Unlocking the investment impact of Biomass energy utilization on Environmental Degradation for an Isolated Island.

HIGHLIGHT

- We explore the combined impact of FDI, economic growth, trade flow, CO_2 emission and renewables on the environmental quality in Cyprus
- Unlike non-renewable energy, an increase in Biomass energy utilization does not increase CO_2 emissions within the study's context
- FDI decreases environmental degradation in the long run in Cyprus.
- Environmental sustainability will be achieved by investing in renewable energy (Biomass energy utilization) for the Cyprus economy.

ABSTRACT

Purpose

Discussions on environmentally friendly production connected with the concerns of growing biomass emissions have gained much attention. In this regard, this study aims to explore the issue of biomass energy consumption and its related emission effects on the economic and environmental well-being of the economy of Cyprus

Design/ methodology/ approach

This study sources time series data on specific variables from the Global Material Flow (GMF) and the World Bank's World Development Indicators (WDI, 2020) between 1990 to 2016. The Robust Least Square (ROB-L^2) in conjunction with Pesaran Autoregressive distributed lag methodology (ARDL) analysis techniques were employed in addition to the Granger Causality tests to examine the direction of causality flow between the variables under consideration

Findings

The results indicate that biomass energy usage in the long reduces pollution and, negatively correlates with CO_2 emissions level. Also, the decline of emission is influenced by increased FDI, thus, activities of foreign investors contribute to combating emission in the country. According to empirical results, non-renewable energy consumption showed both positive and negative influence on increased emission level while economic growth is increasing carbon dioxide emission for the case of Cyprus.

Originality/ value

This study applies current reliable data which offers renewed insights and sheds light on the state of affairs on biomass utilization from a developing country perspective. Additionally, it extends the discourse on the impact of biomass utilization on CO_2 emissions by considering the impact of FDI, trade flow and energy consumption in a carbon-income function built on the liner version of the Environmental Kuznets Curve hypothesis. Although this is by no means exhaustive, the study pioneers the discourse on how FDI with biomass utilization among other relevant variables influences carbon dioxide emission.

Keywords: Biomass energy, Economic growth, carbon reduction; Environmental sustainability; Non-renewable energy, and Cyprus.

Introduction

The consequences of depending on fossil fuels energy sources and the need to reduce greenhouse gas (GHG) emissions motivate the need to explore bio-based reserves. Recent reports on developments in the renewable energy domain highlight biomass energy as a viable alternative to fossil fuel supplies (Hess et al. 2016, Meyer, 2017). Coupled with this assertion, the market volatility of fossil fuels and the increasing greenhouse gas (GHG) pollution heightens the urgency with which economies must turn to the utilization of green energy, like biomass and biofuels (Meyer, 2017). For instance, China has hastened initiatives to facilitate the wider utilization of sustainable energy sources energy through the introduction of massive taxation opportunities to investors engaged in biomass and waste anaerobic digestion schemes in China (Energy Information Administration 2016). Similarly, India also introduced similar initiatives and fiscal incentives to encourage the use of biofuels (Energy Resources Administration 2016).

Among European states, the EU has also set goals for 2020 (Europe, 2030 energy target) with a view of mitigating environmental degradation through the reduction in GHG emissions by 20% from the rates of 1990, raising the proportion of European energy intake from clean energy by 20% and boosting energy performance also by 20%. In the long run, the future objective for European states by 2050 (Europe, 2050 official report) is to reduce greenhouse gas pollution by 80-95%.

However, orthodox and renewable energy sources account for about 81% and 14% of the world's expected availability of main energy sources respectively (IEA, 2017). Oil, carbon and natural gas largely constitute the inputs of non-renewable energy resources, while renewable energy sources (RES) include biomass, sunlight, wind, hydro and geothermal energy sources. The literature largely suggests sustainable energies energy accounts for some 14 per cent of the world's energy source (IEA, 2017), with traditional biomass emerging as one of the key renewable energy sources (RES), particularly among emerging economies. REN21, (2016) reports biomass energy accounted for about 9 per cent of RES. This low level of generation and utilization of biomass energy is also estimated energy to reach a 50 per cent level globally by the year 2050 (EU, 2050; Mondal and Denich, 2010). The bio-mix is mainly derived from three sources: plant residues, forest residues and energy crops (Guta, 2012). Biomass is usually obtained from rice straw, agricultural residues, animal waste, and municipal waste among others (Hossen et al., 2017). Discussions on biomass conversion to bioenergy for electricity generation has mainly emerged from two perspectives: specific vaporization and gasification (Mondal and Denich 2010). Direct use of fire primarily used for many rural settings in most developing economies contradicts the global expectations of biomass energy development and utilization as a means to reducing emissions. Thus, the increased development of biomass could adversely affect the environment, however, its increased effective development by use of advanced technologies or procedure can lead to sustainable environments through the reduction of pollutants energy (Hossen et al., 2017). This in other words calls for increased direct investments into biomass production technology. In that, where development procedure improve biomass generation is likely to increase and subsequently reduce environmental degradation.

Evidence from Cyprus suggests that fossil pollutions from the region were 6,872,427 tons in 2016 suggesting a 3.7% increase in pollutant emission over the previous period of 2015 (WDI, 2020). . CO_2 per capita in Cyprus was equivalent to 5.87 tons per person (base on the population of 1,170,187) in 2016, which also shows an increase of 0.17% over 5.71 tons per person in 2015. Nevertheless, the country contributed 0.02% of the world CO_2 emissions, which has been consistent from 1993 to 2016(WDI, 2020).

Moreover, according to the Cyprus Drafted Integrated National Energy and Climate Plan from 2021 to 2030, the dependence on fossil electricity supplies by Cyprus possess some significant challenges. For its energy requirements, Cyprus relies on imports of fossil fuels and spends over 8% of its GDP on energy. In the EU-28, the island has witnessed the fastest increase in energy usage, from 1.6 million tons of oil (Mtoe) to 2.3 Mtoe in 2015 suggesting an increase by 41 per cent from 1990.

Furthermore, the Renewable Energy Sources (RES) target of 13 per cent is for wind turbines, photovoltaic (PV) systems, solar-thermal and biomass and biogas plants to be generated by 2020. RES has contributed 8.4 per cent of the energy generation in 2016, according to the latest statistics. In 2016, the RES production improved by 6 per cent, mainly due to the high performance of private photovoltaic systems compared to 2015. In 2016, wind farms accounted for nearly 55% of RES electricity, while private photovoltaic system production increased by almost 15% between 2015 and 2016[1].

