

Promoting Sustainable Development by taxation policy The Case of Tunisia

ترقية التنمية المستدامة بالسياسة الضريبية
دراسة حالة تونس

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Abstract

This research aims at studying the role of environmental taxation policy in promoting Sustainable development and facing climate change challenges, focusing on the case of Tunisia.

The study employs a descriptive-analytic approach, using a time-series dataset from 1990 to 2020, to assess the impact of environmental taxation on CO2 emissions. The empirical results reveal a slight positive impact of environmentally related to tax revenue on CO2 emissions, indicating a need for more public awareness and more impactful fiscal policies. On the contrary, taxes on energy demonstrate a negative impact on CO2 emissions, suggesting their potential for reducing CO2 emissions and, thus, climate change mitigation. The

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findings emphasize the importance of revising environmental taxation policies to prioritize energy taxes and promote renewable energy sources for a sustainable future in Tunisia.

Keywords

Sustainable Development, Taxes, Environmental Taxation, Climate Change, CO2 emissions.

الملخص

هدف البحث إلى دراسة دور السياسة الضريبية البيئية في ترقية التنمية المستدامة ومواجهة تحديات التغير المناخي وذلك بالتركيز على الحالة التونسية. اعتمدت الدراسة على المقاربة الوصفية التحليلية باستخدام بيانات السلاسل الزمنية للفترة الممتدة من 1990 إلى 2020 وذلك لتقييم أثر الضرائب البيئية على انبعاثات ثاني أكسيد الكربون.

بينت النتائج الميدانية أن تأثير الضرائب البيئية وكذا الضرائب الطاقوية على البيئة كان إيجابيا لكنه محدودا، الأمر الذي يعني الحاجة إلى المزيد الوعي العام وإلى المزيد من السياسات الضريبية المؤثرة. على العكس من ذلك بينت النتائج الميدانية أن تأثير الضرائب الطاقوية على انبعاثات ثاني أكسيد الكربون كان سلبيا على الرغم من إمكانيات التأثير التي تتيحها. من نتائج هذه الدراسة تتجلى الحاجة إلى مراجعة السياسة الضريبية البيئية في تونس مع إعطاء الأولوية للضرائب الطاقوية وللمصادر المتجددة للطاقة.

الكلمات المفتاحية

التنمية المستدامة، الضرائب، الضرائب البيئية، تغير المناخ، انبعاثات ثاني أكسيد الكربون،

Introduction

Sustainable development (SD), as a global issue, becomes a major concern for all countries in the world, more than that it becomes a new development paradigm required by most international conferences (Mensah, 2019). SD, is not limited to ecology issues, it is linked also to the other global issues such as climate change, poverty and biodiversity. According to the Division of Sustainable Development of United Nations "climate change is an inevitable and urgent global challenge with long-term implications for the sustainable development

of all countries” (United Nations, 2022). Accordingly, world leaders, policymakers, and civil society actors, requested, at the 78th high-level session of the UN General Assembly held in New York, greater efforts and more actions to tackle climate change. Moreover, international actors, such as the United Nations, the World Bank Group, etc., propose assistance through funding programs, technical assistance and human resources training.

Despite the importance of the issue, people still behave with “Stone Age” minds, they place less importance on environmental changes than the other more tangible concerns such as fire, famine, or flood (Van Vugt et al., 2014). Hence, the world is bearing increasing costs and impacts due to this lack of awareness, while certain countries have made remarkable progress with this regard.

In the addition to this lack of awareness, not all countries can support the cost of SD policies or green technologies. Poor countries, due to the lack of financial resources, couldn't send enough on human development such education, health and social protection, and even less on environmental issues such as pollution and climate change in contrast to wealthy nations, which dedicate substantial resources to both social welfare and environmental protection (Miller & Long, 2017).

In order to mitigate pollution, both developed and developing countries rely mainly on taxation to either enforce environmental compliance among companies and individuals, or to fund public environmental policies. As carbon dioxide is considered the most factor contributing to global warming (Nunes, 2023; Kabir et al., 2023; Kovacikova, Janoskovaa & Kovacikova, 2021), Carbon taxation becomes the tool of choice for shifting to green taxation. It has shown its efficiency as a fiscal policy, especially in developed countries (Koval et al., 2023) where it is used also as an economic instrument to leverage development (Mpofu, 2022). In other words, this kind of taxation is

based on the idea of improving both economic conditions and environmental circumstances by levying green or environmental taxes and employing the mobilized resources to reduce the tax rates for other tax heads already in existence.

Thorough a critical review for models of environmental taxation and their application in developing countries, this study tries to shed light on the role of taxation, particularly environmental taxation, in ensuring sustainable development and mitigating climate change effects in Tunisia.

1. Impact of environmental taxation on sustainable development

Several studies were conducted about the role of environmental taxation in order to determine to what extent such tool is performant to achieve sustainable development goals (SDGs). Most of this studies tends to confirm that taxation is the more effective tool to foster the environmental culture among both individuals and corporates.

