Do energy transition and environmental taxation contribute to sustainable development? Evidence from OECD countries

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Zohra Dradra
Faculty of Economics and Management of Sfax, University of Sfax, Sfax, Tunisia

Abstract

Purpose – In this study, the author intend to investigate the impacts of renewable energy use and environmental taxation on sustainable development measured by the adjusted net savings (ANS).

Design/methodology/approach – This study employs the quantile regression (QR) for a set of 24 Organization for Cooperation and Economic Development (OECD) countries over the period 1994–2018.

Findings – The main empirical findings of estimates show that access to renewable energy and environmental taxation generate positive and significant effects in increasing the ANS for most quantiles. Hence, they are practical tools for achieving sustainable development goals (SDGs).

Practical implications – This study has important implications for governments and policymakers of the OECD countries. Therefore, governments can use subsidies and incentives to promote the adoption of renewable energy sources, energy-efficient technologies and sustainable practices. Similarly, by imposing taxes on pollution and resource use, governments can encourage the adoption of cleaner technologies and practices toward more sustainable behavior.

Originality/value – This paper is based on a novel measure of sustainable development (ANS) and a novel econometric method (QR).

Keywords Renewable energy, Environmental taxation, Sustainable development, Quantile regression

Paper type Research paper

1. Introduction

Over the past two to three decades, atmospheric variations have been recognized as the world's most important climate dilemma (Nchofoung & Ojong, 2022; Usman & Radulescu, 2022). Fossil fuel consumption contributes to environmental deterioration, global warming, natural disasters, increased desertification and negative spillovers on natural resources (Islam *et al.*, 2022; Dradra & Abdennadher, 2023). According to the annual bulletin on greenhouse gases (GHGs) published in 2021 by the World Meteorological Organization (WMO), the concentration of carbon dioxide (CO2) stood at 413.2 parts per m (ppm) in 2020, i.e. 149% of the pre-industrial level. Methane (CH4) and nitrous oxide (N2O) were 262% and 123% of 1750 levels, respectively. These issues emphasize the efforts to promote the adoption of policymakers' strategies to achieve sustainable development [1].

To achieve a sustainable development agenda, global efforts are challenged by different factors, among which are environmental protection and efficient natural resource exploitation This reflects the desire to reconcile the obligations of economic growth and the improvement of the social conditions of the population on the one hand, with the requirements of the conservation of natural resources and protection of the environment on

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the other hand (Tchouto, Njoya, Nchofoung, & Ketu, 2022). To achieve these targets, economists and international organizations have recommended several policies. Among these policies, the energy transition and environmental taxation are strongly urged, which are gainful tools for reaching sustainability targets (Shahzad, Jianqiu, Hashim, Nazam, & Wang, 2020; Dogan, Majeed, & Luni, 2022). In this context, numerous conferences have been organized to shape the notion of sustainable development in order to save the health of the individual by developing cleaner sources that are more cost-effective and environmentally friendly and by applying carbon taxes as a tool to restrict carbon emissions (Wang, Khurshid, Qayyum, & Calin, 2022).

With the apparition of the idea of sustainable development, growing interest has been given to the renewable energy industry and several countries have started to establish strategies in this area. That said, energy transition is at the heart of different dimensions of sustainable development. Regarding the economic dimension, energy is clearly an essential driver of economic development. Regarding the environmental aspect, using renewable energy sources would help alleviate local and worldwide environmental stress. Regarding the social aspect, energy is necessary to provide numerous fundamental human needs and services (Ibrahim *et al.*, 2022; Li, Bae, & Rishi, 2023).

The energy transition appears to be an opportunity and a necessity in the sense that it constitutes both a tool for saving the environment and regulating the global economy. Also, it is appropriate to redesign the energy model and move towards a more sustainable model. For this reason, it has become essential, to grow clean resources use such as geothermal, solar, wind, biofuels, and biomass to improve the living standards of individuals and to minimize anthropogenic pollutants (Dradra & Abdennadher, 2022).