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1. [1] Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council

This proportion has been growing and the growth in PV is expected to extend facilities to reach or even exceed the 288MW solar photovoltaic goal in 2020, competitively and sustainably. All the oil utilized comes from imports, even though unsustainable since 1990, has increased by more than 35% from 1990 to 2015. For the case of solid fuels, total intake rose by 85 per cent around 1990 and 2004 due to the development of the building industry. From 2004 to 2008, solid fuel utilization remained constant, until after 2008 where solid fuel usage declined significantly to the 1990's stage.

While the actual amount of energy generated from renewables has risen by more than 310 per cent since 2006 (Figure 2), clean energy only contributes just 8.6 per cent to the overall production. Proportionally, the energy generation mix in Cyprus seems to be fewer emissions strenuous from 2008, when the very first combined-cycle energy production unit was operationalized and the impact of renewable inputs began to be substantial.

Moreover, in total, there has been significant growth in Cyprus' electricity generation from 1990 to 2015. Over time, renewables have dramatically expanded the share of primary energy supply to about 6.07% in 2016 in Cyprus. 68% of the renewable energy produced is provided by solar thermal and biomass. In 1990, biofuels saw the biggest growth increase from 0% to about 6 % in 2016.

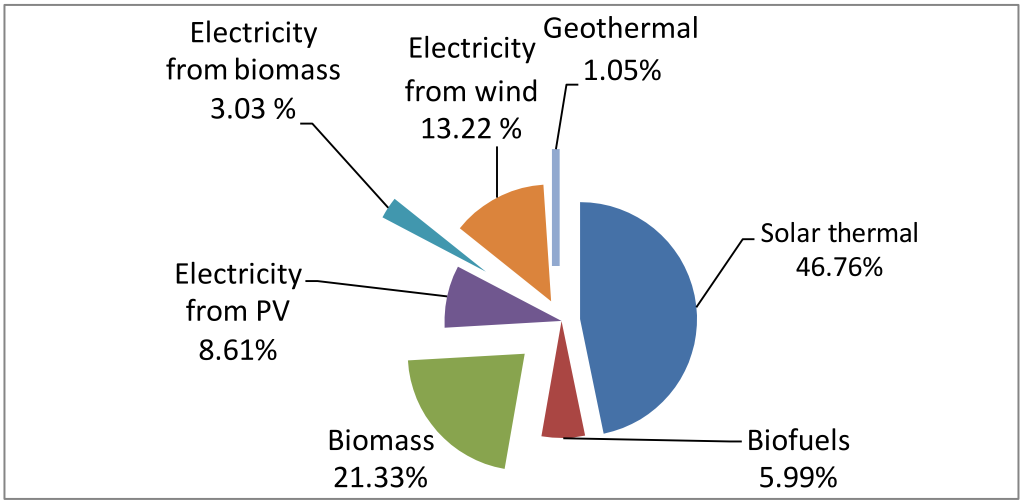

Figure 1. Cyprus Existing Renewable Energy Share between technologies as of the end of 2016

Based on the 2016 estimates, Cyprus, like any other EU states, has a big obstacle to meet the latest Renewable Energy Sources (RES) 2020 goals. Cyprus's target is 13 per cent of total energy intake to be from renewable sources by 2020[2]

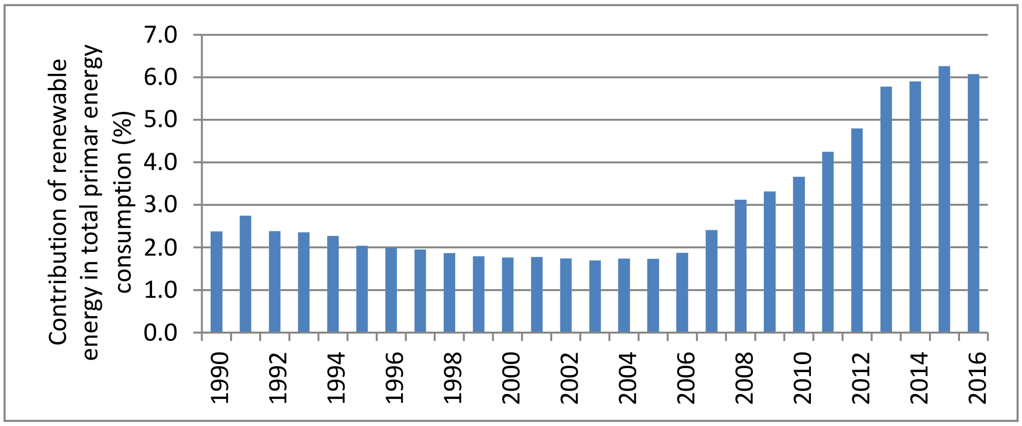

Figure 2. Share of renewable energy in total primary energy consumption in per cent, 1990-2016

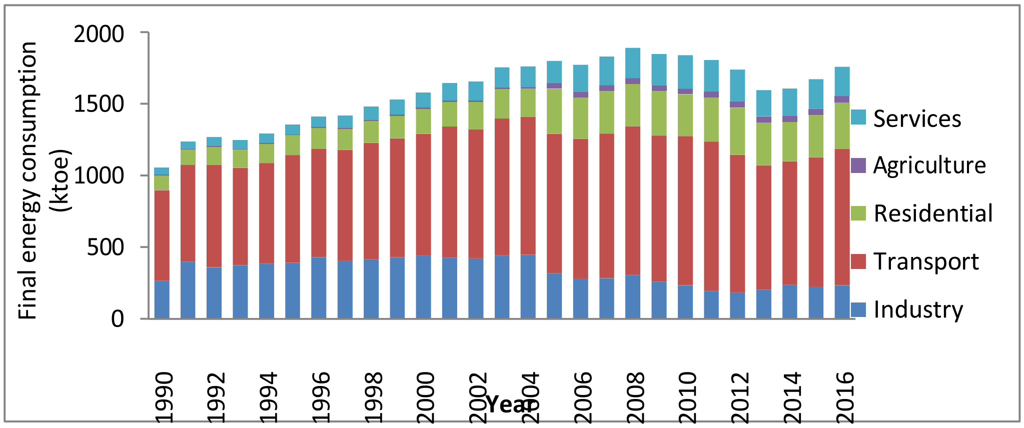

Figure 3. Final energy consumption by sector in ktoe, 1990-2016

Although the information presented suggests that energy utilization within the country seems to contributes a steady proportion of pollution over the years, CO2 emission this development is opposed to the country's efforts to achieve its target of a sustainable environment and energy security determined by its council of Ministers in 2015 (the Paris Accord)[2]. For the EU and the global economy

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2. [2] Cyprus Drafted Integrated National Energy and Climate Plan for the period of 2021 to 203

to achieve the environmental targets on pollutant emissions it paramount that each country can achieve its target on pollutant emission to sustain the global target (EU, 2030).

