The Impact of Lending Interest Rates on Air pollution: The Case of Lebanon

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ABSTRACT

The purpose of this thesis is to determine the association among various variables, including CO_2 emissions, GDP, energy usage, and loan interest rates in Lebanon, within the time frame of 1990 to 2019. To do so, the Autoregressive Distributed Lag (ARDL) approach will be utilized to achieve the goal of the study. The results reveal the existence of a long-term equilibrium relationship (co-integration) between the variables under investigation, namely carbon dioxide emissions, energy consumption, economic growth, and lending interest rates. There is a positive relationship between energy consumption, economic growth, and carbon dioxide emissions, indicating that an increase in economic growth leads to higher energy consumption, which in turn results in increased carbon dioxide emissions. Conversely, GDP^2 and the lending interest rate (LIR) show a negative correlation. Increasing economic growth leads to more energy consumption, which in turn leads to increased carbon dioxide emissions. The environmental pollution is significant problem in Lebanon. Since the average CO_2 emissions in Lebanon is 0.5 kg per 2015$ of GDP, while the global average is 0.3. Hence, the search for clean and low-carbon energy sources (renewable energy) has become an urgent matter, especially since Lebanon possesses water and solar resources that can be harnessed. Thus, it will achieve many goals, including reducing carbon emissions, achieving sustainable levels of growth, preserving the environment, lowering local energy prices, and enhancing welfare.

Keywords: Carbon Dioxide Emission CO_2, Energy Consumption, Economic Growth, Lending Interest Rate.

ÖZ

Bu tezin amacı, 1990 ile 2019 arasındaki zaman dilimi içinde Lübnan'daki çeşitli değişkenler arasındaki ilişkiyi belirlemektir. Bu değişkenler arasında CO2 emisyonları, GSYİH, enerji tüketimi ve kredi faiz oranları bulunmaktadır. Bu amaç doğrultusunda, çalışmanın hedefine ulaşmak için Otoregresif Dağıtılmış Gecikme (ARDL) yaklaşımı kullanılacaktır. Sonuçlar karbondioksit emisyonları, enerji tüketimi, ekonomik büyüme ve kredi faiz oranları arasında uzun vadeli denge ilişkisi (eşbütünleşme) bulunduğunu göstermektedir. Enerji tüketimi, ekonomik büyüme ve karbondioksit emisyonları arasında pozitif bir ilişki bulunmaktadır, bu da ekonomik büyümenin artmasının daha yüksek enerji tüketimine yol açtığını ve bunun da artan karbondioksit emisyonlarına neden olduğunu göstermektedir. Bununla birlikte, GSYİH ve kredi faiz oranı (KFO) negatif bir ilişki göstermektedir. Ekonomik büyüme arttıkça daha fazla enerji tüketimine yol açar, bu da artan karbondioksit emisyonlarına neden olur. Çevresel kirlilik Lübnan'da önemli bir sorundur çünkü Lübnan'daki ortalama CO2 emisyonu, GSYİH başına 2015 doları için 0.5 kg iken, küresel ortalaması 0.3'tür. Bu nedenle, Lübnan'ın kullanabileceği su ve güneş kaynaklarına sahip olmasından dolayı, temiz ve düşük karbonlu enerji kaynaklarına (yenilenebilir enerji) yönelme acil bir konu haline gelmiştir. Bu nedenle, karbon emisyonlarını azaltma, sürdürülebilir büyüme düzeylerine ulaşma, çevreyi koruma, yerel enerji fiyatlarını düşürme ve refahı artırma dahil olmak üzere birçok hedefe ulaşılacaktır.

Anahtar Kelimeler: Karbon Dioksit Emisyonu CO2, Enerji Tüketimi, Ekonomik Büyüme, Borç Verme Faiz Oranı.

To my father and my mother

To my brothers and sisters

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I would like to record my gratitude to ASSIST. PROF.DR. NİGAR TAŞPINAR for her supervision, advice,guidance and encouragement to complete this dissertation.

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Chapter 1

INTRODUCTION

1.1 Brief Introduction

In the past few decades, the world has witnessed environmental deterioration, represented by pollution and global warming. Researchers and environmental experts agree that the high energy demand in economic activities like transportation, industry, and other necessities for development and further accelerating economic growth is what leads to environmental deterioration. This growth is sought in all countries, especially in the major industrialized ones. The use of chemical fertilizers, burning of forests, and excessive usage of fossil fuels have all contributed to an increase in greenhouse gas emissions, particularly carbon dioxide and methane. This has caused health issues for populations and incurred significant costs for governments as a result of the harmful emissions and the high concentrations of carbon in the atmosphere. This has prompted governments worldwide to conclude agreements and put arrangements in place to mitigate global warming and environmental pollution. This effort culminated in the Kyoto Agreement in 1992 and the 2015 Paris Agreement, which aimed at reducing the Earth's temperature to two degrees above pre-industrial levels United Nations Framework Convention on Climate Change, (Paris, 2015). Achieving the 2°C target would require 1.7 tons of CO2-eq. per capita of greenhouse gas emissions by 2050. In order to do this, it has gone through a transitional process, which included the replacement of high-carbon energy sources such as fossil fuels by low-carbon renewable energy such as solar energy, hydro energy, and wind energy.

Following the problems caused by pollution and the alarming rise in global temperatures, a debate has arisen among scientists regarding energy consumption in economic activities and its relationship to economic growth. This has led to the question posed by Al-Hasanin (2021) of whether energy consumption accelerates growth or if growth increases energy consumption.

As argued by the EKC, as industry grows, environmental contamination increases and then gradually decreases as income increases. It increases due to the nature of the relationship that these factors share, which is represented in the form of an inverted U-shape. Figure 1 depicts the relationship between economic expansion and environmental pollution as an inverted U shape using the Environmental Kuznets Curve (EKC).

