DO ENVIRONMENTAL TAXES MATTER FOR ECONOMIC GROWTH? EMPIRICAL EVIDENCE FROM THE EGYPTIAN ECONOMY

Umar Auwal
Department of Economics,
Ahmadu Bello University Zaria,
Kaduna State, Nigeria.
+234 803 227 4567
auwalumar2012@gmail.com

Ashiru Bello
Sustainable Procurement,
Environmental & Social Standards
Enhancement Centre of Excellence
(SPESSECE), ABU Zaria, Nigeria
+234 806 565 4445
ashirubello@gmail.com

Badruddeen Saulawa Sani
Sustainable Procurement,
Environmental & Social Standards
Enhancement Centre of Excellence
(SPESSECE), ABU Zaria, Nigeria
+234 806 553 2262
basaule@hotmail.com

Yahaya A. Hassan
Department of Accounting and Finance,
Ahmadu Bello University Zaria,
Kaduna State, Nigeria.
+234 803 334 1741
aburuqayya2013@gmail.com

***Corresponding Author**
Umar Auwal
Department of Economics,
Ahmadu Bello University Zaria,
Kaduna State, Nigeria.
+234 803 227 4567
auwalumar2012@gmail.com

ABSTRACT

In 2024, Egypt's GDP was estimated at around $380 billion, making it the second-largest economy after South Africa, whose GDP was estimated at $403 billion. To incentivize environmentally friendly behavior, the Egyptian economy has incorporated environmental considerations into its tax system and fiscal policies over time, addressing negative externalities such as pollution and resource depletion by internalizing their costs into the prices of goods and services. Significant developments have occurred in recent years. This study examines the impact of environmental taxes on economic growth in Egypt. Using annual data from 2002 to 2020, the study employs the Autoregressive Distributed Lag (ARDL) model and the Dynamic Ordinary Least Squares (DOLS) method to investigate the long-run equilibrium relationship and long-run elasticities for the Egyptian economy. The results revealed a long-run equilibrium relationship between environmental taxes and economic growth. This implies that as the economy grows, environmental degradation increases alongside it, but at a certain point, with further economic development, the environmental taxes may rise to mitigate pollution and promote sustainable practices, potentially leading to a decrease in environmental damage, in the long run, depending on the specific environmental policies implemented in Egypt. The study recommendations include identifying a critical tax level that balances environmental protection with economic impact, potentially using green tax shifts to offset other taxes and maintain revenue, and investing in resource efficiency and renewable energy to mitigate adverse effects and promote sustainable growth.

Keywords: *Environmental Tax, Economic Growth, ARDL Approach*
JEL Classification: C22, H23, O44

1. Introduction

The economic progress of most developing countries is usually accompanied by environmental deterioration (Latif, et al., 2023). Industrial pollution is one of the main sources of environmental degradation[1], which adversely affects not only the quality of life in the vicinity but also agricultural products, the rapid loss of biodiversity, and the ecosystem (UNEP, 2023; Lythouse, 2024). To address environmental problems, behavioural changes are needed, some of which involve substantial economic costs and affect labour, product, and capital markets. Generally, environmental policy aims to achieve environmental and sustainable development goals.

[1] Environmental degradation is the deterioration of the environment through depletion of resources such as quality of air, water and soil; the destruction of ecosystems; habitat destruction; the extinction of wildlife; and pollution.

Policy-makers use incentive-based tools to ensure that environmental solutions are found at the least cost for correcting externalities and/or raising revenues for specific purposes. Economic instruments for pollution control and natural resource management are thus an increasingly important part of environmental policy (EU, 2013).

Environmental or "green" taxes emerged in the late 20th century as a response to growing environmental concerns, aiming to address pollution and resource depletion by incentivizing sustainable practices through economic measures, complementing traditional regulations (NTO, 2024)[2]. These taxes aim to internalise environmental costs into economic activities, incentivising sustainable practices. The idea was to generate a positive environmental impact by changing the consumption behaviour of the public in related fields and increasing revenue for the government. In the 1990s, the concepts of green tax, ecological tax, and environmental tax were proposed, with the underlying idea being sustainable development. Since then, the term "environmental taxation" suggested by the OECD has gradually been accepted, and many developed countries have started building their environmental taxation systems, while developing countries have begun their attempts at implementing environmental taxation. Due to the development status and depth of reformation, tax items included in environmental taxation may vary, e.g., carbon tax based on carbon content or CO_2 emission amount of fossil fuel was widely implemented in developed countries, while energy tax based on price of energy was adopted in many developing countries (Tan, et al., 2022).

Therefore, environmental tax is one of the instruments (EU, 2013) used on activities with proven negative environmental impacts to promote environmentally friendly alternatives and potentially generate revenue (Li, Zhou, Sun, & Liu, 2023). It is seen as instrumental to both increasing revenue mobilization and tackling environmental issues. It has proved useful in reducing greenhouse gas emissions and improving energy efficiency, especially in developed countries. Indeed, it has been a global trend to advance the implementation of environmental taxation in response to social and economic development. However, it has not been long since the implementation of environmental taxation in developing countries, making it necessary to study its current status and experiences in representative countries to provide references in designing and constructing their environmental taxation system (Tan, et al., 2022).