On this basis, this study seeks to explore the influence of biomass energy utilization on environmental degradation. Giving the assertion that biomass energy emerges as a viable renewable energy source that, when developed with appropriate technology could reduce ecological degradation, the study empirically considers the role of foreign direct investments (FDI) and economic growth, non-renewable energy, trade and biomass energy utilization on carbon dioxide emission. That is, to establish the hypothesis that the effective development and utilization of biomass for energy generation can reduce CO2 emission and contribute to sustainable development. To the best of knowledge from our literature search, several studies have investigated the impact of biomass on ecological degradation without considering the effect of foreign direct investment. In the opinion of this study, a significant influence of FDI on biomass energy development would shape the government's decisions on which areas to direct or incentivize FDI initiatives for renewable energy generation and utilization. To effectively the study's objective, the examination accesses both the long run and short-run effects of CO2 emission on environmental degradation using the Robust Least Squares (ROB-L^2) and ARDL (ARDL) respectively, while the Granger Causality test was employed to check the causality relationship of the variables.

The remainder of this study is structured as follows: a literature summary is provided in the second section. Econometric methods and information are presented in the third section. The fourth divide focuses on empirical analysis, while the last section contains conclusion and policies from policymakers.

2. Related Literature Review

This study highlights the contribution of bioenergy expansion in decreasing emissions, rising energy instability, agricultural advancement to the downside of biodiversity, intensive water usage, deforestation, and increasing energy cost (Burg et al., 2018; He et al., 2018; Shao & Rao, 2018). Bioenergy, in particular compost, besides biomass, is a sustainable energy source that takes green management into justification (Baležentis et al., 2019). The study evaluated both the positive and the negative effects of energy generation on environmental pollution. For instance, Katircioglu (2015) evaluated the connection between biomass energy and greenhouse gases sensitivity in Turkey utilizing the Autoregressive Distributive Lag (ARDL) technique, and reports that biomass energy inhibits corrosion. Bilgili (2012), also noted that biomass development helps to mitigate greenhouse gas emission in the US. In a predefined evaluation, Bilgili et al. (2016) used a wavelet consistency analysis to understand how biomass energy reduces CO2 emission in the USA. Shahbaz et al., (2017) implied nearly equivalent assumptions for the US economic activity through the Autoregressive Distributive Lag (ARDL) bounding investigational process. One of the seminal studies on biomass production was that of Dogan et al. (2017), who investigated the connection between biomass intake and the output of carbon dioxide in biomass-major states and described the important contribution of biomass electricity in the lessening of climate pollutants. Baležentis et al. (2019) confirmed that biomass energy lessens GHG compared to other energy sources. Shahbaz et al. (2019) also examined the influence of biomass electricity on foreign investments as well as CO2 emission across the Middle East and North African states using the GMM methodology and developed a measurable impact of biomass intake on the mitigation of toxic substances. Danish & Wang (2019) then utilized the GMM technique to address the component of biomass energy in lessening carbon dioxide production, in addition to confirming that biomass energy reduces biodiversity stress in the BRICS societies. Using a groundbreaking quantitative approach, specifically the vigorous ARDL, Sarkodie et al. (2019) measured the effect of biomass intake on Climate change mitigation as well as the country's development and determined that biomass energy decreases emission.

Few studies did not support the positive effect of biomass energy on the prevention of pollution (Mahmood et al., 2019; Shahbaz et al., 2018) as well as Ahmed et al. (2016) reported that biomass energy inputs had a negligible impact on the output of CO_2. At the same time, certain explanatory variables in CO_2 pollution, which include foreign exchange and FDI, had already been described in the verification to avoid any damage to the prerequisite. Ren et al. (2014) argued that global trade and Foreign Direct Investment in the Chinese manufacturing segment have worsened ecological efficiency, even though Al-Mulali et al. (2015) noted that global trade meaningfully decreases carbon dioxide pollution across Europe. Liobikien & Butkus (2018) observed the same result on behalf of a team of 147 nations. However Chang (2015) assumed that free import and export would increase carbon dioxide emissions, Zhang & Zhang (2018) noticed that the money system had a detrimental impact on CO2 greenhouse gasses in China? Hille et al. (2019) predictive findings have shown that FDI decreases CO_2 emissions. However, in a survey of numerous areas, Shahbaz et al. (2015) reported the contrary effect of foreign direct investment in carbon dioxide greenhouse gases, underpinning the toxicity hypothesis that the presence of FDI is a pollutant.

A few other findings have shown that, as biomass energy utilization declines, economic growth has expanded, which means that sustainable success is a good indication that the use of biomass energy will be discouraged (Victor & Victor, 2002). In some cases, greater energy use means a decrease in generators, particularly at the household level. For example, Foster et al. (2000) confirmed that households had lessened their total energy use by other methods where energy usage could yield effective results. However, many developing markets have shown lower GDP per capita, and these countries rely mostly on renewable resources that are not clean compared to other countries in advanced countries, such as the G-20 (IEA, 2016).

3. Data and Methodenergy

3.1. Data

This study examined the impact of biomass energy consumption on CO_2 emissions in Cyprus utilizing the most recent available data from 1990 to 2016. The data for biomass energy was obtained from Global Material Flow (GMF) database whiles, CO_2 pollution, economic growth, non-renewable energy utilization, foreign direct investment and trade are all sourced from the World Bank's World Development Indicators (WDI, 2020). Specifically, the variables are measured as fellow: Biomass energy utilization (BM) in tons per capita, CO_2 emissions also in metric tons per capita., Real GDP is measured in constant 2010 US$ and denoted as GDP, Non-renewable energy utilization is measured in the proportion of % total energy and denoted as NREC. Lastly, foreign direct investment is measured in BoP, current US$ and denoted as FDI and trade, measured as a percentage of GDP and denoted as TRD. This information is summarized in Table 1. The selection of the variables was based on the Sustainable Development Goals (SDGs) 7 and 13 (UN, 2015). Resource use — In addition to associated infrastructure, energy supply plays a key role in economic growth and therefore in environmental growth (SDG 7) and climate change mitigation relies on prudent energy use and output choices and associated infrastructure (SDG 13). The variables analyzed have been used in their logarithmic natural order to mitigate heteroscedasticity problems.