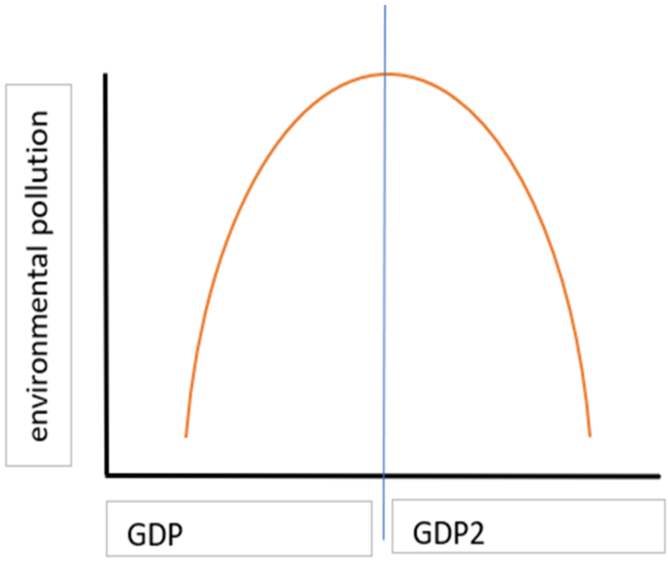


Figure 1: EKC

The lending rate, which represents a percentage of the amount deposited, is the rate of interest charged by financial organizations, such as banks, when someone borrows money for a certain period.

The relationship between lending interest rates and air pollution is mediated by various economic, technological, and policy factors. Lower interest rates can potentially stimulate economic activity and consumption patterns that lead to increased pollution. Lending interest rates can indirectly affect air pollution through their impact on economic activity, investment decisions, and government policies.

Low interest rates typically make it simpler and more cost-effective for firms to borrow money to finance their investments. This can simulate economic growth and investment in many projects, including those that could have a big impact on the environment. For example, a low interest rate environment may encourage investment in fossil fuel extraction or the construction of new coal-fired power plants, both of which can increase greenhouse gas emissions. Conversely, higher interest rates can make it more difficult and expensive for businesses to borrow money. This can act as a deterrent to investment in certain projects, including those that may have environmental consequences on the long-term. Due to the profitability of these projects, higher interest rates may also encourage business to invest in more sustainable and environmentally friendly alternatives (Isiksal et al., 2019).

It must be noted that there are a number of factors, e.g., government policies and regulations, technological advancement as well as the preferences of consumers, which can influence the relationship between interest rates on loans and CO2 emissions. However, the cost of borrowing is certainly an important consideration for businesses when making investment decisions, and changes in interest rates can have a significant impact on the types of projects that are pursued and their environmental impact (Li et al., 2014).

Energy use often rises as the economy grows because consumers and companies demand more goods and services. A rise in emissions during the processes of manufacturing and transportation may result from the growing demand for goods and services (Tang et al., 2018). However, economic growth can also lead to increased investment in technology and infrastructure, which can improve energy efficiency and reduce emissions. For instance, as economies grow, they might make investments in cleaner and more effective energy sources like nuclear, solar, or wind. Additionally, as incomes rise, individuals may be willing to pay more for cleaner and more sustainable products and services, which can incentivize businesses to adopt more environmentally friendly practices (Zhang, 2021).

Interest rates under the Green Credit Framework, by providing low interest loans to companies that take environmental conservation and energy efficiency measures as their main priority, contribute greatly to preventing pollution. However, carbon dioxide emissions associated with energy usage can be reduced by increasing investments in clean energy sources and energy efficiency measures, as mentioned above (Akpan & Akpan 2011).

There are those who believe that environmental management (environmental governance) plays a significant role in determining the interest rates in banks. For example, in China, samples were taken from highly polluting companies and artificial intelligence was utilized to study and examine the connection between interest rate setting and environmental governance. The results showed a negative impact of governance on the setting of interest rates in banks. (Yi & Fang 2021).

Others also believe that the rate of lending increases pollution and is affected by the surrounding socio-economic conditions. There are also banks that rely on low-carbon assets and facilitate contract terms for financing clean and low-carbon activities (Böser et al., 2020).

Despite the widespread interest in recent decades in studying and analyzing the causal relationship between environmental degradation caused by emissions and economic growth, some countries ignore the issue. - Lebanon is one of these countries. It is one of the developing countries that is making great efforts to develop its economy and work towards benefiting from its energy resources, such as natural gas, in order to achieve self-sufficiency and economic growth.

The lending interest rate in Lebanon was very high due to the country's ongoing economic crisis. At that time, the central bank's benchmark interest rate was 10%. However, commercial banks were charging significantly higher rates for loans, reaching up to 25% or even more. This high lending rate was largely a result of the country's currency devaluation, hyperinflation, and political instability, which made it difficult for banks to access foreign currency and caused a shortage of liquidity in the banking system.

Lebanon, as other countries, faces the problem of environmental pollution caused by carbon dioxide emissions and other emissions resulting from the use of energy resources during industrial processes to produce goods and services.

The issue of environmental pollution brought on by carbon dioxide emissions and other pollutants originating from the use of energy resources in industrial processes to generate goods and services is one that Lebanon, like other countries, must deal with. Lebanon is considered one of the poorest countries in terms of energy resources and oil derivatives. It depends on importing energy from abroad, especially from the Gulf countries, at preferential prices because of its unstable economic conditions as a result of political factors. Energy is used in Lebanon for fuel, heating, and generating electricity. The transportation sector consumes approximately 43% of the energy in Lebanon. According to the statistics from LCA (2015), the annual number of imported cars was approximately 100,000. As a result of the weakness of the public transportation sector, individuals depend on private transportation. This encouraged Lebanese to obtain soft loans to purchase private cars. This increases the rate of pollution in the environment, in addition to other pollutants resulting from fossil fuels used in agriculture and the electricity sector. On the other hand, there are other untapped sources of energy in Lebanon, such as hydropower and wind energy. The transition from traditional fossil energy to alternative energy is still very weak, despite the state's attempts to encourage the private sector to invest in alternative energy and try to search for clean, low-carbon energy sources.

This thesis' main goal is to investigate how lending interest rates affect Lebanon's carbon dioxide (CO2) emissions. The ARDL (Autoregressive Distributed Lag) approach will be used in the thesis for time series from 1990 to 2019 to analyze the dynamic correlation between CO2 emissions and GDP in Lebanon. Enerdata and the World Bank's respective data sets will also be used. The importance of this thesis stems from the fact that one of the priorities of countries is to achieve sustainable economic development, economic growth, and its acceleration. This can only be achieved through increasing energy consumption, thus increasing the demand for it.

