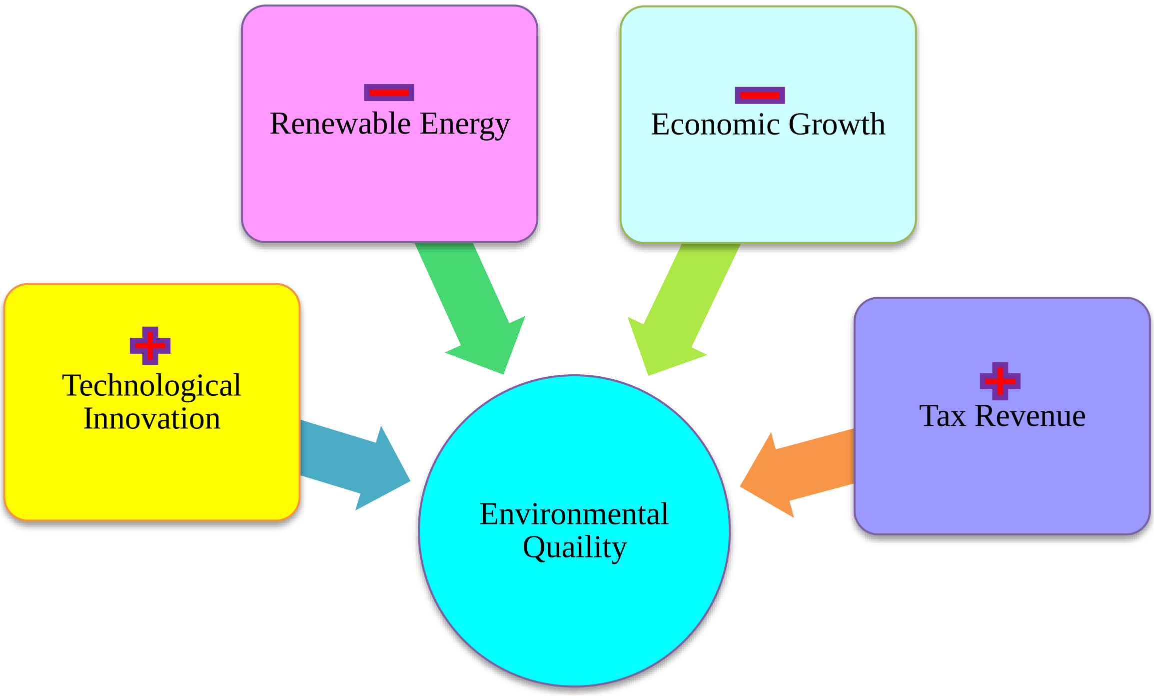


Figure 4 Graphical Short-term results

4.6 Variance Decomposition

Table 1. presents the variance decomposition analysis. The outcomes show that LCF decreases throughout the period ranging from 1 to 10. It witnesses the increase quality of environment in the long run, in case of Switzerland economy. Moreover, economic growth boosts the Switzerland environmental quality throughout the time. It denotes that technological innovation is a major player of the reducing environmental hazards and enhances the clean and green environment with pure air in ecology. However, renewable energy and tax revenue play a major role in reducing the environmental harms from lower to mid of the time period, but the effect reduces later on up to period 10. The economic growth influence increases from period 1 to period 8, however, it reduces the in 9th and 10th period. Hence, the outcomes of variance decomposition analysis validated the ARDL.

Table 8 Variance Decomposition Analysis:

Period	S.E.	LCF	lnTI	lnRNE	lnEG	lnTR	lnTXR
1	0.006	100.000	0.000	0.000	0.000	0.000	0.000
2	0.007	88.388	0.493	0.093	5.411	0.737	4.878
3	0.009	65.729	4.396	6.089	8.799	0.641	14.345
4	0.010	59.376	3.731	13.712	10.751	0.595	11.835
5	0.011	55.212	4.192	15.248	12.810	1.338	11.200
6	0.012	49.420	9.995	16.182	13.004	1.325	10.075
7	0.012	47.384	12.599	15.887	13.028	1.382	9.719
8	0.012	44.852	16.715	15.052	12.329	1.334	9.718
9	0.012	42.762	19.988	14.454	11.884	1.299	9.613
10	0.013	40.849	21.689	14.276	11.785	1.380	10.020

Source: Authors compilation

Note: S.E = standard error, LCF = load capacity factor, lnTI = logarithm of technological innovation, lnRNE = logarithm of renewable energy, lnEG = logarithm of economic growth, lnTR = l logarithm of trade, and lnTXR = logarithm of tax revenue.