Table 1. Description of Variables

Name of Indicator	Abbreviation	Proxy/Scale of Measurement	Source
Carbon dioxide emissions per capita	CO_2	measured in metric tonnes	WDI
Gross Domestic Product	GDP	Constant 2010 US$	WDI
Foreign direct investment	FDI	BoP, current US$	WDI
Non-renewable energy	NREC	% of total energy	WDI
Trade	TRD	% of GDP	WDI
Biomass energy utilization	BM	tones per capita	GMF

Source: authors compilation

3.2. Methods

Similar to the works of Danish and Wang, (2019), Mahmood et al., (2019), and Shahbaz et al., (2019) the study analyzes the relationship between real GDP, biomass energy and CO_2 emissions while considering foreign direct investment and trade from an economic point of view of the Republic of Cyprus. The research model has expressed in equation an equation.

$$CO_2=f\ (BM, GDP, NREC, FDI, TRD) \qquad (1)$$

Where CO_2 represent carbon emission, GDP denotes gross domestic product, NREC as non-renewable energy consumption, FDI as foreign direct investment and TRD as trade openness respectively. The logarithmic transformation has been performed to enable the variables in this current study to maintain constant variance across all the series which is presented as:

$$LnCO_{2t}=\alpha_0+\beta_1\ LnBM_t+\beta_2\ LnGDP_t+\beta_3\ LnNREC_t+\beta_4\ LnFDI_t+\beta_5\ LnTRD_t+\mu_t \qquad (2)$$

Where α is the constant term, and β's are slope perimeters that need to be examined.

4.0 Econometric Methodology

In line with Engle and Ganger (1987), the result from a regression becomes spurious when there is no evidence of stationarity among the variables. Based on this, the error correction model (ECM) is employed to check both the error correction and cointegration among the variables.

We, therefore base the long-term relationship on robust least square (ROB-L^2) and -ARDL techniques are used to check the short-run effects of the variables. The -ARDL approach, possesses several econometric strengths compared with the conventional time-series data models. For instance, it could fix endogeneity problems at the same time handle either short-or long-term parameters. The

ARDL co-integration method is also capable of taking into account variables in a combined integration order, such as level (I (0)) and first difference (I (1)) but not second difference (I (2)). Pesaran et al. (1999) also highlight the Pool Mean Group (PMG) estimator to be accurate, resilient and high to lag orders and outliers. lastly, the Pairwise Granger Causality Tests were employed to examine the causal relationship of the variables.

Based on Emir and Bekun (2018) and Mikayilov et al., (2020) studies, we primarily carried out a stationary test to ensure that we identified the maximum level of detailed estimates and the asymptotic characteristics of the variables under study. The Augmented Dicky-Fuller (ADF), Philip and Perron (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests were used to determine the root unit so that the approximations of the variables would not produce bias regressions estimates. Additionally, Engle and Ganger error correction model checks both cointegration and spurious of variables. However, the possibility of a long-run equilibrium relationship was established through Johansen Fisher Cointegration Test. The Robust Least Square (ROB-L^2) was also carried out to access the long-run association equilibrium of the variables. This estimation can provide a robust standard error and coefficient for determining long-run associations. The short-run association regarding the variables was assessed using the ARDL test and lastly, the causality test was carried out by Granger Causality tests to obtain the causal relationships between the variables. The Causality Checks provide effective and consistent estimations even in the case of a mixed order of integration between variables.

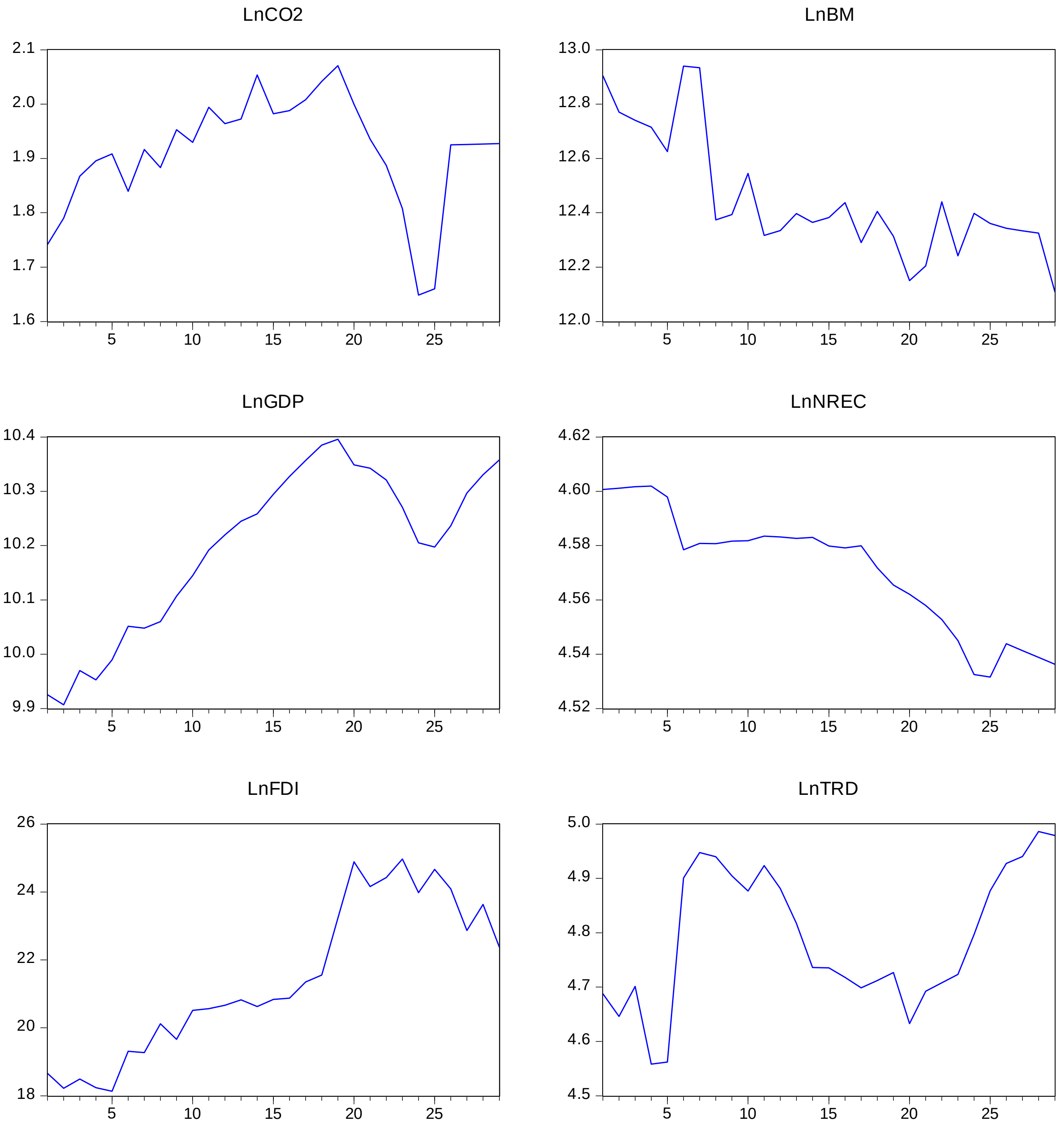

Figure 4. The movement pattern of the series NB: The plot shows the dynamics of the biomass energy, nonrenewable energy, FDI and trade relative to carbon dioxide emissions of Cyprus from 1990 to 2016