Rahman (2022) tried to study the impact of tax rate on SD in both BRIC (Brazil, the Russian Federation, India, China, and South Africa) and CIVETS countries (Colombia, Indonesia, Vietnam, Egypt, Turkey, and South Africa). Based on statistical analysis and tests of the panel dataset for 2000-2021, the study confirmed that a higher rate of taxation adopted by emerging countries contributed in achieving efficiently sustainable development goals by these countries.

Accordingly, the researcher emphasizes the positive correlation between higher tax rates and the effectiveness of taxation.

In the same context, Hannah et al., (2023) conducted a similar study in Sub-Saharan Africa countries. Using the Government Revenue and Development Estimations (GRADE, V3.3.0) applied to the data related to certain public services particularly access to water, education, sanitation, and maternal and child mortality, the authors tried to

confirm that even a small rise in government revenue in lower-income countries could has a massive impact on the coverage of the SDGs.

The study allowed authors to conclude that the government revenue, equivalent to Vodafone's average contribution, ensured the access for 966,188 people to clean water and for 1,371,972 to sanitation each year, as well it enabled 858,054 children to spend an additional year in school. In short, adopting fair corporation tax, governments, and countries could play an important role in sustainable development. Otherwise, SDGs remain out of rich.

Regarding the impact of fiscal policy on environmental management then ensuring sustainable economies, Koval et al., (2023) studied, from their part, the impact of green financial instruments on environmental management and the economic sustainability in European Union (EU) countries. Using correlation and Varimax analysis of EU budget revenues for the period 2000-2021, the authors concluded that environmental taxes are closely related to indirect taxes. In other words, green taxes motivate polluters to reduce the overall level of the release of toxic substances. In addition, they emphasis that it is necessary to develop more appropriate methods or tools for assessing the impact of fiscal policy on managing the environment and ensuring a sustainable economy.

Focusing on reducing CO2 emission, Omodero et al. (2022) tried to assess the impact of environmental taxes on CO2 emission control in Nigeria. Since the business operations of the oil and gas sector generate a significant level of pollution to the environment, the research tried to assess the impact of green taxes such as gas exploration tax and petroleum profit on CO2 emissions. The authors concluded that the gas exploration tax has an inconsequential negative influence on CO2 emission management unlike petroleum profit tax which hasn't a significant impact on CO2 emission control. On the other side, the cost of environmental preservation has a large beneficial influence on CO2

emission control. Accordingly, the authors advocate for more green taxes setting to lower pollution levels in Nigeria.

Ben Youssef, Dahmani and Mabrouki (2023) analyzed the relationship between environmental related taxes and productive capacities on climate change in European economic area countries using the advanced second-generation econometric techniques. The study revealed an inverted U-shaped relationship between GDP growth and environmental degradation in the EEA economies. While data revealed a significant negative correlation between environmental taxes and CO₂ emissions, authors found that productive capacities have a more significant impact on reducing these emissions.

In the same order of idea, He et al. (2023) asked: Will environmental taxes help to mitigate climate change? They tested the role of environmental taxes in mitigating climate change process and reducing extreme weather events in 36 OECD countries using the Auto-Regressive Distributed Lag (ARDL) model. Authors concluded that the environmental taxes can contribute significantly to reducing the frequency of abnormal temperature weather, as well, they can reduce significantly carbon dioxide emissions. A similar result has been concluded by Sackitey (2023) who studied the impact of environmental taxes on consumption and energy intensity in OECD countries. Using ratios such as tax to total tax ratio, total energy consumption, and total energy intensity and the fully modified and dynamic OLS techniques and the Dumitrescu and Hurlin's panel granger causality test, the author concluded that environmental taxes have a strong significant impact on energy consumption and energy intensity among OECD member countries.

As a result, all the studies above proved that taxation does have an important impact on sustainable development then on reaching SDGs in both developed and developing countries. While the results are

different according to the sample analyzed or the context studied, the goal remained the same: promoting sustainable development. Hence, growing evidence shows that environmental conservation for sustainability of natural resources is not, anymore, a luxury but a necessity when considering long-term economic growth and development. In this regard, environmental taxation tends to be a strong tool to address environmental issues and reach sustainability.

2. Environmental Taxation approaches for sustainable development

The previous literature review allowed us not to confirm only the role played by environmental taxation in mitigating climate change issue only, it confirmed also the role of such taxation in promoting economic growth and development. However, what are the main taxation approach used by policymakers?

2.1. Pigouvian approach

The first important approach has been proposed by Arthur Cecil Pigou, British economist, in 1920. This famous economist suggested that the polluter should be, simply, taxed according to the cost of the harm he caused to others; thus, this tax is set equal to the external cost caused by the polluter. Accordingly, independent variables could be chosen the set the level of tax such the level of emissions caused by the polluter.

The most common variable considered to set the Pigouvian tax is carbon emissions. For example, Canada, in the province of British Columbia, introduced a carbon tax in order to limit greenhouse gas emissions. They set the tax per ton of carbon dioxide emissions. By 2022, it would reach \$50 per ton. As a result, the tax has effectively not only reduced emissions but also generated revenue for the province (British Columbia Government, 2022).