Developing countries increasingly adopt environmental taxes to address environmental challenges and raise revenue (Occhiali, 2024). For example, South Africa, Gabon, and Senegal all have environmental taxes in place or are considering implementing them, with a focus on carbon pricing and related environmental levies. South Africa has a carbon tax on industrial emissions and CO2 emissions from motor vehicles (PwC, 2025). It has implemented a carbon tax since 2019, initially at R120 per tonne of CO2e, with increases to R134 by the end of 2022 (Baker, 2022). Gabon has implemented a carbon levy for the aviation and maritime

[2] Specifically, it originates from the fact that the States, faced with the phenomenon of pollution, agreed on guidelines, in the 70s with the recommendation of the OECD - 1972, reaffirmed in 1974 and 1989, the principle “who polluter pays” principle taken into account by the European Community in the 1975 recommendation at the United Nations (UN) Conference on the Human Environment – Stockholm-Sweden. In 1987, Norway issued a report, “Our Common Future”. In 1992, “The Earth Summit”, reaffirmed the Declaration of the United Nations Conference on the Human Environment. In 1997, in Japan, the Kyoto Summit was held within the framework of the Third Conference of the Parties. of the Framework Convention on Climate Change. The Kyoto Protocol came into force on February 16, 2005, and expired in 2012. In 2015, the Cop21-Paris Summit was held in Paris, France, where the necessary actions and investments for a sustainable future were specified. Added to all this are the Sustainable Development Goals - 2030 UNESCO (Muñoz-Ccuro, et al., 2024).

sectors (DGB, 2025). The levy, priced at \$17 per tonne of CO_2 equivalent (tCO_2e)[3], is expected to cover 3–5 million tCO_2e of emissions annually, according to Africa Carbon Solutions, which helped design the mechanism. Senegal is exploring carbon pricing and has updated its environmental code to address environmental challenges (UNCC, 2025).

In the Egyptian context, the environmental taxes can stimulate economic growth and development by raising revenue and improving fiscal responsibility[4]; incentivise cleaner production and consumption, and foster innovation in green technologies. Essentially, the environmental taxes can make polluting activities more expensive, encouraging businesses and individuals to adopt cleaner technologies and practices (WB, Environmental Tax, 2025). This can drive innovation in green technologies and create new economic opportunities in the renewable energy, waste management, and environmental services sectors. These taxes can also help reduce environmental damage and improve public health, leading to a more sustainable and equitable economy (Hamdy, 2025).

Its environmental taxes have a relatively short history compared to ancient times, where taxes were collected in the form of goods and labour[5]. The current environmental legislative framework was established under Law No. 4 of 1994, with amendments in 2005, and Law No. 102 of 1983 (on Natural Protected Areas). The 2014 Constitution also includes provisions for environmental protection (UNDP, 2022). Indeed, the modern environmental taxes aimed at reducing pollution and promoting sustainability have been the focus of government policy and policy reviews in recent years (Lukomski, 2023).

The Egyptian government has taken several important steps over the past few years to reduce carbon dioxide emissions. It is committed to mitigating greenhouse gas emissions by ratifying the Paris Agreement. However, this will be hard to achieve because energy subsidies have been in place for decades, but are being gradually phased out (Elshennawy & Willenbockel, 2021)[6]. Egypt's environmental tax policy primarily focuses on energy use rather than directly addressing pollution or GHG emissions. While Egypt does not have a carbon tax or a CO2 emissions trading system[7], it does collect excise taxes on various energy products like coal, petroleum, diesel, and gasoline. These excise taxes, while not explicitly designed as carbon taxes, contribute to a Net Effective Carbon Rate (ECR)[8] for a portion of the country's GHG emissions (OECD, 2024).

[3] It's a standard unit used to measure greenhouse gas (GHG) emissions by converting different gases into their equivalent amount of carbon dioxide, allowing for a single metric to compare their impact.
[4] Raising revenue can fund public services, social programs, and investments in sustainable infrastructure. And, the environmental taxes reduce reliance on other taxes, potentially leading to a more stable and predictable tax system. By internalizing environmental costs, these taxes can assist Egyptian governments in achieving a more efficient and sustainable fiscal policy..
[5] Primarily, taxes in ancient Egypt were collected as a portion of agricultural products, livestock, and labor, used to finance public works like temples and pyramids. Farmers played a crucial role in the state's economy, contributing to tax revenue through grain and livestock.
[6] The complete removal of fossil fuel subsidies is imperative before it makes sense to implement any kind of market-based incentives to reduce fossil fuel use.
[7] Therefore, the emissions from electricity production and industry remain largely unpriced (OECD, 2024).
[8] In 2023, approximately 52.9% of GHG emissions in Egypt were subject to a positive ECR, primarily due to fuel excise taxes.