To achieve valid and significant results in this study, the researcher begins by using preliminary (stability) tests such as conventional unit root tests, Dickey-Fuller, and Phillips-Peron tests. Then he describes the model and chooses the appropriate logarithm for analysis. Next, he conducts post-tests such as the pound test for both long and short-term tests, followed by correlation tests for Heteroscedasticity. The following sections compose the chapters of this study: Chapter 2 summarizes prior literature review; Chapter 3 analyzes the data and presents the methodology; Chapter 4 describes the results of the experiments; and Chapter 5 concludes the thesis.

Chapter 2

LITERATURE REVIEW

The relationship between environmental pollution and economic growth is commonly measured by the Environmental Kuznets Curve hypotheses EKC. The first scholars to measure this relationship were Grossman and Krueger (1991). After that, many studies were conducted by numerous researchers to enrich the economic literature in this regard.

The hypothesis states that environmental pollution initially increases and then decreases as income increases, following an inverted U-shaped relationship. Most studies focus on whether or not this hypothesis exists within the framework of the ongoing discussion on the applicability of the Environmental Kuznets Curve hypothesis. Some studies on this subject have yielded inconsistent results. For example, Eyup Dogan and Roula Inglesi-Lotz (2019) did not find the Kuznets hypothesis applicable to their study. On the contrary, Adeel- Farooq et al. (2020) found that economic growth is an important factor for emissions, thus confirming the credibility of the Environmental Kuznets Curve (EKC) hypothesis. In addition, Kong and Khan (2019) confirmed the hypothesis of the EKC that emissions come from industrial gases and construction activities.

A number of studies and their findings will be presented in this thesis to demonstrate the applicability of the hypothesis in different fields and contexts.

Freire et al. (2023) investigated the relationship between economic growth and greenhouse gas emissions in Brazilian states using the hypothesis. The results are consistent with the EKC hypothesis, showing an inverted U-shaped correlation between CO2 emissions (quadratic form of GDP per capita) and an N-shaped relationship between N2O emissions (cubic form of GDP per capita). In another study by Gokmenoglu and Taspinar (2018), they found that CO2 emissions in Pakistan are positively and elastically influenced by GDP, while energy consumption and agricultural value added have positively but inelastically impacted CO2 emissions. The squared of GDP, conversely, has negatively and inelastically affected CO2 emissions.

Many researchers extensively applied the EKC approach to test the relationship nature between many variables and factors in various studies, including environment and income. For instance, utilizing an environmental footprint, Al-Mulali et al. in 2015 studied thoroughly 93 countries with varying incomes in an attempt to test the EKC's applicability. The results discussed that in high-income countries, an inverted U-shaped relationship exists between the GDP and the environmental footprint. Besides, Akbostancı et al. (2009) studied the relationship between carbon dioxide emissions and per capita income, as well as air contamination and income relationship nature in Turkey. Utilizing the panel data, the analysis results showed a consistent relationship between income and carbon emissions over the long term when using time series. The Kuznets hypothesis is not, however, applicable to the study of Turkish provinces using panel data because the results display an N-shaped correlation.

In the United Arab Emirates (UAE), Sabia et al. (2014) did research in regards to gross domestic production (GDP) and what kind of implications it had on energy usage, urbanization, and environmental degradation. According to the research, there is a U-shaped association between economic growth and carbon dioxide emissions. Diao et al. (2009) utilized an academic approach to analyze what kind of relationship both environmental degradation and economic advancement have in Jiaxing, China. The analysis results presented show that the connection between environmental quality and GDP is not adequately captured by the EKC. The connection is more complicated than is commonly perceived, and because the economies and countries are diverse, so are the points of value. For instance, a study by Bodin (2022) conducted in several European countries, including Sweden, Austria, and Portugal, examined the presence of the Environmental Kuznets Curve in these countries. This study indicated that the curve does not exist in all of these countries, but there is a similar curve to the Environmental Kuznets Curve in Sweden and Austria.

Furthermore, Sriyalatha (2019) examined the existence of Kuznets curves in South Asian countries. The results showed that the Kuznets curve appeared in different forms in the countries under study, including countries in which the curve appeared in the form of N-shaped curves and others in the form of U-shaped curves. Fridhi, B. (2019) analyzed variables that influence economic advancement in both North Africa and the Middle East (MENA) region using the EKC hypothesis. According to this study, the amount of natural gas emitted into the atmosphere is positively related to the consumption of electricity and energy and the per capita GDP of Kuwait, which, in turn, naturally affects the amount of natural gas emitted into the atmosphere. Gill et al. (2018) evaluated the validity of the Environmental Kuznets Curve hypothesis (EKC) for environmental pollution problems. According to the evaluation results, significant resources were required, and a substantial environmental cost that may not be sustainable was incurred.

The relationship between Pakistan's GDP, energy usage, and CO_2 emissions was studied by Khan et al. in 2020. The study's findings showed that both energy demand and GDP growth lead to a rise in CO_2 emissions in the short and long term. Khobai and Le Roux (2017) also looked at the connections between South Africa's energy use, economic growth, carbon dioxide emissions, urbanization, and trade openness.

Based on the study's findings, it was perceived that each of the following factors, namely, urbanization, energy usage, economic advancement, CO_2 emissions, and trade openness, share a two-way causal relationship along with a long-run one. The study findings discussed that energy usage and consumption result in the release of CO_2, the promotion of trade openness, and the growth of urban areas as well. Adom et al. (2012) also investigated the causal relationship in the short and long term between carbon dioxide emissions, economic growth, efficient technology, and industry structure in Morocco and Ghana. The results showed evidence for two types of equilibrium relationships, the first of which was identified as multiple long-run equilibrium relationships, which was relevant to the cases of both countries, Ghana and Senegal. On the other hand, a one-way long-run relationship was identified in the case of Morocco.