However, the Pigouvian tax could has positive externalities. To resolve this problem government can lay on subsidies. Overall, Pigouvian tax offers a double advantage: environmentally, it will cut pollution by raising the polluter's cost under the principle "the polluter pays"; financially, it raises tax revenues, so the government can efficiently fund public services. Thus, the Pigou tax shaped the economical behavior of stakeholders by shifting investments towards clean and suitable technologies.

Certainly, the Pigouvian approach has provided a clear framework for addressing pollution; nevertheless, it has been subject to several criticisms regarding its applicability, particularly its impact on demand.

2.2. The Standard and Tax Approach

To address the shortcomings of the Pigouvian approach, Baumol and Oates (1971) proposed another approach called The standard-and-tax approach. This approach tried to introduce taxes or incentives to encourage corporate to adopt environmental behavior and at the same time, it tried to avoid the unworkability of the Pigouvian solution by adding predetermined standards (Berta, 2020). The idea of mixing standards and taxes had already been suggested by Kneese and Bower in 1965. Based on empirical studies, these authors confirmed that mixing standards and taxes can provide important cost savings (Nishibayashi, 2019).

According to Baumol and Oates, the optimal level of pollution, which is the main object of the Pigouvian tax approach, depends not only on the total amount of damage associated with pollution but also the marginal damage. They set it clearly in their paper as follows: «The optimal tax level on an externality generating activity is not equal to the marginal net damage it generates initially, but rather to the damage it would cause if the level of the activity had been adjusted to its optimal level. if there is little hope of estimating the damage that is

currently generated, how much less likely it is that we can evaluate the damage that would occur in an optimal world, which we have never experienced or even described in quantitative terms » (Baumol and Oates 1971, p. 43). As a result, the authors claim to support environmental taxes by political and technical standards.

2.3. Unhealthy products taxation

Society's health is listed as the third SDG. In this regard, governments use taxation to encourage any behavior that can safeguard the human health and ensure the well-being of population. Accordingly, governments set taxes on the consumption of unhealthy products. For example, tobacco taxation is one of many health taxes. By taxing tobacco, governments target two main objectives: discouraging people from consuming products considered unhealthy, and generating at the same time revenue for covering other public services. Therefore, tobacco taxation seems to be an effective tool.

2.4. Environmental Fiscal Reform

Based on more than two decades of research results in development and environmental economics, many researchers have advocated for environmental taxation reforms in order to optimize fiscal policies, then achieve both environmental and development objectives (Fullerton & West 2001).

“Environmental fiscal reforms” or “Green Tax Reforms” (EFR) refers to a range of taxation and pricing measures that can raise fiscal revenues while furthering environmental goals (OECD, 2005). EFR represents a shift in the logic of taxation, it proposes taxing activities that have a direct impact on the environment instead of taxing capital, or labor. It includes also the reforms of subsidies that counteract environmental policy (Freire-González, et al. 2018). As examples of this range of taxes available to policymakers we mention taxes on greenhouse gas emissions (carbon and sulfur dioxide/ taxes), energy generation and consumption (coal, coke, electricity, kerosene...),

vehicles (road taxes, vehicle registration taxes, and congestion charges), air transport (airport duties, air passenger duties, and aviation fuel duties), shipping (fuel oil and port taxes), water and sanitation (water, wastewater, and effluent charges), and many others (Pigato, 2019).

Overall, taxation plays more than a classic role in promoting sustainable development, especially on an environmental scale. The literature has fully explored the importance of taxation in achieving the SDGs, particularly in developed countries. Empirical literature proves that the more tax revenue increases, the more we are moving towards sustainable development. However, a recent literature review (Freire-González 2017) mentioned conflicting results regarding employment and economic output of environmental taxation.

3. Tunisian fiscal policy and sustainable development

Tunisia is considered by international institutions as one of the African countries with a commendable environmental policy. The country ranks first in Africa and 59th in the world in terms of SDG achievement according to the recent ranking. For instance, Tunisia's score is 72.5 out of 100. With this kind of score, Tunisia has fully attained SDG 1: No poverty. However, Tunisia is still dealing with malnutrition, obesity, and anemia. Such performance reflects the country's coherent and continuous efforts toward sustainable development (United Nations, 2022). Despite these promising results, the journey is still long for Tunisia to achieve the UN 2030 Agenda, which means achieving the rest of the SDGs. In fact, the country still struggling to manage water scarcity, climate change effects, and many other problems.

Tunisia's environmental policy was marked by its timidity for, basically, three reasons, which are: the imbalance of sustainable development actors; applying classic tax incentives in the form of tax reductions; and the lack of environmental taxes (Krouda, 2014).

In terms of environmental taxes, there were only two, which are the Environmental Protection Tax (TPE) and the tax on biological rest paid on the local turnover of fish product producers.

The TPE has been introduced by The 2003 Finance Act launching the pollution control fund at a rate of 2.5%, payable by manufacturers and importers of plastic raw materials falling under numbers 39-01 to 39-14 of the tariff of customs duties. This rate was increased to 5% by the Article 55 of Law No. 2003-80 of December 29, 2003, enacting the 2004 Finance Act.