While some progress has been made in implementing environmental taxes, challenges remain in achieving a sustainable economy and an effective social adaptation system (Lukomski, 2023). The primary objective is to determine whether environmental taxes have an impact on economic growth in Egypt. The study proceeds as follows. Section 2 provides a brief overview of the literature on environmental taxation and economic growth, highlighting areas that have received the most attention in academic research and what is currently available in Egypt. While Section 3 discusses the data and methodology, Section 4 describes the data and empirical results. Finally, Section 5 provides the conclusion.

2. Literature Review

Environmental taxes are categorically defined into four main dimensions: energy, transport, pollution, and resources. They align economic activities with sustainability goals, targeting carbon emissions, waste disposal, air and water pollution, and sustainable resource management (NTO, 2024). There is a general perception that as the economy grows, industrial activities increase, leading to a higher release of CO2 into the environment. The environmental effects of CO_2 emissions have been enormous, affecting both the ecosystem and the human beings inhabiting it (Aye & Edoja , 2017). Therefore, the two significant challenges facing humanity are economic development and environmental preservation. However, the environment has come to the forefront of contemporary issues for both developed and developing countries since the deterioration of environmental quality raises concerns about global warming and climate change, arising mainly from greenhouse gas (GHG) emissions (Kasman & Duman, 2015). Generally, environmental degradation, both in terms of quantity and quality, is a significant hallmark of industrialization and development, which are key drivers of economic growth.[9]

To reduce the environmental damage by making polluters pay for the harm they cause, environmental taxes can incentivise businesses and individuals to reduce their environmental footprint. These are charges levied on physical units of items that have proven negative impacts on the environment - charges on the environmental externalities derived from the production or consumption of goods and services, which are applied to correct market prices and force producers or consumers to internalize these costs (Pigou, 1920). Although it is very complex to determine the exact societal cost of many environmental externalities, one can define their desired level and then choose a tax that will lead to its achievement (Spratt, 2012).

While aiming to curb pollution and promote sustainability, this approach can have complex effects on economic growth. Economic growth and environmental carbon emissions are intertwined, with economic activities often leading to increased energy consumption and, consequently, higher carbon emissions. However, there is a growing recognition of the possibility of decoupling economic growth[10] from environmental degradation through technological advancements and policy changes.

The environmental tax that has been discussed the most is undoubtedly the carbon tax, which is levied on the carbon content of different goods and strongly correlates with the amount of fossil fuels required in their production. Carbon taxes are viewed as a crucial tool for reducing greenhouse gas emissions, and there is

[9] It is the deterioration of the environment through depletion of resources such as air, water and soil; the destruction of ecosystems; habitat destruction; the extinction of wildlife; and pollution

[10] The process of separating or reducing the link between economic growth and environmental impact or resource consumption, aiming for sustainable development where economic progress doesn't necessarily require increased resource use or harm to the environment.

near-universal support for their introduction worldwide.[11] However, there is limited evidence that African governments see environmental taxes as a domestic priority (WB, State and Trends of Carbon Pricing Dashboard, 2025). For example, only Gabon and Senegal are considering their introduction, following the introduction of one in South Africa in 2019, which arguably has not achieved much to date. While one could argue that carbon taxes can still play a significant role in making investments in fossil fuel generation less attractive, renewable energy generation is already cheaper across most of the African continent. However, lack of financing solutions, high perceived risk, and extensive fossil fuel subsidies are the factors holding back investments (ICTD, 2023).

Although there are quite a few empirical works in this area, the findings have not been consistent. several papers demonstrate that environmental taxation policy may boost economic growth via various channels. Lans Bovenberg and Smulders (1995), Ewijk and Wijnbergen (1995), and Lans Bovenberg and de Mooij (1997) propose that an environmental tax improves the quality of the environment, which increases the productivity of other productive inputs, and thus the total factor productivity of the economy, thereby stimulating economic growth. Based on the Uzawa–Lucas endogenous growth model extended by elastic labor supply, Hettich (1998) and Oueslati (2002) show that a higher environmental tax enhances long-term growth as follows: The increased environmental tax induces firms to raise their private abatement activities, which reduces final output net of abatement at the expense of household consumption. In contrast, Bovenberg and Heijdra (1998), using an overlapping generations model and modelling the quality of the environment as a durable consumption good, found that an environmental tax increase will make future generations suffer from a smaller physical capital stock, but benefit from a larger stock of natural capital. This result is reversed with older generations. In the long term, economic growth is expected to decrease due to the limited physical capital available to the younger generation. Similarly, Wang et al. (2015), based on an overlapping generations model, show that pollution tax can reduce pollution but causes a distortion in the rate of return to capital and thus damages growth. In the same context, Siriwardana et al. (2011) developed a computable general equilibrium (CGE) model to analyze the effects of a carbon tax on the Australian economy.