4.7 Diagnostic estimation

Table 9 presents the diagnostic test results. The Autoregressive conditional heteroskedasticity (ARCH) test shows that there is no serial autocorrelation in the times series. Moreover. Breusch-Pagan-Godfrey test results show that the p values of F-statistic (0.0066) and T-statistic (0.0818) are greater than 5% significance level. Hence results reject the null hypothesis of the no homoscedastic. Moreover, results of serial correlation test show that P-value (0.0615) of the F-statistic (4.625) is greater than 5% significance level. It shows that null hypothesis is accepted, and alternate hypothesis is rejected, implying that the time series is free from auto correlation.

Table 9 Diagnostics Tests

Heteroskedasticity Test: Breusch-Pagan-Godfrey		
	F-statistic	P-Value
	0.692	0.738
Breusch-Godfrey Serial Correlation LM Test:		
	F-statistic	P-Value
	4.625	0.062
Heteroskedasticity Test: ARCH		
	F-statistic	P-Value
	0.010	0.920
Ramsey RESET Test		
	t-statistic	F-statistic
	0.082	0.007
	P Value	P Value
	0.936	0.936

Source: Authors compilation

4.7 Pairwise granger causality

The results of the paired Granger Causally test is presented in Table 10. If and only if the two variables have an impact going in both directions, then the results are said to have a bidirectional relationship. When there is no distinct direction to the impact traveling from one variable to another, the result is considered non-directional. Therefore, if the probability value is greater than 5%, the null hypothesis should be accepted, and if it is less than 5%, the test should be rejected. There is unidirectional causality between lnTI and LCF, as indicated in the table, with a p-value of 0.05 indicating that lnTI causes the LCF. Additionally, the data demonstrates unidirectional causality between lnRNE and LCF. Furthermore, there is no evidence linking lnEG, lnTR, or lnTXR to LCF.

Table 10 Pairwise Granger Causality Tests

Null Hypothesis:	F-Statistic	Prob.
lnTI does not Granger Cause LFC	3.705	0.041
LCF does not Granger Cause lnTI	0.830	0.449
lnRNE does not Granger Cause LCF	0.465	0.635
LCF does not Granger Cause lnRNE	5.284	0.013
lnEG does not Granger Cause LCF	1.025	0.375
LCF does not Granger Cause lnEG	0.846	0.443
lnTR does not Granger Cause LCF	0.402	0.674
LCF does not Granger Cause lnTR	0.061	0.941
lnTXR does not Granger Cause LCF	0.555	0.582
LCF does not Granger Cause lnTXR	1.469	0.252

Source: Authors compilation

Note: LCF = load capacity factor, , lnTI = logarithm of technological innovation, lnRNE = logarithm of renewable energy, lnEG = logarithm of economic growth, lnTR = l logarithm of trade, and lnTXR = logarithm of tax revenue.

4.8 Stability Test

As can be seen in Figures 4.2 and 4.3, our model's coefficients are stable because both the cumulative sum of squares and the cumulative sum of residuals remain inside the red lines.