Another study by Wang et al. (2016) investigated the relationship between economic growth, energy use, and CO_2 emissions in China over a span of 23 years, focusing on the temporal nexus and the casual connection between these factors. The findings showed that there was a long-term, integrated connection. In some provinces of China, the nexus of GDP growth and energy usage was examined by Fei et al. in 2011. The findings indicated that the effects of energy consumption, GDP growth, and emissions are positively and efficiently correlated in the longer term.

Another study was conducted in eastern Asia, in particular South Korea, in 2013 by Park and Hong. The study examined the relationship between economic growth, energy consumption, and carbon dioxide emissions in South Korea. The results revealed a strong correlation between economic growth and energy consumption, particularly the use of fossil fuels, which cause carbon dioxide emissions. In Thailand and Malaysia, Anatasia (2015) also examined what kind of connection exports, energy consumption, GDP, and CO2 emissions have. The results revealed a one-way causal relationship extending from exports to carbon dioxide emissions, GDP to carbon dioxide emissions, and GDP to energy consumption in Thailand. A one-way causal correlation between consumption of energy and emissions of carbon dioxide, as well as between exports and carbon dioxide emissions, was also discovered in Malaysia.

Ohlan (2015) analyzed India's carbon dioxide emissions impacts with regard to several variables, namely, economic openness, economic acceleration, population density, and energy consumption. Based on the study findings, a substantial relationship was identified between carbon dioxide emissions and socioeconomic factors in the long run. Also, population density, energy consumption, and economic growth have an important positive impact on carbon dioxide emissions in the short and long term. Chen et al. (2016) studied the nexus between many variables, namely, renewable energy usage, CO2 emissions, and economic advancement, with results confirming the presence of a dynamic relationship between these variables over a long-term period. It also showed that the impact of energy consumption on GDP is negative in all countries in the world except for developed countries. This has also revealed that all countries in the world except developed countries have negative effects on GDP due to power and energy resource consumption. Besides, the study found that in both industrialized and developing countries, there is a one-way correlation between energy consumption and CO_2 emissions.

On the other hand, the results of Dogan (2016) showed that CO_2 emissions and the performance of agricultural activity in Turkey share a relationship that is compatible with the hypothesis of the Kuznets curve. Liu et al. (2017) examined the Kuznets curve hypotheses by analyzing how CO_2 emissions in four Southeast Asian countries were impacted by both the value added to agriculture and the use of per capita renewable resources. The results revealed that KEC does not exist. The influence of carbon dioxide emissions on Malaysia's economic development, renewable energy, urbanization, and agriculture was investigated by Ridzuan et al. in 2020. The results of the study indicated that the relationship between economic growth and carbon dioxide emissions is consistent with the Kuznets hypothesis. Moreover, Gokmenoglu and al. (2019) carried out a study to explore the Kuznets hypothesis with regard to induced agriculture in an attempt to determine whether it affects energy consumption, real income, CO_2 emissions, and the agricultural production chain. The results have demonstrated the Kuznets hypothesis' applicability to the agricultural sector.

Selcuk et al. (2021) investigated what kind of effect agricultural activity, energy use, free trade, and foreign direct investment (FDI) have on CO_2 emissions according to the EKC hypothesis for eleven countries (Turkey, Bangladesh, the Philippines, Mexico, Indonesia, Egypt, Iran, Nigeria, Pakistan, South Korea, and Vietnam). The results revealed an inverse U-shaped EKC hypothesis in Bangladesh, Mexico, Nigeria, and Turkey, indicating both positive GDP growth as well as negative GDP2. In a study by Cetin (2022), Cetin examined 47 developing countries using the hypothesis (EKC), demonstrating an association between CO_2 emissions and income, resembling an inverted U-shaped relation. Alola and Alola (2018) conducted a study to investigate how the use of renewable energy affects the growth of tourism and agricultural land in the short and long term in 16 Mediterranean coastal countries. The findings showed that the expansion of tourism and the use of agricultural land had an impact on the consumption of renewable energy. Mohammed et al. (2019) investigated the causal relationship between Tanzania's per capita economic development, environmental pollution, and energy consumption. The result showed that energy use and economic growth rates unidirectional cause environmental pollution. An additionally, when using the impulsive response, they found significant and positive economic growth due to shocks in energy consumption and carbon emissions. Govindaraju and Tang (2013) examined the relationship between coal consumption, economic growth, and carbon dioxide emissions in China and India. They also examined the causal relationships. The findings indicated a long-term relationship between China's coal consumption, economic advancement, and CO2 emissions. Additionally, it was perceived that there is a direct causal connection between China's economic advancement and CO2 emissions. In the case of India, there is a two-way casual connection between economic growth and coal consumption, as well as between carbon dioxide emissions and coal consumption, in both the short and long run.

Regarding the use of the Environmental Kuznets hypothesis in research and development (R&D), relationships, and innovation and financial development, several studies have contributed to the economic literature.

In 2022, a study targeting the Organization for Economic Cooperation and Development's (OECD) countries was undertaken by Khan et al. The focus has been on finding out whether carbon dioxide emission reduction could be achieved through the use of innovation, renewables, and foreign direct investment (FDI). Barnes (2019) studied the relationship between plastic waste and environmental pollution, income, and investment in scientific research across 151 countries. The results showed the presence of the Kuznets hypothesis and indicated that scientific research reduces pollution.

Jiao et al. (2018) also studied the impact of direct research and development technology (DS) and the indirect technological impact (IS) on carbon dioxide emissions in 29 Chinese provinces using a geographical economic distance matrix. The impact of information systems varies across sub-regions. With regard to the impact of technology, the center region is largely unaffected, the western region benefits, and the eastern region is completely unaffected.

The researcher claims that this thesis is the first to investigate the impact of lending interest rates on CO_2 emissions in the EKC framework in Lebanon. It concludes that by analyzing CO_2 emissions and their relation to GDP growth, along with energy demand and its relation to interest rates in developing countries like Lebanon, this study has added value to an already rich literature on economics.