But to date, most of the taxes, particularly environmental ones, and the growth literature have been scanty and theory-based on developing countries, either using environmental taxes in an endogenous growth framework (Bovenberg & de Mooij, 1997) or as a general measure of environmental policy (Ricci, 2007). For instance, Sharif et al. (2023) confirmed the positive influence of environmental taxes and economic growth on green technology innovation in ASEAN countries from the standpoint of government obligations to include environmental taxes as a policy instrument in their environmental programs and agendas. Bian & Zhao (2020) cited two categories of environmental regulation policies: subsidisation and taxation. Under subsidisation, governments incentivise manufacturers to invest in green technology to reduce pollution. Additionally, this can be supported through various financial instruments secured with the assistance of banks, such as green loans (Mirovic et al., 2023) or similar products and services. Conversely, governments can levy taxes on manufacturers according to their pollution emissions. Rakpho et al. (2023) indicated that implementing environmental policy through environmental taxation could stimulate various economic sectors. The study by Liu et al. (2022) demonstrated that environmental taxes enhance a company's performance by increasing environmental investments.

[11] This includes African countries, with the United Nations, the International Monetary Fund, and the OECD all promoting their implementation in various countries in the region at different points in time (https://www.ictd.ac/blog/environmental-taxation-africa-curb-environmental-damage/).

Similarly, Guo & Huang (2021) highlighted that carbon taxes and subsidies for reducing emissions are two frequently used environmental instruments. Song et al. (2020) pointed out supportive measures, such as R&D tax incentives, to subsidize companies creating environmentally friendly product innovations. Likewise, Yi et al. (2022) noted that subsidies are more effective than taxes in encouraging green innovation. Therefore, the government should strengthen incentive mechanisms, such as green taxes, feed-in tariffs, and various green penalties (Kwilinski et al., 2023). In line with this, Muhammad et al. (2021) suggested that environmental tax policy should be supported by public backing, encouraging positive environmental attitudes that are instilled from an early age through social and educational campaigns. Similarly, Ali et al. (2023) noted that governments should foster a sustainable mindset, motivating individuals to adopt eco-friendly practices and advance environmental sustainability. Liu et al. (2023) emphasized that environmental taxes and effective governance can improve the quality of the environment in the long run.

In most African economies, including Egypt, the empirical literature on this issue has mainly concentrated on the use of simulation exercises rather than the use of econometric modelling (Abdullah & Morley, 2014). To our knowledge, there are no empirical studies on the Egyptian economy on environmental taxes and economic growth except for Elshennawy & Willenbockel (2021) that addresses the distributional effects of a carbon tax within the framework of an intertemporal general equilibrium model, the simulation results suggest that a carbon tax at a rate of USD 20 / ton CO2 could reduce Egypt's fossil-fuel-related GHG emissions by around 6 to 10% relative to the baseline path.

3. Methodology

3.1. Data and Description

Aggregate environmental tax data research faces limitations due to data availability, comparability across countries, and difficulties in accurately quantifying the environmental impact of taxes beyond revenue generation.[12] The study focuses on the available aggregate government revenues from environmental taxes on energy, transport, pollution, and resource consumption to demonstrate the Egyptian government's response to climate change through taxation and spending, based on official statistics and implicit and explicit fossil fuel subsidies, as estimated by models. Table 1 provides a detailed explanation of the data included in a dataset covering the period from 2002 to 2020, along with its origin. This context allows for a better understanding and interpretation of the data the study intends to use for analysis.

Table 1: Description of the dataset

Variable Description	Notation	Data Source
Gross Domestic Product	**GDP**	World Bank and OECD (2025): This data is expressed in constant 2015.
Environmental Taxes, Domestic Currency	**ETD**	IMF: Climate Change Dashboard & OECD Environmentally Related Tax Revenue
Taxes on Energy (Including Fuel for Transport), Domestic Currency	**TED**	IMF: Climate Change Dashboard & OECD Environmentally Related Tax Revenue
Taxes on Transport (Excluding Fuel for Transport), Domestic Currency	**TTD**	IMF: Climate Change Dashboard & OECD Environmentally Related Tax Revenue

Source: Author's computation

[12] Indeed, aggregating data for various types of environmental taxes (e.g., carbon taxes, pollution taxes) can obscure the specific effects of each type. But, data on environmental taxes, especially in developing countries, may be incomplete or inconsistent, making it difficult to conduct rigorous analysis (Occhiali, 2024).

Empirically, using time-series data requires understanding the time properties of the variables to determine the most appropriate econometric techniques. To achieve this, the study employs descriptive analysis and unit root tests to describe the properties, as well as to determine the stationarity of time series data and identify the order of integration[13] before examining the relationship between the variables and estimating the long-run elasticities, it employed the Augmented Dickey-Fuller (ADF) test to determine the level of stationarity to ensure that none of the series is stationary at the second difference I(2) and to avoid spurious regression.