In fact, TPE appears to be the initial implementation of environmental taxation, as it applies to specific polluting energy products, and its revenues are allocated to two special funds within the Treasury: the Pollution Abatement Fund and the Environmental Protection and Aesthetics Fund. These green taxes were set at a very low rate.

Recently, the 2023 Finance Act has implemented a new chapter known as "Encourage the financing of research and development expenditure in the fields of green, blue, circular economy, sustainable development, and renewal costs." This chapter has introduced different measures in order to ensure progress towards the SDGs.

In terms of incentives, the government has applied classic tax benefits in the form of tax reductions. The latter are granted to fields having either a direct or indirect link with the environment. These tax reductions are mainly motivated by productivity, which is not a criterion for sustainable development. Also, the benefits of encouraging regional development are granted to businesses that are localized in regional development zones with the aim of promoting their economic growth. These benefits encompass projects related to infrastructure and public facilities, particularly in the construction and real estate promotion sectors.

Additionally, incentives are provided for agricultural development, aiming to utilize available natural resources to enhance agricultural and fishing production, along with the modernization of these sectors, all with the overarching goal of improving productivity. (See Article 65 of the Income Tax Code for Individuals and Corporate Income Tax.)

To sum up, legislative farmwork in Tunisia has tried to implement legal texts related to the environment. However, in terms of environmental taxes, there is an obvious lack of green taxes. Therefore, before adding more environmental taxes to the Tunisian tax system, it is appropriate to study the impact of current implemented taxes.

4. Methodology

Our study makes use of a descriptive-analytic approach. The descriptive method describes the various scientific phenomena and solves problems and questions that fall within the scope of scientific research. Then the collected data is analyzed using a descriptive analytical approach so that the appropriate explanation and results can be extracted. Descriptive analytics looks at data to examine, understand, and describe something that's already happened. The results are typically presented in heatmaps and other visualizations that are easily understood.

This empirical study aims to investigate the impact of environmental taxation on CO2 emission control in Tunisia. So, the used approach provides insights into historical trends in variables, relationships, and patterns. Therefore, it aids in investigating the influence of one variable on another.

The study uses a time series dataset running from 1990 to 2020, based on the multiple regression model according to the following model:

$$CO_2 = f(EnvT_R, EngT_R) \quad (1)$$

The econometric form is as follows:

$$CO_{2t} = \beta_0 + \beta_1 EnvT_Rt + \beta_2 Eng_RTt + \varepsilon_t \quad (2)$$

Where :

- **CO₂** = carbon dioxide emissions, **EnvT_Rev** = Environmentally related Tax Revenue;
- **Eng_RT**= Energy Tax Revenue;
- **β₀** = constant; (**β₁**, **β₂**) regression coefficients;
- **ε_t** = error term.

The selection of data variables was an essential step in this study. Specifically, we focused on the following key variables: CO₂ (carbon dioxide emissions), SDGs (Sustainable Development Goals), and taxation proxies: tax revenue percentage of GDP (Environmental Tax Revenue and Energy Tax Revenue). In short, these variables were chosen based on their relevance to our research objectives.

The variables employed in this research are presented in the following Table. All of the information is gathered from secondary sources that are publicly available. Therefore, the table contains information about the data sources, including their descriptions and units

Table 1: Data Description

Variables	Sign	Measurement	Sources
CO2 emissions	CO2	CO2 indicates CO2 emissions in metric tons per capita at each year	https://www.climatewatchdata.org/ghg-emissions
Sustainable development goals	SDG	SDG indicates sustainable development goals (SDG Index) at each year	https://dashboards.sdindex.org/
Environment ally related tax revenue	EnvTaxByGDP	“EnvTaxByGDP” indicates revenue generated from environmental taxes each year.	https://stats.oecd.org/Index.aspx?DataSetCode=ERTR
Revenue from taxes on energy	RevTaxEngGDP	"RevTaxEngGDP" indicates revenue generated from taxes on energy	https://stats.oecd.org/Index.aspx?DataSetCode=ERTR

Source : developed by authors

CO2 emissions are the main dependent variable that is measured in metric tons per capita. Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement, which include carbon dioxide produced during consumption.

Sustainable development goals (SDGs) are measured by the annual SDG index. The higher and more positive values of the SDG indicate better achievement of sustainable development goals.

When it comes to independent variables, we have taxation proxies. First, environmentally related tax revenue is calculated as a percentage of GDP. This variable provides the revenue generated from taxes on different domains, such as: air pollution, biodiversity, etc. Second, revenue from taxes on energy represents the revenues from taxes raised on energy products (fossil fuels and electricity), including those used in transportation (petrol and diesel). It is also calculated as a percentage of GDP. Through these two variables, we are aiming to determine the impact of actual environmental instruments used by the Tunisian policymakers to control CO2 emissions.