Chapter 3

DATA AND METHOLOGY

3.1 Theoretical Framework and Data

The relationship between the following factors, including economic development, energy consumption and usage, and CO2 emissions, is a reciprocal one, as economic growth cannot be achieved without energy consumption. Energy is the primary and crucial driver of economic growth. However, there are negative consequences associated with energy consumption, represented in the form of environmentally harmful emissions, such as carbon dioxide emissions. Therefore, in the literature review, there are several studies that discuss these respective variables and their relationships, such as Apregis and Payne (2010) and Soytas and Sari (2009). Most debates revolve around which element drives the other: does energy usage promote economic advancement or does economic advancement promote energy usage?

Accordingly, the Co2 emission function is constructed as follows:

$$CO2t = f\,(GDPt, GDPt2, ENGt, LIRt) \qquad (1)$$

The study estimated the nexus between gross domestic product (GDP), CO2 emissions, GDP square, energy consumption, and loan interest rates using annual time series data during the period 1990–2019. Data was gathered from Enerdata, an energy intelligence and consulting company, and World Bank Development Indicators. Table 1 shows the variables and their corresponding descriptions. A logarithm was taken for all of the variables in the model. There are multiple advantages to adopting the logarithm, as it decreases the problems of outliers and simplifies the interpretation of the results. Another important use of the natural logarithm is to obtain a constant elasticity model (Wooldridge, 2015).

Table 1: The Variables

Log form	*Explanation*	*Variable Type*	*Unit of Measure*
Ln CO_2	Carbon Emission	Dependent variable	kg per2015US$ OF GDP
Ln ENG	Energy Consumption	Explanatory variable	kiloton of oil equivalent KTOE
Ln GDP	Gross Domestic Production	Explanatory variable	GDP (constant 2015 USD)
Ln GDP^2	GDP square	Explanatory variable	GDP square
Ln LIR	lending interest rate	Explanatory variable	Percentage %

Descriptive Statistics

The descriptive statistics in Table 2 show that there are no unusual trends in the data, which means that all variables are consistent. The standard deviation shows that some variables, like GDP squared, are more volatile compared to others. The square with the highest value is GDP, whereas the square with the lowest value is CO2.

Table 2: Descriptive Statistics

	LNCO2	*LNENG*	*LNGDP*	*LNGPD2*	*LNLIR*
Mean	-0.607465	8.570690	24.15728	583.7448	2.626295
Maximum	-0.401421	9.115040	24.65709	607.9721	3.694012
Minimum	-0.897386	7.577634	23.01545	529.7109	1.958803
Std. Dev.	0.123582	0.383059	0.420183	20.18487	0.554090
Kurtosis	2.549758	3.434309	3.034343	2.931570	2.042563
Jarque-Bera	1.217465	3.491206	2.283514	2.023211	2.570092
Probability	0.544040	0.174540	0.319258	0.363635	0.276638

The line graph in figure 2 presents the time series plot of the estimates over the period 1990 to 2019, for LNCO2, LNENG, LNGDP, LNGDP2 and LNLIR.

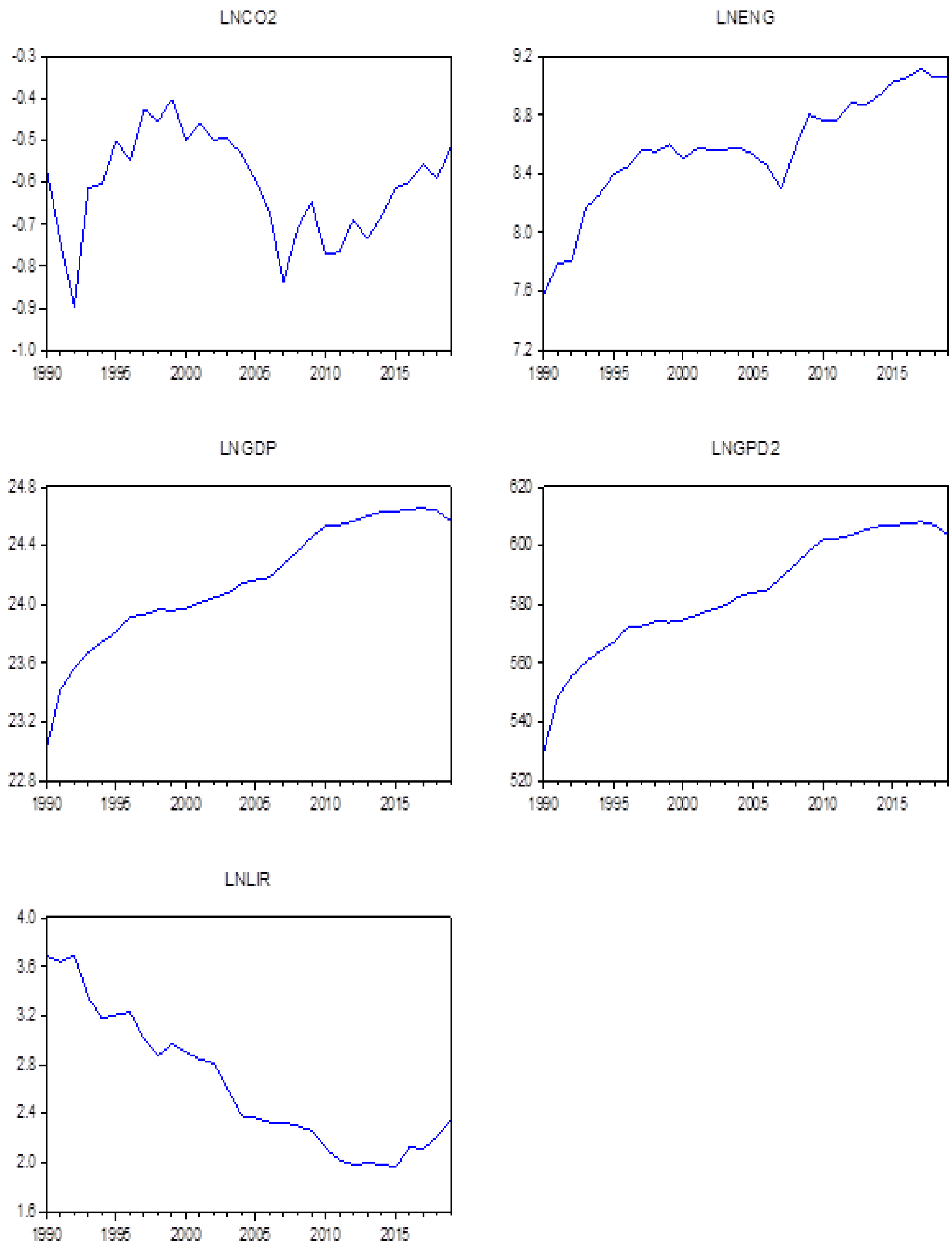


Figure 2: Variables Plots

3.2 Model Specifications and Methodology

The empirical model is used to assess the correlation between CO2 emissions, energy usage, GDP growth, and lending interest rates.