3.2 Model Specification

Environmental taxes, designed to internalise the costs of pollution and resource depletion, can promote economic growth by encouraging cleaner production and innovation and generating revenue for public services. However, their impact can be complex and depend on various factors, including how the revenue is used and the specific design of the tax. The "double dividend" hypothesis suggests that environmental taxes can simultaneously improve environmental quality (the first dividend) and reduce overall economic costs by using the revenue to lower other, potentially more distorting taxes (the second dividend). To determine the long-run equilibrium relationship and estimate the degree of responsiveness of economic growth to changes in ETD, TED, and TTD in Egypt, the functional form of the relationship is expressed as:

$$GDP = f\ (\mathrm{ETD}, \mathrm{TED}, \mathrm{TTD})$$

The study employed the Autoregressive Distributed Lag (ARDL) modeling technique and the Dynamic Ordinary Least Squares (DOLS) approach to determine the long-run equilibrium relationship between GDP, ETD, TED, and TTD and estimate the degree of GDP's responsiveness to changes in ETD, TED, and TTD, respectively.

3.3. Empirical Models

The empirical estimation is two-fold: first, it uses the autoregressive distributed lag (ARDL) approach to co-integration following Pesaran et al. (2001). It can remove spurious regression results and differentiate between long-run and short-run coefficients. Several other approaches can be used in place of ARDL. Nonetheless, the model is applicable irrespective of the underlying variables' integration order[14]. The ARDL approach allows the inclusion of other models with dissimilar variables that take a diverse optimal number of lags. These problems lead to the direct estimation of the long-run parameters using unrestricted error correction models (UECM) that specify the inclusion of dynamics (Olokoyo et al., 2009). When an unrestricted dynamic model includes both lagged and current values of dependent and independent variables, it becomes an autoregressive distributed lag model. The bounds-testing approach, together with the ADRL modelling approach to co-integration analysis developed by Pesaran et al. (2001), involves an ordinary least squares estimation of an ECM of the following form:

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 X_{t-1} + \sum_{i-1}^{p-1} \beta_i \Delta Y_{t-1} + \sum_{i-1}^{q-1} \beta_i \Delta X_{t-1} + e_t \qquad (1)$$

[13]Usually, the order of integration indicates the number of times a variable needs to be differenced to become stationary, meaning its statistical properties do not change over time.

[14]It accommodates variables of varying integration orders, including stationary I(0)) and integrated of order one I(1) variables, addresses endogeneity issues that arise when variables are mutually determined, and at the same time estimates long-run relationships and also captures short-run dynamics.

In this expression, Δ is the first difference operator, α_0 is the constant, Y_t is the dependent variable (output), X_t is the independent variable, e_t is the error term, p and q are the maximum lag orders, α_1 is the long-run relationship (elasticities) among the variables, and β i is the short-run relationship among the variables. One of the main benefits of expending the ARDL is the existence of a long-run level relationship in an ECM framework between the dependent variable Y_t and the independent variable X_t that can be tested when it is not known whether the underlying independence is stationary, non-stationary, or mutually co-integrated with the ARDL model (Odhiambo, 2009).

Short-run coefficient estimation

The short-run elasticity will be estimated through a typical dynamic short-run function as specified below.

$$\Delta InGDP_t = l_0 + \sum_{j=1}^{2} \chi_j \Delta GDP_{t-j} + \sum_{j=1}^{2} \theta_j \Delta ETD_{t-j} + \sum_{j=1}^{2} \pi_j \Delta TED_{t-j} + \sum_{j=1}^{2} \varpi_j \Delta TTD_{t-j} + \zeta ECT + \mu_t \qquad (2)$$

where $\zeta ECT + \mu_t$ is the error correction term.

Long run elasticity estimation

In this study, the long-run equilibrium function is specified as:

$$\Delta InGDP_t = l_0 + \alpha_1 \ln ETD_t + \alpha_2 \ln TED_t + \alpha_3 \ln TTD_t + \partial_t \qquad (3)$$

Where ∂_t is the error term.

The test involves calculating an F-statistic and comparing it to critical bounds based on the estimated model. If the calculated F-statistic exceeds the upper critical bound, it suggests a strong likelihood of a long-run relationship between the variables. Conversely, if the F-statistic is lower than the lower critical bound, it indicates a lack of evidence for a long-run relationship. If a long-run relationship is established, the ARDL bounds test allows for the estimation of both long-run and short-run coefficients.

The long-run coefficients represent the equilibrium relationship between the variables, while the short-run coefficients capture the dynamic adjustments towards the long-run equilibrium. The statistically significant and negative sign of the ECT_{t-1} coefficient (ϑ) Implies that any short-run disequilibrium among the dependent variable and some independent variables will converge back to the long-term equilibrium association. However, if a long-run relationship is not found in an ARDL model, it is generally not recommended to proceed with estimating short-run coefficients as the whole premise of the ARDL approach is to analyse the short-run dynamics within the context of a long-run equilibrium; without that equilibrium, the short-run estimates would not have a meaningful interpretation.

Post estimation diagnostic tests

The study evaluates the long-run coefficient and short-run dynamics of the model for stability, reliability, and validity of the estimated models and identifies potential issues that could compromise the accuracy of research findings. First, tests for the presence of Normality using the Jarque-Bera test. The null hypothesis for the Jarque-Bera test is that the data is normally distributed. If the p-value is less than the chosen significance level (usually 0.05), then the null hypothesis is rejected, indicating that the data is not normally distributed[15].