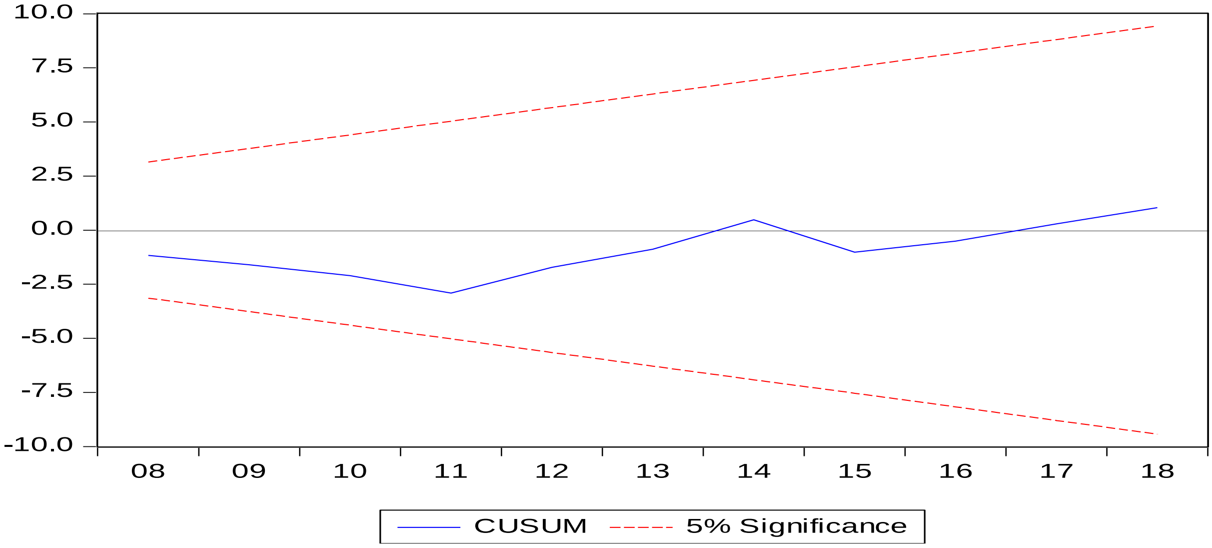


Figure 5 CUSUM Test

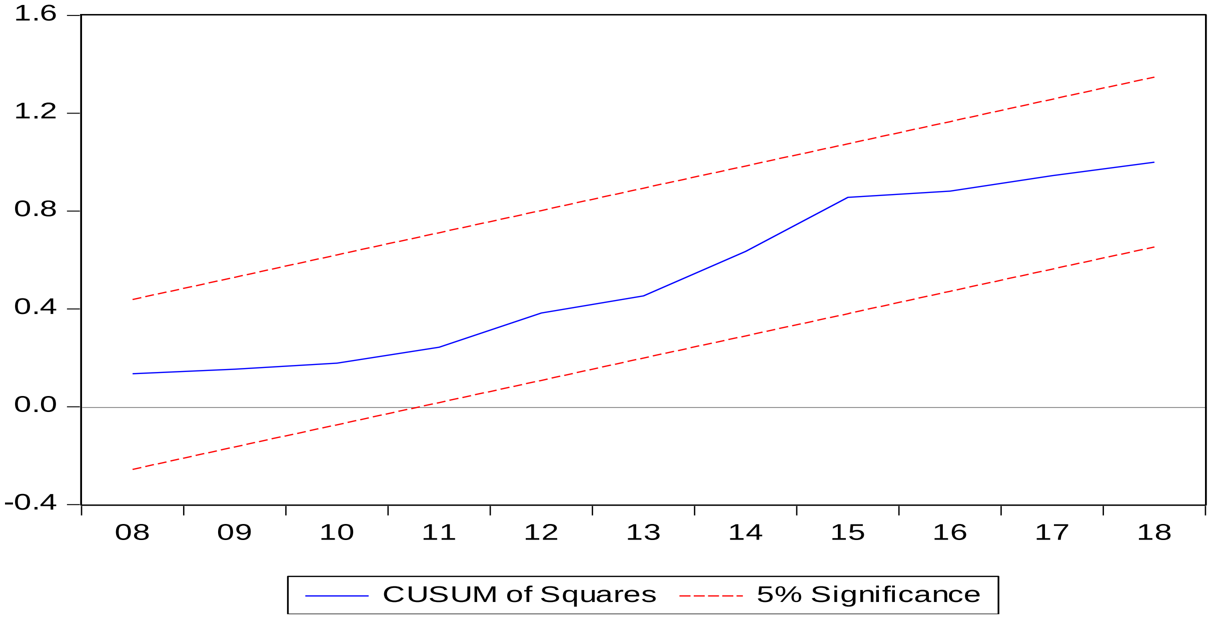


Figure 6 CUSUM SQUARE Test

CHAPTER V
Conclusion and Policy remarks

5.1 Conclusion

We use the phrase "climate change" to describe long-term shifts in weather patterns such as average temperatures and precipitation rates. It's possible that the solar cycle and other natural phenomena are responsible for these movements. Yet, since the 1800s, human activity has been the primary cause of climate change. The burning of fossil fuels like coal, oil, and gas is largely to blame for this. When we burn fossil fuels, we release greenhouse gases into the atmosphere. By acting like a blanket to lock in the sun's heat, these pollutants are contributing to the planet's warming trend.