4.1. RESULTS

4.1.1. Pre-estimation Diagnostic

The summary statistics of the analysis of the data drawn for this study is presented in Table 2. The summary statistic reveals that foreign direct investment has the highest mean, median, maximum and minimum and CO2 emissions have the least variables mean, median, maximum and minimum. The variance inflation factor (VIF) or tolerance factor, which is the inverse of VIF, resonates the position of Pearson correlation analysis (see Appendix for VIF/I/VIF results). In examining the variable associations, the correction matrix (Table 3), provides proofs that, Biomass is negatively correlated with carbon pollutant and real GDP positively correlates with carbon pollutant., Biomass energy is negatively associated with real GDP and foreign direct investment but negatively correlated with non-renewable energy. Real GDP on the other hand negatively correlates with non-renewable energy and positively correlates with foreign direct investment. Lastly, non-renewable energy negatively correlates with both foreign direct investment and trade.

Table 2. Summary Statistics

VARIABLES	LnCO$_2$	LnBM	LnGDP	LnNREC	LnFDI	LnTRD
Mean	1.911884	12.45139	10.19787	4.570956	21.42070	4.790975
Median	1.926670	12.38251	10.23631	4.579861	20.83556	4.736239
Maximum	2.070690	12.93989	10.39591	4.601917	24.97137	4.986376
Minimum	1.648620	12.10883	9.906736	4.531591	18.13532	4.558250
Std. Dev.	0.104010	0.226764	0.151097	0.022265	2.248683	0.126831
Skewness	-0.973167	0.912487	-0.554269	-0.391929	0.154471	-0.057821
Kurtosis	3.675739	2.888639	2.013308	1.973121	1.733513	1.817612
Jarque-Bera	5.129184	4.039378	2.661255	2.016605	2.053484	1.705458
Observations	29	29	29	29	29	29

Table 3. Correlation matrix Analysis

VARIABLES	LnCO$_2$	LnBM	LnGDP	LnNREC	LnFDI	LnTRD
LnCO$_2$	1.0000					
Prob.	---					
LnBM	-0.3503c	1.0000				
Prob	(0.0624)	-----				
LnGDP	0.4919a	-0.8141a	1.0000			
Prob	(0.0067)	(0.0000)	-----			
LnNREC	0.2296	0.6091a	-0.6379a	1.0000		
Prob	(0.2309)	(0.0005)	(0.0002)	-----		
LnFDI	-0.0548	-0.7259a	0.7620a	-0.8914a	1.0000	
Prob	(0.7777)	(0.0000)	(0.0000)	(0.0000)	-----	
LnTRD	-0.0311	-0.1693	0.1591	-0.4477b	0.1802	1.0000
Prob	(0.8730)	(0.3799)	(0.4097)	(0.0149)	(0.3495)	-----

NOTE: a, b, c represent 1%, 5% and 10% significant levels.

4.1.2. UNIT ROOT RESULTS

The need to explore time-series properties of variables is pertinent to avoid spurious analysis. Especially the error of modelling variables integrated of order 2. Thus, the need to investigate the time-series properties is presented in the study with both unit root and stationarity test presented in the subsequent section.

$$\Delta Yi = \beta 1 + \beta 2 + \beta 3 + \beta 4 + \beta 5 + \ \delta Yt - 1 + \sum_{i=1}^{m} \alpha t \Delta Yi - t + \in t \text{.........................} \ (3)$$

This approach was also critical to assess the likely implementation of the factors for the analysis. In this case, we have enacted three various approaches (Pesaran and Shin, 1998; Philip & Perron, 1999: Kwiatkowski, 1992) with a probabilistic variable and a tendency to evaluate the potential of unit root affiliated with variables. These techniques were suitable because they are capable of identifying heterogeneity and cross-sectional dependence between modules.

These strategies are determined to provide the ability to resolve the problem of low strength produced by the pseudo-stationary data set and to exploit the extra information given by the integrated cross-section time series for robust test results. The findings in Table 4 show that the variables are combined in the order I (1), i.e. the same number. It is also a measure of the non-stationarity of the parameters at the point, but at the first stationary difference, the difference, e.g. CO_2, is observed to be stationary at [I (1)] under the heterogeneity variance system. The unit root test in Table 4, also demonstrates that most of the variables were not stationary at the level but were stationary at the first difference, indicating that the variables were suitable for analysis and that the results are generalizable.

Table 4. Unit Root Test

	PP		**ADF**		**KPSS**	
VARIABLES	LEVEL	1^{ST} DIFF	LEVEL	1^{ST} DIFF	LEVEL	1^{ST} DIFF
$LnCO_2$	-2.5015	-4.7468a	-2.4246	-4.7611a	6.8001a	0.041
LnBM	-2.1566	-11.526a	-2.3693	-3.3572b	12.45a	-0.028
LnGDP	-1.5161	-3.3594b	-2.0968	-3.3594b	10.198a	0.015b
LnNREC	-0.3314	-4.3636a	-0.3863	-4.4203a	4.5709a	-0.002b
LnFDI	-1.2668	-5.7945a	-1.2599	-5.8081a	21.421a	0.132
LnTRD	-1.5433	-4.6219a	-1.5433	-4.6483a	4.791a	0.010

NOTE: a, b, c represent 1%, 5% and 10% significant levels.