5. Results and Discussion

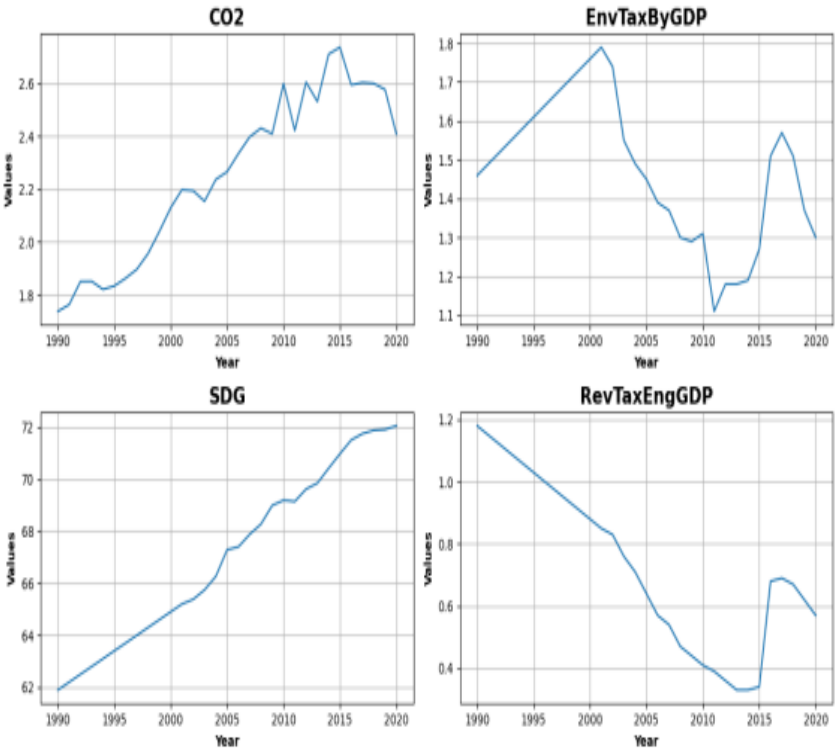
Here, we will unveil the results, discoveries, and insights that have emerged as the fruits of our empirical study. These findings provide a window into the core outcomes of our study, fostering a nuanced comprehension of the intricate interplay between environmental taxation and sustainable development.

5.1. Results presentation and Analysis

5.1.1. Descriptive Statistics

Based on the data provided in the appendix 1, the graphs below (Fig. 1) provide a visual evolution of all variables from 1990 to 2020.

Fig. 1: Trend analysis



Source : constructed by authors from the data given in the appendix 1

Looking at the CO2 emissions, there is an increasing trend, which signifies that pollution in the environment does exist and is not likely to end soon as there is not yet a suitable solution. This uptrend in CO2 emissions makes Tunisia the 112th country in the ranking of countries by CO2 emissions, out of 184 countries, in which countries are ranked from least to most polluting.

In contrast, the SDG index has increased over time. This upward trend is associated with the accomplishments realized by the Tunisian

authorities in their pursuit of the Sustainable Development Goals (SDGs).

For "environmentally related tax revenue", the trend was up until 2002, and then it decreased significantly over time. At the beginning of the 1990s, Tunisia joined the Rio de Janeiro Convention on Biodiversity. In this context, the government began to, seriously, consider depollution through the establishment of the Pollution Abatement Fund (FODEP).

Different tax resources were established for the benefit of the fund. Otherwise, there were only two environmental taxes that were established in 2003 and 2009. These taxes were set at a very low rate. For these reasons, Tunisia's tax policy was described as "weak and shy" in terms of implementing green taxes (Kourda, 2014), which explains the low revenue generated from these taxes. The "energy tax revenue" has also decreased over time. Since 2000, Tunisia has had a serious energy deficit due to an increase in energy demand more than national production. This deficit explains the low revenue generated from taxes on energy. As a result, both environmental and energy tax revenues varied and decreased over time, indicating a lack of appropriate support for the country's needed environmental cleanup. The following descriptive statistics confirm this trend:

Table 2 : Descriptive Statistics

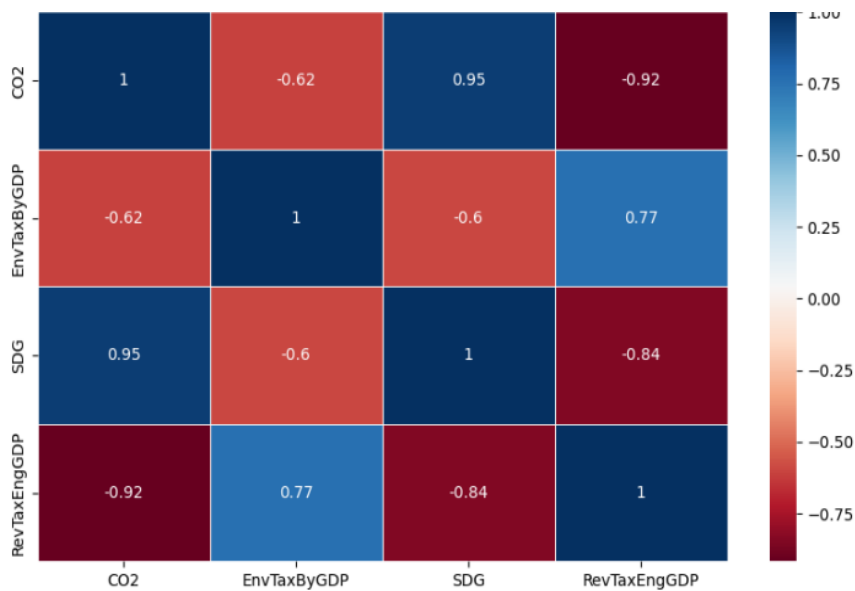
Criteria	CO2	SDG	EnvTaxByGDP	RevTaxGDP
Mean	2.250150	67.033512	1.470323	0.726774
Median	2.265866	67.284227	1.490000	0.690000
Std	0.315996	3.340175	0.188741	0.271310
Min	1.738372	61.900000	1.110000	0.330000
Max	2.736460	72.044334	1.790000	1.180000
Obs	31	31	31	31

Source : calculated by authors

The table above provides a descriptive summary statistic of the variables. Regarding CO2, the overall mean is 2.25, with a standard deviation (Std) of 0.31. It indicates that the moderate level of average CO2 emissions for Tunisia is 2.25 metric ton/capita. The mean value for SDG is 0.67, with a standard deviation of 3.34. The moderate level of average SDG values indicates that Tunisia is more likely to achieve sustainable development goals. The mean of taxation proxies EnvTaxByGDP and RevTaxEngGDP are 1.47 and 0.72, with standard deviation of 0.18 and 0.27, respectively. These values mean that Tunisia's taxation policies related to environmental protection and energy are moderately implemented.

To assess the relationship among variables, a correlation matrix is presented in the following matrix:

Table 3 : Correlation Matrix



Source: developed by authors

According to this matrix, there is a negative correlation between CO2 and EnvTaxByGDP, which means that when one variable increases, the other tends to decrease. There is also a strong negative correlation between CO2 and RevTaxEngGDP. This result is similar to Koval et al. (2023) whom confirm that green taxes can affect polluters by creating incentives for industry to reduce the overall level of emissions of harmful substances.

However, there is a positive correlation between CO2 and SDG. This result could be explained by the existence of trade-offs among the SDGs. Reducing the CO2 emissions level is related to the environmental dimension of SD. Handling environmental issues doesn't mean improving other dimensions of sustainable development. There will always be trade-offs among the three pillars of SD (Mensah, 2019).

5.1.2. Regression Analysis

The following table 4 summarizes the regression output based on the Ordinary Least Squares (OLS) model. The latter is most widely used due to its efficiency. It selects the parameters of a linear function of a set of explanatory variables using the principle of least squares.

Table 4 : Result of linear regression

Dependent Variable: ΔCO2 Method: Least Squares Sample: 1990–2020 Included observations: 30				
Variables	Coeffecient	Std.Error	t-Statistic	Prob.
ΔEnvTaxByGDP	0.7969	0.206	3.863	0.001
ΔRevTaxEngGDP	-0.9966	0.243	-4.099	0.000
Const	0.0063	0.014	0.468	0.643
R-squared: 0.416 R-squared: 0.373 F-statistic: 9.611 Prob (F-statistic): 0.000705 Log-Likelihood: 38.725 AIC: -71.45 BIC: -67.25		Adj.	Omnibus: 2.107 Prob(Omnibus): 0.349 Skew: 0.116 Kurtosis: 3.836 Durbin-Watson stat : 2.424 Jarque-Bera (JB): 0.941 Prob(JB): 0.625 Cond. No. 22.7	

Source : calculated by authors

Looking to this summary, the R-squared gives some information about the goodness of fit of the model. In our case, the value of R-squared is 0.416, which means that there is a 41.6% variation in the dependent variable (CO2) that can be explained by independent variables. However, Adjusted R-squared is important for analyzing multiple dependent variables’ efficacy of the model. Here, the adjusted R-squared is 0.373, which means that the two variables are

contributing to the model by almost 38%. Therefore, there is room for other variables that are not included in the model, such as the public acceptability index, which should be considered in future research.

Additionally, the F-statistic p-value of 0.000705, which is less than 5%, confirms that the model is statistically significant and suitable for the research. Also, the Durbin-Watson result in the same table shows a value of 2.424, which is relatively close to 2, which indicates that any negative autocorrelation present is likely weak. Since this value is slightly above 2, it suggests a mild negative autocorrelation in the residuals of our regression model. However, the deviation from 2 is not substantial. The low score: 0.941 for the Jarque-Bera (JB), the normality test, demonstrates that errors are normally distributed.