Thus, this research examines the impact of technical advancement, renewable energy, economic growth, trade, and tax income on Switzerland's environmental quality using time series data from 1990 to 2020. The data trend was analyzed with stationary tests. We use the Johansen co-integration test and the ARDL. In addition, the "Auto Regressive Distributed Lag" (ARDL) model is used to examine the long- and short-term relationship between the TI, RNE, EG, TR, TXR, and LCF.

Results from the ARDL estimator reveal that the TI, RNE, and TXR all have positive and statistically significant coefficients with LCF in the long run. When comparing the effects of TI and RNE, tax revenue emerges as a clear winner in terms of environmental impact. Results show that EQ is negatively associated with EG and trade. Thus, results show that Switzerland's growing economy and increased commerce reduces environmental quality.

The coefficient of the TI and TXR is positive and significantly associated with LCF, as shown by the results of the ARDL estimator in the abstract. When comparing the effects of TI and RNE, tax revenue emerges as a clear winner in terms of environmental impact. According to the data, both economic expansion and the use of alternative energy sources have negative and statistically significant coefficients in relation to ecological well-being. Thus, results show that Switzerland's growing economy and increased commerce reduces environmental quality.

5.2 Recommendation and policy implication

The Swiss economy is advised to consider the following recommendations and policy implications considering the findings. Switzerland's economic stakeholders, lawmakers, and environmentalists are first urged to increase R&D spending to foster technological innovation. By doing so, we can create renewable energy sources that are less harmful to the environment. Second, the Swiss economy must prioritize the shift away from fossil fuels and toward renewable, sustainable energy. Capital investment in renewable initiatives, such as Solar energy projects, hydro energy projects, and wind energy projects, should receive higher priority from the country's government. Third, government tax is essential because it funds clean and green projects, which improves environmental quality. The Swiss government may benefit from a more efficient and effective tax collection system to increase the amount of money available for use in environmentally friendly endeavors. To achieve long-term economic growth and boost international trade, Switzerland must seriously investigate using renewable energy sources.

Finally, this study suggests the potential limitations and gaps in future research. As a first step, additional environmental elements including FDI, RD, HC, pop, and gov't debt might be incorporated into this model to further improve it. Second, this study only covers the Swiss economy, thus similar studies in other countries would be needed to generalize the findings. Third, while the emphasis here is on numbers, qualitative and quantitative methods can be used together to probe the connection if necessary. In addition, since this study makes use of time series data, panel and cross-sectional data can be used to verify the findings in the future. Finally, we utilized a time range from 1990 to 2020 because that was all the data we could find; other researchers, depending on the availability of data in their own nations, may choose to use a longer time period.

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Appendices

Appendix A

Turnutin Report

Thesis

ORIGINALITY REPORT

15%	11%	8%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	docs.neu.edu.tr Internet Source	5%
2	Ugur Korkut Pata, Ahmed Samour. "Assessing the role of the insurance market and renewable energy in the load capacity factor of OECD countries", Environmental Science and Pollution Research, 2023 Publication	1%
3	Tomiwa Sunday Adebayo, Ahmed Samour. "Renewable energy, fiscal policy and load capacity factor in BRICS countries: novel findings from panel nonlinear ARDL model", Environment, Development and Sustainability, 2023 Publication	1%
4	Xuan Liu, Victoria Olushola Olanrewaju, Ephraim Bonah Agyekum, Mohamed F. El-Naggar, Mohammed M. Alrashed, Salah Kamel. "Determinants of load capacity factor in an emerging economy: The role of green energy consumption and technological	<1%

Appendix B

Etical communite Report

NEAR EAST UNIVERSITY

SCIENTIFIC RESEARCH ETHICS COMMITTEE

05.06.2023

Dear Prof. Dr. Turgut Tursoy

Your project **"INFLUENCE OF ECONOMIC GROWTH, TECHNOLOGY, ENERGY, AND TAX REVENUE IN THE SWITZERLAND:EVIDENCE FROM ARDL MODEL"** has been evaluated. Since only secondary data will be used the project does not need to go through the ethics committee. You can start your research on the condition that you will use only secondary data.

Prof. Dr. Aşkın KİRAZ

The Coordinator of the Scientific Research Ethics Committee