4.1.3. Error Correction Model

After accessing the stationarity of all the variables, the Error-correction model is further used to check the spurious level of the variables and cointegration among them. The general form of the error correction model of the unit is given as:

$$\Delta C_t = \alpha 0 + \varrho 1 C_{t-1} + \beta 0 \Delta Y_t + \theta 1 Y_{t-1} + u_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

Where ΔY_t is stationary, C_t and Y_t cointegrated (thus together I (0)), then u_t must be I (0)

Table 5. Engle-Granger Error correction model test.

		t-Statistic	p-value			Adj. t-Stat	p-value
Augmented Dickey-Fuller test statistic		-4.0578a	(0.0041)	Phillips-Perron test statistic		-3.9891a	(0.0049)
Test critical values	1% level	-3.6892		Test critical values	1% level	-3.6892	
	5% level	-2.9719			5% level	-2.9719	
	10% level	-2.6251			10% level	-2.6251	

NOTE: a, b, c represent 1%, 5% and 10% significant levels

From Table 5, it is observed that the t-statistics of the ADF and Adj t-statistics of the PP are greater than all the test critical values at 1%, 5% and 10% levels, which proves that the variables are not spurious. Which make the variables stationary at either level or first difference. Thus, the significant level at both ADF and PP shows sufficient cointegration among the variables.

4.1.4 Cointegration Test Outcome

After determining stationarity among the variables, the analysis proceeds to identify the probability of cointegration to access the long-run equilibrium among the variables. The Johansen Fisher PCointegration Test by Johansen (1992).was employed. It was observed that the variables were not significant at both r ≤4 and r ≤5which proofs a rejection of the null hypothesis by concluding that, the variables are cointegrated.

Table 6. Johansen Fisher Cointegration Test

HYPOTHESIS NO. OF CE(S)	EIGENVALUE	TRACE STATISTIC	CRITICAL VALUE	PROB.
r≤0	0.883871a	149.7704	95.75366	(0.0000)
r≤1	0.775278a	91.63797	69.81889	(0.0004)
r ≤2	0.567131b	51.32995	47.85613	(0.0227)
r ≤3	0.482158c	28.72233	29.79707	(0.0661)

r ≤4	0.333400	10.95403	15.49471	(0.2143)
r ≤5	0.000140	0.003786	3.841466	(0.9497)

NOTE: a, b, c represent 1%, 5% and 10% significant levels.

4.2. ESTIMATION RESULTS

Table 7 shows the long run Robust Least Squares (ROB-L^2) estimations in four models where the authors add and drop some variables to confirm their robustness. From the estimation, it was identified that BM was negatively significant in both model 1 and model 4 at a 10% level. It was identified that an increase in CO2 emission will decrease BM (model 1) by 0.1395% and (model 4) by 0.1378%. This proves that utilization of Biomass in Cyprus in the long run help minimizes ecological degradation and can help the country to achieve the reduction of pollutants target for 2030. It again affirms the analysis of Bilgili et al. (2016), Shahbaz et al. (2017) and Dogan et al. (2017) that BM reduces CO2 emissions.

Moreover, the estimations prove that the effect of real GDP is positively significant in all the 3 models at a 1% level. This result is inconsistent with Ulucak, (2020). From the Chines energy/economy, Ulucak (2020) found a negative long-run significant association regarding Real GDP and pollutants. This present analysis shows that a 1% rise in CO2 emission will increase real GDP by 0.5246%, 0.7293%, 0.6609% and 0.5257%. The Environmental Kuznets Curve (EKC) hypothesis is not supported by this study since economic growth in the long run positively and significantly relates to carbon dioxide pollution. Besides, NREC was found not significant from the first model when the entire set of the variable was examined together. However, after BM was dropped in the second model, it showed a negatively significant effect at 1%. Indicating that a percentage rise in CO2 emissions will decrease NREC by 0.8110%. when the real GDP variable was dropped in addition to BM, then the significant change from negative to positive at 1% level was attained. Indicating, a percentage increase in CO2 emission will increase NREC by 0.3760%.

Nevertheless, the result from the table shows a robust negative long-run association between FDI and CO2 emissions. This analysis is in line with the finding of Hille et al. (2019) who affirms that foreign direct investment (FDI) reduces CO2 emission. Similarly, this current analysis confirms that an increase in FDI will decrease CO2 emissions by 0.0330%, 0.0368% and 0.0338%. This outcome is healthy for the country because, funds from outside sources in the form of FDI are effectively used for setting up better energy infrastructure, which helps in reducing C0$_2$ pollution.

Table 7. Robust Least Squares (ROB-L^2) long-run relationship

	MODEL 1	MODEL 2	MODEL 3	MODEL 4
VARIABLES	ROB-L^2	ROB-L^2	ROB-L^2	ROB-L^2
LnBM	-0.1395c	-	-	-0.1378c
Prob	(0.0734)	-	-	(0.0561)
LnGDP	0.5246a	0.6609a	-	0.5257a
Prob	(0.0001)	(0.0000)	-	(0.0000)
LnNREC	-0.1845	-0.8110a	0.3760a	-0.2179
Prob	(0.6542)	(0.0005)	(0.0025)	(0.5750)
LnFDI	-0.0330a	-0.0368a	0.0128c	-0.0338a
Prob	(0.0001)	(0.0001)	(0.0852)	(0.0000)
LnTRD	-0.0284	-0.0668	-0.0117	-
Prob	(0.7305)	(0.4491)	(0.9258)	-
R^2	0.4332	0.4219	0.0473	0.4493
ADJ-R^2	0.3388	0.3526	-0.0260	0.3832
Rn^2 stat	35074.36a	29343.67a	14348.01a	39247.78a
Prob	(0.000000)	(0.000000)	(0.000000)	(0.000000)

NOTE: a, b, c represent 1%, 5% and 10% significant levels.

4.2.1. **Short Run Relationship**.

Table 8 presents the short run estimations of the ARDL (3, 2, 2, 2, 1, 2) of the variables. From analysis, it was observed that there is a negative short-run association regarding the lagged value of CO_2 ($LnCO_2$ (-2), $LnCO_2$ (-3)) and CO2 emissions in the current period. It was clear that lagged value of CO2 reduces CO2 emission by 0.41% and 0.355% in the current period. Furthermore, the lagged value of BM (LnBM (-1), LnBM (-2)) has a positive short-run association with pollutant at 0.41% and 0.278% in the current period. Moreover, the lagged value of real GDP (LnGDP (-2)) confirms a negative association with CO2 emissions at 2.349% in the current period. NREC lagged value (LnNREC (-2)) on the other hand has a positive association with CO2 emission at 16.36% in the current period. Nevertheless, for the FDI both the log value and the lagged value (LnFDI, LnFDI (-1)) confirm a positive association with pollutant at 0.041% and 0.11% in the current period. Lastly, TRD confirmed a negative association with CO2 emission at 0.9% but the lagged value (LnTRD (-2)) revealed a positive association with CO2 emission at 1.032% in the current period.