The second is the Autocorrelation and Heteroscedasticity test with the null hypothesis that there is no first-order positive or negative autocorrelation between the error terms and no conditional heteroscedasticity, respectively[16]. The study also used the Ramsey RESET test with the null hypothesis that the model has no omitted variables. This means that the powers of the fitted values have no relationship to the dependent variable, GDP. The alternative hypothesis is that the model has an omitted variable problem. If the null hypothesis is rejected, the model's specification is inadequate. This could be due to incorrect functional forms or omitted variables. The cumulative sum (CUSUM) and Cumulative sum of squares (CUSUMSQ) tests developed by Durbin and Evans (1975) state that if the plotted CUSUM and CUSUMSQ statistics lie within a 5% significance level, the coefficient estimates are accepted.

The DOLS Method Specification

The DOLS adopts a parametric approach to estimating a long-run relationship in a model in which the variables are integrated in a different order but are still cointegrated (Masih & Masih, 1996). This model deals with simultaneity bias and small sample bias by including leads and lags (Kurozumi & Hayakawa, 2009). The estimators of DOLS can be obtained from least-squares estimates, and these estimators are unbiased and asymptotically efficient even in the presence of the endogenous problem. The parameters also adjust the possible autocorrelation and residual non-normality (Herzer et al., 2006b; Stock & Watson, 1993).

$$y_t = \alpha + \beta X_t + \sum_{i=-k}^{i=k} \phi_i \Delta X_{t+i} + \varepsilon_t \tag{4}$$

In equation (4), β is the long-run elasticity. The term ø's are the coefficients of leads and lags differences of I(1) regressors. These coefficients are considered nuisance parameters, adjusting for possible endogeneity, autocorrelation, and non-normal residuals (Herzer & Nowak-Lehmann D, 2006a; Herzer et al., 2006b).

4. Results and Discussion

Table 2 presents the results of the descriptive statistics, including the average, minimum, and maximum values, as well as skewness, kurtosis, and the Jarque-Bera test, among others. Table 2 also shows that the spread or variability of the data points around the mean is more pronounced for GDP, indicating significant deviation from the average for the variable. The skewness values, which measure distribution asymmetry, are positive, indicating a right skew. The kurtosis values, which measure a distribution's "tailedness" or peakedness compared to a normal distribution, are all positive, indicating heavier tails. The Jarque Bera test values all have high p-values (typically > 0.05), which suggests that the data may be normally distributed.

[15] It is important to note that, rejecting the null hypothesis can have serious implications for model diagnostics. Many statistical methods rely on the assumption that the data is normally distributed, so if this assumption is violated, it may lead to invalid inference.

[16] The two are very important tools in econometrics to ensure the accuracy of regression models.

Table 2: Descriptive Statistics

Statistic	GDP	ETD	TED	TTD
Mean	2.91E+11	1.38E+10	1.18E+10	2.01E+09
Median	2.94E+11	9.40E+09	7.56E+09	1.84E+09
Maximum	4.12E+11	4.72E+10	4.15E+10	5.79E+09
Minimum	1.90E+11	6.60E+08	4.56E+08	2.04E+08
Std. Dev.	6.79E+10	1.50E+10	1.36E+10	1.64E+09
Skewness	0.131763	1.168839	1.230394	1.059378
Kurtosis	2.004845	3.016059	3.120954	3.591723
J-B test (P-value)	0.838992 (0.6574)	4.326456 (0.1150)	4.805503 (0.0905)	3.831083 (0.1473)
Obs.	19	19	19	19

Source: Author's computation

Model Estimation Results and Discussion

This section presents the findings and results of the econometrics analysis conducted on the variables of interest as stated in the research objectives. The analysis begins with a stationarity test of the variables. The ARDL Bounds tests are performed to estimate the long-run and short-run coefficients. Lastly, post-estimation diagnostic tests are conducted to ensure the accuracy and reliability of the results. The second part also estimates the degree of responsiveness of GDP to changes in ETD, TED, and TTD using the DOLS method.

4.3.2 Stationarity and Unit Root Tests

Table 3 shows the Augmented Dickey-Fuller test results, which indicate that the variables GDP, ETD, TED, and TTD have the same order of integration. They are integrated at the level. From the Table, the p-values are all less than the significance level (e.g., 0.05), indicating the rejection of the null hypothesis (that a unit root exists, meaning non-stationarity) and concluding the series is stationary.