While the dependent variable is carbon dioxide emissions, the model is presented as follows:

Ln CO2 = β0 + β2 Ln GDP +β3Ln GDP2 β1Ln ENG + + β4Ln LIR + Ɛt (2)

Where Ln denotes the natural logarithm, CO2 indicates carbon dioxide emissions in kg per US$, ENG denotes energy consumption (kilo tone of oil equivalent), GDP denotes gross domestic product, GDP2 denotes gross domestic production square, and LIR indicates lending interest rate. β1, β2, β3, and β4, represent the slope coefficients. It should be noted that "t" refers to the time (year), and Ɛt refers to the error term.

Traditional unit root tests like the augmented Dickey-Fuller (ADF) test from 1979 and the Philips Perron (PP) test from 1988 serve as the foundation for this analysis. The ADF test and PP test are both based on the same underlying regression model, which can be expressed as three specifications. According to Gokmenoglu and Taspinar (2018), models I and T show a break in the intercept and trend, respectively, whereas model B shows a break in both, the intercept and trend.

They are displayed in the order mentioned below:

Model I $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \theta DU_t + \sum_{i=1}^{m} \alpha i \, \Delta Y_{t-1} + \epsilon_t$ (3)

Mode T $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \gamma DT_t + \sum_{i=1}^{m} \alpha i \, \Delta Y_{t-1} + \epsilon_t$ (4)

Model B $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \theta DU_t + \gamma DT_t + \sum_{i=1}^{m} \alpha i \, \Delta Y_{t-1} + \epsilon_t$ (5)

As $DU_t = 1$ and $DT_t = t - T_b$ if $t > T_b$ and 0 on the other hand T_b represents a possible break point.

To further explain, it should be noted that there are two types of hypotheses to describe whether a certain variable changes over time or is consistent. The one that states time series change over a certain period of time in mean and variance is called non-stationary, which represents the null hypothesis (H0). While the other that states consistency of the time series in mean and variance is called stationary, which is referred to as the alternative hypothesis (H1). Based on the small-sample technique, the Autoregressive Distributed Lag model (ARDL) developed by Pesaran et al. (2001) is suitable to apply in this thesis. First, it helps to test whether there is a short-run and/or long-run equilibrium relationship between the variables shown in Equation 1. Second, the ARDL approach offers advantages over traditional integration tests. Third, it can be used in situations where the data is stationary at level I (0), at an initial difference, or in a combination of levels I (0) and I (1). Fourth, the ARDL model is appropriate for a small sample size.

Long-run and short-run ARDL models

The estimation of the ARDL models shall be carried out in the following cointegration tests. As demonstrated below, equations number 6 and 7 reflect both the long-term and short-term models, respectively, while the" error correction term (ECT)" is expressed in equation (8).

$$LNCO2_t = \alpha 0 + \lambda 1 \; LNCO2_{t-i} + \lambda 2 \; LNGDP_{t-i} + \lambda 3 \; LNGDP2_{t-i} + \lambda 4 \; LNENG_{t-i} + \lambda 5 \; LNLIR_{t-i} + \; \varepsilon \mathrm{t} \quad (6)$$

$$\Delta LNCO2_t = \alpha_0 + \sum_{i=1}^{n} \beta_{1i} \Delta\, LNCO2_{t-i} + \sum_{i=0}^{n} \beta_{1i}\, \Delta LNGDP_{t-i} +$$

$$\sum_{i=0}^{n} \beta_{2i}\, \Delta LNGDP_{t-i} + \sum_{i=0}^{n} \beta_{3i}\, \Delta LNENG_{t-i} + \sum_{i=0}^{n} \beta_{4i}\, \Delta LNLIR_{t-i} \qquad (7)$$

$$\Delta LNCO2_t = \alpha_0 + \sum_{i=1}^{n} \beta_{1i}\, LNCO2_{t-i} + \sum_{i=0}^{n} \beta_{1i}\, \Delta LNGDP_{t-i} +$$

$$\sum_{i=0}^{N} \beta_{2i}\, \Delta LNGDP2_{t-i} + \sum_{i=0}^{n} \beta_{3i}\, \Delta LNENG_{t-i} + \sum_{i=0}^{n} \beta_{4i}\, \Delta LNLIR_{t-i} +$$

$$\alpha\, ECM_{t-i\, +\, \varepsilon t} \qquad (8)$$

The F-statistic is compared to the upper bound I (1) and lower bound I (0), which are critical values at a given level of significance (Pesaran et al., 2001). The null hypothesis of the bounds test is λ1 = λ2 = λ3 = λ4 = 0, suggesting the variables' long-term relationships. Conversely, the alternative hypothesis is λ1 ≠ λ2 ≠ λ3 ≠ λ4 ≠ 0.

There are factors that determine whether the null hypothesis can be rejected or not. As Pesaran et al. (2001) stated, "When the F-statistic is greater than the critical value of the upper bound," then it cannot be rejected. Nonetheless, "when the F-statistic is lower than the critical value of the lower bound at significant levels of 1%, 5%, and 10%," then it can be rejected. In terms of determining if the F-statistic is between the upper and lower bounds' critical values, the test is not conclusive. The "error correction model is used to investigate the short-run interdependencies". The short-run ARDL models are shown in equation (4).

Where ECMt-1 illustrates the needed speed of the short run adjustment to reach the long-run equilibrium.