Table 8. ARDL (3, 2, 2, 2, 1, 2) short-run result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$LnCO_2$(-1)	-0.020789	0.227063	-0.091555	(0.9293)
$LnCO_2$(-2)	-0.411436c	0.204525	-2.011661	(0.0791)

LnCO$_2$(-3)	0.355412c	0.172420	2.061320	(0.0732)
LnBM	0.236168	0.130964	1.803306	(0.1090)
LnBM(-1)	0.409771a	0.118873	3.447126	(0.0087)
LnBM(-2)	0.278339a	0.077578	3.587861	(0.0071)
LnGDP	4.154688a	0.951211	4.367789	(0.0024)
LnGDP(-1)	-1.364306	0.887446	-1.537340	(0.1628)
LNGDP(-2)	-2.348723a	0.624478	-3.761098	(0.0055)
LnNREC	-2.208674	3.779248	-0.584422	(0.5750)
LnNREC(-1)	-5.132572	4.066642	-1.262115	(0.2425)
LnNREC(-2)	16.35977a	4.332557	3.776008	(0.0054)
LnFDI	0.040860b	0.015499	2.636332	(0.0299)
LnFDI(-1)	0.106661a	0.027289	3.908513	(0.0045)
LnTRD	-0.900167b	0.322104	-2.794650	(0.0234)
LnTRD(-1)	0.131842	0.304643	0.432776	(0.6766)
LnTRD(-2)	1.032192b	0.318453	3.241267	(0.0119)
C	-59.72418a	14.34025	-4.164794	(0.0031)
R^2	0.972239			
ADJ-R^2	0.913248			
F-STATISTIC	16.48104a			
F-STAT(PROB)	(0.000204)			

NOTE: a, b, c represent 1%, 5% and 10% significant levels.

4.2.2. Granger Causality Tests

Apart from assessing the long and short-run interconnectedness among variables, it is important to evaluate the legitimacy of the direction of causality among the selected variables. This will help inform policy direction. Table 9 displays the outcomes from the Pairwise Granger Causality Tests

The outcome of the analysis proofs that, there is a one-way causal association between real GDP and $_{CO2}$ emission; Real GDP and biomass utilization, non-renewable energy utilization and Biomass energy utilization. Then biomass energy utilization and trade, non-renewable energy utilization and real GDP; real GDP and foreign direct investment, real GDP and trade, foreign direct investment and non-renewable energy utilization as well as non-renewable utilization and trade.

Table 9. Result of Causality Analysis

Null Hypothesis:	**F-STATISTIC**	**p-value**	**Causality Remark**
LnBM ↗ LnCO2	0.10548	(0.9003)	No Causality
LnCO2 ↗ LnBM	0.35881	(0.7025)	
LnGDP ↗ LnCO2	2.73273c	(0.0871)	One way Causality
LnCO2 ↗ LnGDP	0.93752	(0.4067)	
LnNREC ↗ LnCO2	0.30168	(0.7426)	No Causality
LnCO2 ↗ LnNREC	1.18640	(0.3241)	
LnFDI ↗ LnCO2	1.43513	(0.2595)	No Causality
LnCO2 ↗ LnFDI	2.44309	(0.1101)	
LnTRD ↗ LnCO2	0.65557	(0.5290)	No Causality
LnCO2 ↗ LnTRD	1.06875	(0.3606)	
LnGDP ↗ LnBM	5.86715a	(0.0091)	One way Causality
LnBM ↗ LnGDP	1.45629	(0.2547)	
LnNREC ↗ LnBM	2.86239b	(0.0785)	One way Causality
LnBM ↗ LnNREC	1.04908	(0.3671)	
LnFDI ↗ LnBM	2.22738	(0.1316)	No Causality
LnBM ↗ LnFDI	1.24539	(0.3073)	
LnTRD ↗ LnBM	4.68267b	(0.0202)	One way Causality
LnBM ↗ LnTRD	0.03840	(0.9624)	
LnNREC ↗ LnGDP	3.80099b	(0.0382)	One way Causality
LnGDP ↗ LnNREC	1.19036	(0.3230)	
LnFDI ↗ LnGDP	1.06326	(0.3624)	One way Causality
LnGDP ↗ LnFDI	3.73810b	(0.0400)	
LnTRD ↗ LnGDP	3.83253b	(0.0373)	One way Causality
LnGDP ↗ LnTRD	0.59980	(0.5577)	
LnFDI ↗ LnNREC	2.49885	(0.1052)	One way Causality
LnNREC ↗ LnFDI	2.69175b	(0.0900)	
LnTRD ↗ LnNREC	4.14273b	(0.0297)	One way Causality
LnNREC ↗ LnTRD	0.56840	(0.5745)	

LnTRD ↗ LnFDI	0.77481	(0.4730)	No Causality
LnFDI ↗ LnTRD	0.59571	(0.5598)	

NOTE: a, b, c represent 1%, 5% and 10% significant levels. ↗ Means do not Ganger cause**.**

5.1. Discussion of Results

The impact of investments in biomass energy usage on Pollutant emission in Cyprus from 1990 to 2016 is empirically investigated in the present analysis. The study employs numerous dynamic approaches to analyze the interactions that take into account the heterogenic complexity of the variables under analysis. Pollutants have become a big global concern expressed by various, policymakers, stakeholders and nations as a whole. Most governments and environmental sustainability organizations have failed to find answers to these multiple energy consumption problems across economic sectors. For this purpose, this study is conducted to understand the nature of this phenomenon as a whole and propose some measures towards tackling this problem. In this respect, the study analyzes the effect of the use of biomass energy generation on the environment. Also, the study included some significant economic metrics such as real GDP, foreign direct investment, non-renewable energy usage and trade to determine the pollutant effect. The study similar to some prior studies (Bilgili, 2012; Bilgili et al., 2016; Schahbaz et al., 2019) establishes an important and negative relationship between the use of biomass energy and CO_2 emissions. This outcome indicates that biomass being a sustainable energy source can reduce the production of greenhouse gases in the ecosystem.