Table 3: Augmented Dickey-Fuller test (ADF) Results

Variable	Test Method & Critical Values		@Level		@ 1st Difference	
			t-Statistic	Prob.*	t-Statistic	Prob.*
GDP	ADF test statistic		-3.704339	0.0525		
	Test critical values:	1% level	-4.667883			
		5% level	-3.733200			
		10% level	-3.310349			
ETD	ADF test statistic		-4.411180	0.0156		
	Test critical values:	1% level	-4.667883			
		5% level	-3.733200			
		10% level	-3.310349			
TED	ADF test statistic		-4.401569	0.0159		
	Test critical values:	1% level	-4.667883			
		5% level	-3.733200			
		10% level	-3.310349			
TTD	ADF test statistic		-3.851036	0.0392		
	Test critical values:	1% level	-4.616209			
		5% level	-3.710482			
		10% level	-3.297799			

Source: Authors' computation

Bounds Test Results

The calculated F-statistics are reported in Table 4, where economic growth is considered a dependent variable (normalised) in the ARDL-Ordinary Least Squares (ARDL-OLS) regressions, with a value of 11.6604. The result clearly shows a long-run relationship between the variables because its F-statistic (11.6604) is higher than the upper-bound critical value (3.670) at the 5% level. This implies that the null hypothesis of no co-integration between the variables is rejected.

Table 4: ARDL Bound Test

Test	Value		10%		5%		1%	
F-statistic	**11.6604**	**Sample Size**	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
		30	2.676	3.586	3.272	4.306	4.614	5.966
		Asymptotic	2.370	3.200	2.790	3.670	3.650	4.660
* I(0) and I(1) are respectively the stationary and non-stationary bounds.								

Source: Author's computation

ARDL - Error Correction Regression

The results of the short-run dynamic coefficients associated with the long-run relationships obtained from the ECM equation are given in Table 5. The signs of the short-run dynamic impacts are maintained in the long run. However, except for TTD, the ETD and TED variables are statistically significant at 17.2% (0.171672) and -13.5 % (-0.134859), respectively. The equilibrium correction coefficient (*ECM*) lies between 0 and -1, estimated at -0.08 (-0.078725), is highly significant, has the correct sign, and implies a fairly high speed of adjustment to equilibrium after a shock.

Table 5: ARDL ECM Results

Dependent Variable: D(LEGDP)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
COINTEQ*	-0.078725	0.008714	-9.034546	0.0000
D(LETD)	0.171672	0.067966	2.525843	0.0242
D(LTED)	-0.134859	0.051842	-2.601353	0.0209
D(LTTD)	-0.001193	0.018272	-0.065308	0.9489

Source: Author's computation

ARDL Post-Estimation Diagnostic Tests

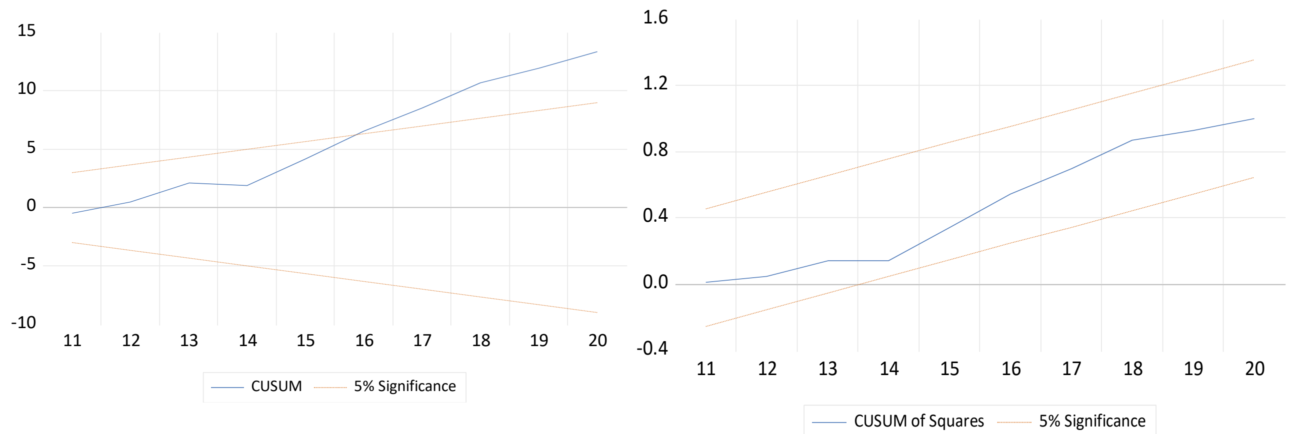
From Table 6 above, the underlying ARDL model passes all the diagnostic tests against serial correlation (Breusch-Godfrey test), heteroscedasticity (Harvey Test), and normality of errors (Jarque-Bera test). The test for heteroskedasticity revealed that the Null Hypothesis should not be rejected (= no heteroskedasticity exists). LM test statistic for the null hypothesis of no serial correlation shows that the (effectively) non-zero probability value strongly indicates no serial correlation in the residuals. The short-run dynamics test the stability of the long-run coefficient. Figure 1 shows that, except for the CUSUM of squares, the CUSUM plots fall within the 5% level of significance (indicated by the two red dotted lines) over the sample period; this satisfies the condition for structural stability of the model.