Chapter 4

EMPIRICAL ANALYSIS AND RESULTS

To investigate the relationships between the variables under study, both short-term and long-term, various techniques can be applied. To begin the analysis, standard tests for unit root are conducted to check whether stationarity is present or not. Some well-known unit root tests that are valid for this context are the ADF (Augmented Dicky-Fuller, 1979) test and the PP (Philips Perron, 1988) test. These tests are used with two options: constant and constant + trend. According to these results, a unit root exists at the level of each variable. Thus, as table 3 shows, the variables are generated when the series becomes stationary in the first difference.

According to the test results, the variables are incorporated in order I (1). According to Pesaran et al. (2001), the most suitable method for analyzing relationships in this series is by applying the boundary testing approach of ARDL.

According to the findings of the co-integration test utilizing the bound test approach, the computed F-statistics (81.91) are greater than the critical values of the upper limit at the 5%, 10%, and 1% significant levels. This indicates a long-term correlation between the explanatory variables GDP, GDP2, ENG, LIR, and the dependent variable CO2. By utilizing the Akaike criterion, it was found that the maximum one-lag for ARDL is (1, 1, 0, 0, 0), as shown in table (4).

Table 3: Unit Root Testes Results

DICKEY FULLER (ADF)				
VARIABLE	**At Level**		**At First Difference**	
	C	**C&T**	**C**	**C&T**
LNCO2	(- 2.205)	(-2.112)	(-6.360)***	(-6.228)***
LNGDP	(-1.803)	(0.187)	(-7.074)***	(-7.311)***
$LNGDP^2$	(-1.750)	(0.191)	(-6.738)***	(-6.966)***
LNENG	(-2.764)	(-2.968)	(-5.060)***	(-5.162)***
LNLIR	(-2.299)	(0.168)	(-3.932)***	(-4.814)***
	PHILIPS-PERRON (PP)			
	C	**C&T**	**C**	**C&T**
LNCO2	(-2.205)	(-2.112)	(-6.514)***	(-6.803)***
LNGDP	(-4.046)	(-4.607)	(-6.642)***	(-6.311)***
$LNGDP^2$	(-3.953)	(-4.804)	(-6.350)***	(-6.505)***
LNENG	(-2.764)	(-2.968)	(-5.060)***	(-5.162)***
LNLIR	(-2.241)	(1.307)	(-3.960)***	(-4.836)***

Note: The figure in the parenthesis () denote t-statistic. C, C&T indicates the model with Intercept, with intercept and Trend, respectively.

Table 4: ARDL Bound Test

Optimal lag length selection	(1,1,0,0,0)	
F-statistic 81.91***		
Significant Level	Lower bound I(0)	Upper bound I(1)
1%	4.4	5.72
5%	3.47	4.57
10%	3.03	4.06

ARDL indicates as an Autoregressive Distributed ***, **,*, denotes significant at 1%, 5%, and 10%, respectively SC: Schwarz information criterion and HQ: Hannan-qunin information criterion was used to determine the optimal lag.

Table 5: Long-Run Estimation

Variables	Coefficient	t-Statistic	Prob.
LNENG	0.866***	21.767	0.000
LNGDP	15.672***	6.308	0.000
$LNGDP^2$	-0.347***	-6.772	0.000
LNLIR	-0.074**	-2.186	0.040

***, **,*, denotes significant at 1%, 5%, and 10%, respectively.

We can see the estimated long-run coefficients in Table 4. Findings have shown that for all models, F-statistics are substantially greater than the upper bound of critical values. Consequently, the null hypothesis is dismissed, and it can be accepted that these variables share a cointegration. This implies that an equilibrium relationship between variables has been in place for a long time. It's been evident that both energy consumption (ENG) and GDP share a positive nexus. Thus, when a 1% percentage increase in the ENG happens, a 0.866% percentage increase in the CO_2 takes place as well. Likewise, when GDP increases by 1%, CO_2 emissions increase by 15.672%. These findings are compatible with those of Khan et al. (2020).

Conversely, the estimated coefficients of the squared gross domestic product (GDP2) and lending interest rate (LIR) have negative signs. This indicates that GDP2 and LIR are negatively correlated with carbon dioxide emissions (CO_2). It means that when GDP2 and LIR increase, CO_2 decreases.

In other words, they have an inverse relationship, meaning that an increase in lending interest rates leads to a decrease in CO_2 emissions. Increasing lending interest leads to a transfer of funds from the industrial market to the financial market, which, in turn, slows down economic growth. As a result, it leads to a reduction in air pollution.

Table 6 illustrates the error correction model. The error correction term (−0.827) is negative and significant. This indicates that the rate of adjustment for CO_2 emissions in Lebanon towards their long-term equilibrium level is 83% per year. This convergence is attributed to the contributions of economic development, energy consumption, and leading interest rates.

Table 6: Error Correction Model

Variable	Coefficient	Std. Error	t-Statistic	prob
C	-152.23	6.890	-22.094	0.000
@Trend	0.008	0.000	19.422	0.000
D(LNENG)	0.874	0.029	30.535	0.000
Cont-Eq(-1)*	-0.827	0.037	-22.081	0.000

Diagnostic Tests

Table 7: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.009	Prob. F(2,19)	0.990
Obs*R-squared	0.030	Prob. Chi-Square(2)	0.985

Table 8: Heteroscedasticity Breusch-Pagan-Godfrey test

F-statistic	1.845	Prob. F(7,21)	0.131
Obs*R-squared	11.044	Prob. Chi-Square(7)	0.137
Scaled explained SS	5.204	Prob. Chi-Square(7)	0.635

Table 9: Heteroscedasticity Harvey Test

F-statistic	0.558	Prob. F(7,21)	0.781
Obs*R-squared	4.545	Prob. Chi-Square(7)	0.715
Scaled explained SS	3.318	Prob. Chi-Square(7)	0.854