The use of biomass sources is a healthier type of energy to contribute to the pollution reduction in Cyprus. The finding indicates that green sources of energy, including biomass, best support these ecosystems in reducing CO_2 emissions. Moreover, economic growth in the evaluated nation is not a driving force to combat pollutant emissions as it helps increase greenhouse gas pollution. The Environmental Kuznets Curve (EKC) philosophy is not validated by this study because long-run economic growth does not contribute to a reduction in CO2 emission. There was a confirmation from Ulucak (2020) that output is a positive association with pollutants and it does not immediately imply that the country will have a healthy environment or will be exempt from pollutant if the economy expands. Also, the analysis proof that when Biomass was dropped non-renewable was found significant. It implies that, if the country does not utilize clean energy for production, it can rely on fossil fuel, which will help in reducing pollutant in the ecosystem. But after dropping also real GDP to Biomass utilization, the outcome from the estimation changed by proofing that non-renewable at this moment is positively significant in producing emission. It can therefore be observed that the expansion of the economy has an impact on fossil fuel in reducing CO2 emission. Foreign Direct Investment, on the other hand, shown from the estimation a negative association with CO2 emission. Investment from outside the country into the economy helps expand the economy, which in the long run affect the energy sector. This sector always needs fund in areas like infrastructure expansions, R&D, tannings, subsidizing of taxes and other payments etc. to effectively have an impact on the pollutants emitted into the ecosystem. Therefore, the country is effectively utilizing these fund in good use and the outcome is affirming the finding of Hille et al. (2019).

From the short run association, it was confirmed from the estimations that, the lagged value of CO_2 reduces CO2 emission in the current period. Additionally, the lagged value of Biomass energy utilization has a positive association with CO2 emission. That is in the current period, Biomass energy utilization increases CO2 emission. Moreover, the lagged value of real GDP confirms a negative association with CO2 emissions, which implies that economic development on the other hand decreases CO2 emission in the current state. Nevertheless, non-renewable energy utilization lagged value has a positive association with pollutants. It indicates that in the current state, non-renewable increases CO2 emission. Both foreign direct investment and it lagged for has a positive relation with CO2 emission. By this, it implies that foreign direct investment increases CO2 emission in the current period. However, for trade, it has two different significant levels. The normal log form of trade indicated a negative significant relationship with emissions by implying that at this stage, trade reduces CO2 emission in the current stage but with its lagged value, the significant proofed a positive association with CO2 emission indication that at this time trade increases CO2 emission in the current period.

The outcome of the Pairwise Granger causality test analysis proofs that, there is a one-way causal association regarding real GDP and CO_2 pollutant, real GDP and biomass utilization. Similarly, non-renewable energy utilization and Biomass energy utilization, biomass energy utilization and trade, non-renewable energy utilization and real GDP, real GDP and foreign direct investment, real GDP and trade, foreign direct investment and non-renewable energy utilization as well as non-renewable utilization and trade all showed a one-way causal association.

Another essential thing to take into account is that although energy generation from biomass may result in reducing carbon emissions, its efficiency depends heavily on the efficiency of the country's direct investment by investing in energy generation technology as well as on the amounts of fossil fuel used for manufacturing biomass. Consequently, we could conclude that the technologies used for biomass production in the Republic of Cyprus have a degree of positive effect and that an improved development of biomass energy will minimize these countries' reliance on fossil fuel, and find solutions to the environmental problems connected with fossil fuels in the energy mix.

5.2. Conclusion and Implications of Policies

The impact of biomass energy sources on CO_2 emission for the case of Cyprus is examined from 1990 to 2016 was empirically studied in this study. To determine this, the paper applied the ROB-L2 and ARDL techniques. The study concluded that biomass utilization in the Republic of Cyprus is a decent source of energy that aims to minimize CO2 emission. Here it should therefore be noted that expansion of the renewable source of energy and the emphasis on renewable sources of energy such as biomass is to the nation's advantage (Bilgili et al. 2017). The higher productivity levels of pollutant are confirmed by the ever-existing emission loop from conventional energy sources (Owusu & Asumadu-Sarkodie, 2016). This study, derived from the higher inflation of biomass energy generation as a renewable device in CO2 emissions, however, has gained much greater credibility in this regard. Literature has shown that biomass energy is a renewable energy option that aims to add to the International Energy Agency's (IEA) emissions reductions policy.

It is discovered that the effective utilization of foreign direct investment in the economy is a good way to combat environmental damage. Because the outcomes of a negative correlation among foreign direct investment as well as pollution are a strong demonstration of the decent financial influence of foreign countries' funds to reduce pollution. The results of these observations are evidence that global investors' funds are going to support the sustainable environmental movement in the long run. Because this fund is non-country investment money to help expand the economy, the right structures that will contribute to trucking the use of such funds in the economic expansion are incumbent on stakeholders. However, steps to use any portion of the Fund to implement and arrest infringements of development awareness on the path to preserve the atmosphere should also be updated in any action or scheme that may have an impact on the long-term output of further pollutant waste being funded by the Fund. The achievement of the Sustainable Development Goal (SDG7) 7 for Agenda 2030 will be a disaster without such measures taken in protecting the environment. Given the relation between biomass energy and economic growth, it will be obvious to extend this energy source segment as natural resources are being used well as producing energy for consumption, which would promote industrial growth and expansion.

To promote renewable energy and the effective energy consumption source in their economies, a multilateral agreement should be concluded between North and South Cyprus. It is the responsibility of the authorities on both sides to guarantee that both formal and informal investment in alternative energy sources such as biomass, wind or solar is provided with a pleasant atmosphere. The nation must take advantage of innovation and creativity by sharing knowledge in technological advances as well as other related key projects conducted by government institutions. Authorities on both sides can also provide an incentive for quick access to the funding of renewable energies, as stated in the Paris COP21 Agreement to promote renewable energy investment partners. The tax holiday is a successful method of funding that raises private-sector investors' participation in the development of renewable energy, which eventually has a ripple effect on final use. Lastly, we enter the discussion on the creation of a market for renewable energies and awarding certificates as well as operations of a consolidated clean energy platform that will create more room within the category of sustainable energy.

Declarations.

1. **Ethical approval**

   Answer; not applicable

2. **Consent of Participate**

   Answer; not applicable

3. **Consent to publish**

   Answer; not applicable

4. **Availability of data**

   Answer; the data for this study will be available upon a reasonable request

5. **Competing interest**

   Answer; the authors declare that they have no competing interest

6. **Funding**

   Answer; authors did not receive any funding for this study.

7. **Authors contribution**

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Murad A. Bein; supervision, validation.

Festus Victor Bekun; supervision, validation

Festus Fatai Adedoyin; writing- original draft, conceptualization

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Appendix

Table A.1: VIF Estimations

Variables	VIF	1/VIF
LnGDP	2.13	0.470101
LnBM	1.68	0.595926
LnNREC	1 .46	0.685366
LnFDI	1.75	0.786346
LnTRD	1.52	0.685936
Mean VIF	1.708	