Table 6: Post Estimation Diagnostic Tests

Test Statistic	F-statistic	P-Value
Normality Test	1.605674	0.448056
Heteroskedasticity Test: Harvey	1.145152	0.4086
Serial Correlation LM Test:	0.347155	0.7168
CUSUM	Unstable	
CUSUMSQ	Stable	

Source: Author's computation

Stability Test of the Model (Figure 1: CUSUM and CUSUMSQ Plots)



Long-Run Elasticities from the DOLS Method

Table 7 presents the results of the DOLS method estimation. The estimated coefficients can be used as long-term elasticities. The estimated coefficients are statistically significant, except for the case of TTD. Therefore, the analysis that accounts for the robustness of long-run parameters by estimating the long-run elasticities or coefficients of the independent variables provides further evidence of the existence of a long-run equilibrium relationship.

The estimated coefficients are adequate only if the method is statistically viable. Therefore, the diagnostic test for the three models is provided in the bottom panel of Table 7, which reveals that R^2 and adjusted R^2 indicate that the regressors in the model explain approximately 99% of the changes in GDP. The goodness-of-fit indicator for the models shows that the estimated long-run elasticities are efficient and adequate. The F-statistic of the models is highly significant, indicating that the model's overall performance is sound. Each model's Jarque-Bera test (J-B test) result accepts the null hypothesis that "residuals are normally distributed". To this end, it is evident that all variables of interest, except for TTD, have a statistically significant influence on GDP in Egypt.

Table 7: Dynamic Ordinary Least Squares (DOLS) Results

Dependent Variable: LGDP				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LETD	1.444412	0.489940	2.948143	0.0601
LTED	-1.055541	0.379341	-2.782561	0.0688
LTTD	-0.183855	0.138040	-1.331903	0.2750
C	21.16479	0.489150	43.26847	0.0000
R-squared	0.997889			
Adjusted R-squared	0.989445			
S.E. of regression	0.020278			
Long-run variance	0.000247			
J-B test (P-Value)	0.856318 (0.651708)			
F-statistic (P-Value)	261.2874 (0.0004)			

Note: The asterisks ***, **, and * are respectively the 1%, 5%, and 10% significance levels

Source: Author's computation

Summary of Key Findings

The study determines the long-run equilibrium relationship between economic growth and environmental taxes. This implies that, in the long run, the relationship between environmental taxes and economic growth is complex and depends on various factors, potentially resulting in both positive and negative impacts. The second part substantiates the former results by estimating the degree of responsiveness of economic growth to changes in environmental taxes. Except for taxes on transport (excluding fuel for transport), environmental taxes, and taxes on energy (including fuel for transport), these elements exert significant and long-term positive and negative influences on economic growth, respectively, highlighting the interconnectedness of these critical elements to economic growth in Egypt.

5. Conclusion and Recommendations

The positive influence of environmental taxes on economic growth implies a "double dividend" effect, where environmental improvements are coupled with economic benefits. This is achieved by shifting the tax burden from traditional areas, such as labour and capital, to pollution, waste, and resource depletion, potentially reducing economic distortionary effects. The study recommends using revenues generated to reduce other taxes, boosting employment, investment, and overall economic growth. Secondly, focus on maximising the benefits and mitigating potential negative impacts. This includes using revenue from environmental taxes to fund public goods and services, reduce other distorting taxes, and invest in green technologies and sustainable infrastructure. Additionally, public education and awareness campaigns are crucial for fostering a sustainable mindset and encouraging eco-friendly practices.

The lack of a significant economic growth response to transportation taxes has several implications, including potential inefficiencies in the transportation system, reduced government revenue from taxes, and the possibility of unintended economic consequences for businesses and consumers. This suggests that the tax structure is not optimally designed or that the tax benefits are not being effectively channeled into the economy. The study recommends that adjustments be made, such as broadening the tax base beyond transportation, increasing the progressivity of taxation, and ensuring that tax revenue is effectively channelled into productive public expenditures. Also, more research into the relationship between transportation infrastructure and economic growth, including the impact of transportation on industrial agglomeration and total factor productivity, could lead to more effective policies.

On the other hand, the negative influence of taxes on energy, which includes fuel for transport, implies that taxes on energy can negatively impact economic growth by increasing production costs for businesses, potentially leading to reduced investment and slower economic expansion. This adverse effect can be particularly pronounced in economies heavily reliant on fossil fuels or industries with high energy consumption. The study recommends carefully designing and implementing energy taxes to minimise their negative impact on economic growth, potentially including measures to relieve energy-intensive industries. Second, the revenue generated from energy taxes should be used to fund other important public services or to lower other taxes, such as income taxes, to offset the negative impact of energy taxes. The third is promoting investment in renewable energy sources and energy efficiency measures to reduce reliance on fossil fuels and mitigate the negative impacts of energy taxes.

The findings support some of the empirical studies suggesting that environmental taxes can negatively impact economic growth in the short and long term such as Bovenberg & Heijdra (1998), Wang et al. (2015), and Siriwardana et al. (2011) among others, while others suggest that they can promote growth under certain conditions such as Ewijk & Wijnbergen (1995), (Hettich, 1998), Lans Bovenberg & de Mooij (1997), Lans Bovenberg & Smulders (1995), and Oueslati (2002), among others. Further development of research methodologies is needed to better quantify the environmental impact of environmental taxes and account for the complexities of their interactions with other factors.

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