Table 10: Heteroscedasticity ARCH Test

F-statistic	0.34	Prob. F(1,23)	0.66
Obs*R-squared	0.36	Prob. Chi-Square(1)	0.55

Table 11: Normality Test

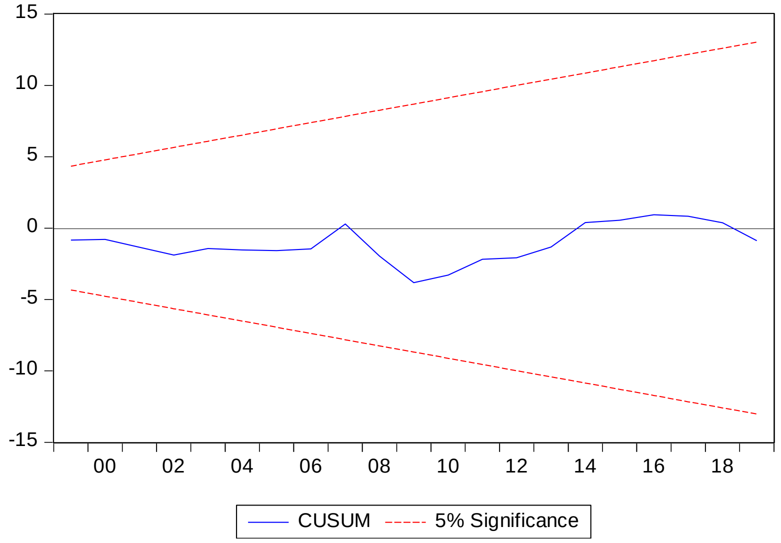
Jarqe-Bera	0.75	Prob.	0.68

Table12: Ramsey Test

	Value	Df	Prob.
t-statistic	0.531	17	0.602
F- statistic	0.282	(1.17)	0.602

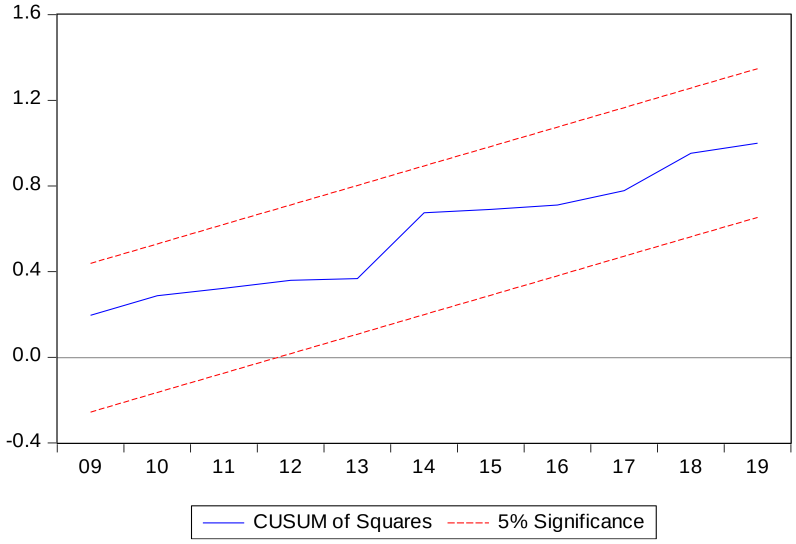
Econometric techniques are developed based on certain underlying assumptions. Violation of these assumptions leads to certain econometric problems, including serial correlation, Heteroscedasticity, and specification errors. These problems invalidate the estimates of regression techniques. The validity of the regression analysis estimates depends on the results of the tests for any potential problems. When a model fails the tests, its estimates are considered inconsistent and invalid for policy inferences. Therefore, diagnostic tests were conducted for all the models in this thesis, and the results are reported in tables 7, 8, 9, 10 and 11. The R-squared and adjusted R-squared statistics indicate that all the models have good fits, while the Breusch-Godfrey statistics show that there is no serial correlation in any of them. Additionally, the model shows no sign of Heteroscedasticity based on the results of the BPG Heteroscedasticity test. This suggests that they have accurate and homoscedastic specifications.

In addition, all the models passed the normality tests, as shown in Table 11, and the linear-based Ramsey test, as shown in Table 12. Finally, the CUSUM and CUSUM square test results demonstrate the models' stability and consistency. Therefore, the estimates of all the modes are valid for policy analysis and inferences. To summarize, the model is free from Heteroscedasticity, normality, ARCH, and serial correlation.



The straight lines represent critical bounds at 5% significance level.

Figure 3: Cusum Test



The straight lines represent critical bounds at 5% significance level.

Figure 4: Cusum Squares Test

Chapter 5

CONCLUSION

This thesis examines the correlation among the following factors: CO_2 emissions, lending interest rates, GDP, and energy use in Lebanon. The ARDL technique was utilized in the thesis to detect both long-term and short-term impacts. The findings indicated that there was cointegration between the variables, as evident by the value of the F-statistics.

The empirical data results also validated the co-integration's presence, confirming the existence of an ongoing correlation between the aforementioned variables. Economic growth (GDP) and energy use are positively correlated with CO_2 emissions. Energy consumption in numerous economic activities has increased CO_2 emissions. On the contrary, GDP2 and lending interest rates (LIR) are negatively correlated, and an increase in GDP2 and a decrease in CO_2 can be illustrated by the ECK hypothesis. According to this hypothesis, environmental pollution will be more prevalent during the early phases of economic growth but will become less of a concern as development progresses.

This informs us of the validity and relevance of the EKC for this study’s results. Increasing in LIR and decreasing in CO_2 is compatible with Isiksal et al.'s (2019) study. Hence, the search for clean, low-carbon energy sources (renewable energy) has become an urgent matter in Lebanon, especially when considering its water and solar resources. If these resources are properly exploited, they can help achieve important goals, such as reducing carbon emissions, achieving sustainable levels of growth, preserving the environment, lowering local energy prices, and improving welfare.

Policymakers should be aware of the impact that promoting economic growth has on the environment. While striving to maintain economic growth, they should also prioritize efforts to reduce carbon emissions.

Therefore, authorities must find environmentally friendly energy resource alternatives to be used in economic activities and encourage environmentally friendly projects by offering low interest rates for such projects. In addition, when setting policies and rates for the leading interest rate, policymakers should be aware of the far-reaching consequences of these decisions and regulations on air pollution.

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