In terms of the coefficient section, the p-values for variables are less than 5%, which means that both variables are statistically significant. The findings revealed the next equation:

$$\Delta \text{CO2} = 0.0063 + 0.7969 \Delta \text{EnvTaxByGDP} - 0.9966 \Delta \text{RevTaxEng GDP} + \epsilon$$

Accordingly, the environmentally-related tax revenue (EnvTaxByGDP) is positively and significantly related to CO2. For instance, if EnvTaxByGDP rises by 1 unit, then CO2 rises by 0.7969. Hence, our findings regarding revenue from taxes on energy imply a negative and significant relationship between this taxation proxy and CO2 emissions. For example, if RevTaxEng rises by 1 unit, then CO2 emissions decrease by 0.9966.

The results show that environmentally-related taxes are not yet enhancing the Tunisian environment for healthy living, which means the actual applied levies do not help to regulate pollution. In contrast, taxes on energy may help reduce CO2 emissions. Taxing energy does not only reduce energy use, but it can also switch people's behavior towards more renewable energy.

Moreover, the model for this study was evaluated for heteroscedasticity, normality, and multicollinearity, as detailed in Table 5, at a 5% level of significance, and the p-values were found to be greater than 5%. According to the results, the model is stable, normal, and devoid of heteroskedasticity.

Table 5 Diagnostic Tests

Type of Test	Test-statistic	P-value
Breusch-Pagan Test	0.1825	0.91277
F-test	0.08264	0.92091
Shapiro-Wilk Test	0.9695	0.5276
Δ EnvTaxByGDP-VIF	1.7551	1.7551
Δ RevTaxEngGDP-VIF	1.7551	1.7551

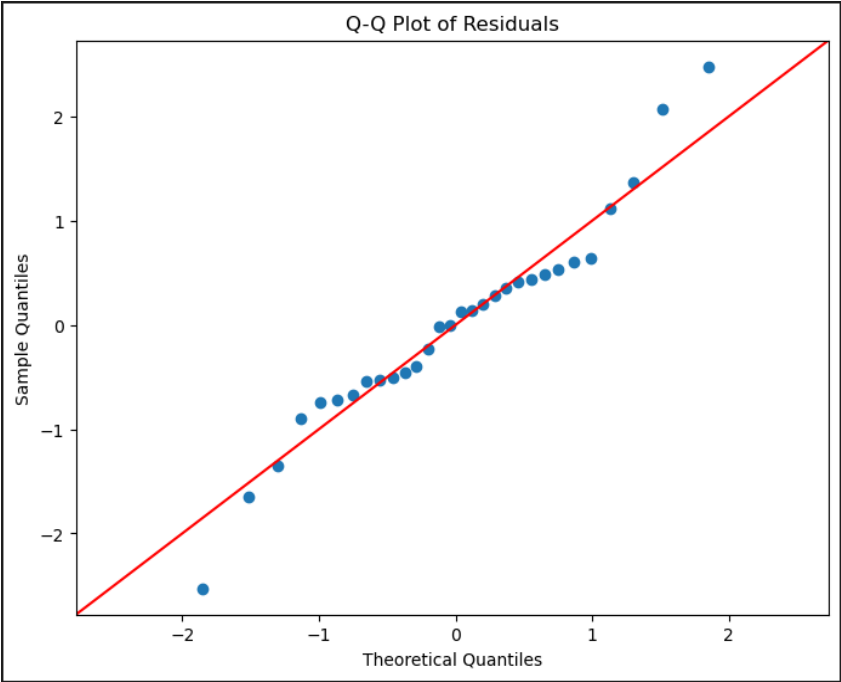
Source : calculated by authors

In terms of homoscedasticity, the p-values of the Breusch-Pagan test and the F-test are both much higher than the typical significance levels (like 0.05 or 0.01). This means that there is not enough evidence to reject the null hypothesis of homoscedasticity. The results suggest that the variances of the residuals are approximately equal across the range of values predicted by the model (i.e., the residuals are homoscedastic). Based on these tests, there is no evidence of heteroscedasticity in the model's residuals, which is a sign of the validity of our OLS regression estimation.

In terms of normality, the normality of residuals can be checked using a Q-Q plot. If the residuals follow the 45-degree line in the Q-Q

plot, this means that they are normally distributed. By looking at Fig.2, where the x-axis displays the theoretical quantiles of the normal distribution while the y-axis displays the actual quantiles of the residuals from the model,

Fig. 2 : Q-Q Plot of Residuals



Source: developed by Authors

The graph above shows clearly that the points (errors) lie close to the 45-degree line, which means that the residuals have a distribution that is close to normal.

To check normality with a statistical test, the Shapiro-Wilk is a commonly used test. The result of the test statistic in Table 9 is 0.9696. Usually, this value ranges from 0 to 1, where a value closer to 1 indicates that the data is more likely to be normally distributed, which is the case for our model. Also, the p-value is greater than the common

significance level (5%). Therefore, there is no strong statistical evidence to suggest that the residuals are not normally distributed. The combination of a high p-value and a statistic test close to 1 implies that the assumption of normality for the residuals in the regression model is reasonable.

In terms of interdependence, the variance inflation factor (VIF) of all independent variables is less than 10, indicating that the model is not multi-collinear (Gujarati et al. 2009).

Overall, the diagnostic tests and visual inspection indicate that the regression model is stable, normal, and devoid of heteroscedasticity and multicollinearity. This strengthens the confidence in the validity and reliability of the regression results.

5.2. Results Discussion

The study used environmentally-related tax revenue (EnvTaxByGDP) and revenue from taxes on energy (RevTaxEng) as taxation proxies. According to the findings, environmentally related tax revenue (EnvTaxByGDP) is positively and significantly related to CO₂. This result is similar to the results found by Omodero et al. (2022), where green taxes had a negligible positive impact on CO₂ emission control. The environmentally-related taxes have not yet helped in enhancing the Tunisian environment for healthy living. Additionally, it raises awareness about the efficacy of these taxes. It was noted that green taxes in Tunisia were designed at a very low tax rate. For instance, TPE was at 5%. Otherwise, international organizations such as OCED and UN recommend raising environmental taxes over time. Only last year, through the Finance Act 2022, TPE was raised to 7%. As a result, Tunisia's tax policy was described as hesitant in terms of environmental taxes (Krouda, 2014). This kind of behavior was explained by the public's reaction to green taxes, which implies the importance of public acceptability in terms of tax policies.

Regarding revenue from taxes on energy, this implies a negative and significant relationship between this taxation proxy and CO2 emissions. This indicates that taxes on energy could help control CO2 emissions. Taxes on energy have shown, early on, its efficiency. These findings suggest that the Tunisian government should consider revising its environmental taxation policies to prioritize taxes on energy consumption and production over other types of environmentally related taxes. Taxes on energy can directly incentivize individuals and businesses to reduce their energy consumption and adopt cleaner energy sources, thereby contributing to a more sustainable and environmentally friendly economy (Lin & li, 2011).

As a recommendation, the government should invest the revenue generated from taxes on energy into renewable energy infrastructure and research and development initiatives. Promoting renewable energy sources, such as solar and wind power, can further reduce the country's reliance on fossil fuels and mitigate CO2 emissions.

Conclusion

To sum up, this research studied Tunisia's experience in terms of environmental taxation. Recently, in its national strategy, Tunisia showed intention to make a transition towards a low carbon economy. In this regard, our empirical study tried to assess the impact of environmental taxes on CO2 emission control in Tunisia from 1990 to 2020. The study made use of revenue from environmentally related taxes, revenue from energy taxes as taxation proxies, and the level of CO2 emissions.

The findings suggest that the Tunisian government should consider revising its environmental taxation policies to prioritize taxes on energy consumption and production over other types of environmentally related taxes. Taxes on energy can directly incentivize individuals and businesses to reduce their energy consumption and

adopt cleaner energy sources, thereby contributing to a more sustainable and environmentally friendly economy.

Furthermore, the government should invest the revenue generated from taxes on energy into renewable energy infrastructure and research and development initiatives. Promoting renewable energy sources, such as solar and wind power, can further reduce the country's reliance on fossil fuels and mitigate CO2 emissions.

All in all, while environmental taxes can play a role in environmental protection, the current taxation structure in Tunisia is not effectively reducing CO2 emissions. A shift towards energy taxes and investments in renewable energy can provide a more effective and sustainable approach to environmental protection in Tunisia.

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Appendix 1: Dataset

Year	CO2	EnvTaxByGDP	SDG	RevTaxEngGDP
1990	1.73837204	1.46	61.9	1.18
1991	1.763488256	1.49	62.2	1.15
1992	1.851136149	1.52	62.5	1.12
1993	1.851629683	1.55	62.8	1.09
1994	1.821518448	1.58	63.1	1.06
1995	1.833969543	1.61	63.4	1.03
1996	1.863305958	1.64	63.7	1
1997	1.897185463	1.67	64	0.97
1998	1.957136545	1.7	64.3	0.94
1999	2.040443736	1.73	64.6	0.91
2000	2.129599418	1.76	64.9	0.88
2001	2.198172049	1.79	65.2	0.85
2002	2.19396366	1.74	65.3830732	0.83
2003	2.154417814	1.55	65.74200415	0.76
2004	2.236659226	1.49	66.2626031	0.71
2005	2.265866436	1.45	67.28422736	0.64
2006	2.334331531	1.39	67.3951197	0.57
2007	2.397519185	1.37	67.87625319	0.54
2008	2.430690668	1.3	68.26874364	0.47
2009	2.409401489	1.29	68.98812767	0.44
2010	2.59948015	1.31	69.18732796	0.41
2011	2.421693378	1.11	69.14065123	0.39
2012	2.604725469	1.18	69.61516662	0.36
2013	2.53107798	1.18	69.84364657	0.33
2014	2.710310695	1.19	70.41459293	0.33
2015	2.736460007	1.27	70.96848172	0.34
2016	2.594443261	1.51	71.50065756	0.68

2017	2.602781049	1.57	71.74599813	0.69
2018	2.599764804	1.51	71.87417187	0.67
2019	2.576495226	1.37	71.90369878	0.62
2020	2.408622528	1.3	72.04433359	0.57

Source: developed by the authors from resources mentioned in the table 3.