In the same vein, environmental taxation is one of the tools that boost long-term sustainable development (Kotlán *et al.*, 2021). Indeed, it permits the correcting of negative externalities, such as pollution, which is generally credited to Pigou (1920). This Pigouvian tax has its origins in theoretical literature relating to the social cost issue. The initial insight refers to the behavior of an agent that practices troubles in its environment. As far as we are concerned, the underlying thought of Pigou would seem to be the following: if there is a divergence between social and private costs, the intervention of the state through a tax equivalent to such a divergence would lead to a social optimum (balance). The "double-dividend" theory, according to which a carbon tax has two-way effects, was the first to propose the introduction of such taxes. Encouraging energy savings and investments in energy efficiency, can, on the one hand, encourage energy substitution and, consequently, changes in structures of energy generation and use. On the other hand, it affects investment and consumption behaviors via the recycling of collected carbon tax revenues, known as the "revenue-recycling effect" (Zahedi, Ahmadi, & Dashti, 2021). Environmental taxes may, therefore, be able to address the various facets of environmental and conservation issues.

At this point, the world economy, including the Organization for Cooperation and Economic Development (OECD) countries, has made efforts toward sustainable development. They employ tax carbon to promote investments in the renewable energy industry and foster energy efficiency. From the survey above, the aim of our paper is to investigate the effects of the energy transition and environmental taxation on sustainable development in a sample of OECD countries. The contribution of our article manifests itself in the use of the "adjusted net saving" (ANS) rate as a measure and suitable indicator for sustainability instead of other traditional variables such as gross domestic product (GDP). Also, we employ panel quantile regression to scrutinize the model while the existing research used conventional regression techniques based on the mean values. Finally, there is a lack of studies, which relate fiscal policy to the sustainability issue.

The remainder of the article is divided into five sections: section 2, which is devoted to a brief review of the literature; Section 3, which specifies the empirical model and variables selection; Section 4, which fully explains the econometric methodology and the obtained results and section 5, which presents conclusions and policy recommendations.

2. Literature review

Various theoretical perspectives can be discussed that underpin the relationships between energy transition, environmental taxation and sustainable development. The framework includes concepts from environmental economics, ecological modernization and sustainable development theories. The interactions between economic systems, environmental factors and social well-being are explored to establish a comprehensive foundation for the study. This section is divided into two parts; the first part focuses on the relationship between the usage of renewable energy and sustainable development, while the second part concentrates on the relationship between environmental taxation and sustainable development.

2.1 Renewable energy consumption–sustainable development nexus

You (2011) assessed the association between energy consumption and sustainable development measured by ANS in China from the period 1980 to 2004. They carried out that the consumption from renewables and non-renewables sources contributes positively to increasing the rate of ANS.

Behboudi, Mohamadzadeh, and Moosavi (2017) employed the BVAR model to estimate the dynamic interlinkages between sustainable development, energy and the environment in the case of Iran over the period 1980 to 2013. The empirical findings showed the existence of a long-run relationship between the variables. Besides, the positive and significant impacts of renewable and nonrenewable energy consumption on sustainable development are confirmed by using the impulse response functions.

Kamoun Abdelkafi, and Ghorbel (2019) analyzed the impacts of renewable energy consumption on sustainable growth measured by ANS in a set of OECD countries during the period 1990–2013. The results revealed that renewable energy technologies positively influence the ANS. Likewise, electricity generated from renewable sources has a positive effect on the ANS. Güney and Kantar (2020) studied the energy consumption–ANS nexus for 40 developed and 73 developing countries. The main results revealed that renewable energy and sustainable development are significantly and positively correlated in the overall countrie.

For 17 OECD countries between the 1990s and 2017, Hassoun and Hicham (2020) examined the link between renewable energy consumption (REC) and ANS. Based on the autoregressive distributed lag (ARDL) model, the results showed that REC not only has a significant short-term negative impact on ANS but also has a significant long-term impact.

For a panel of 25 African economies, Tiba and Belaid (2021) evaluated the effects of REC and sustainable development. They used the modified human development index (MHDI) as a proxy of sustainable development. The results showed that REC and MHDI had a positive correlation, and higher quantities of renewable energy can support achieving the sustainability target.

For a panel of 14 mediterranean countries, Dradra and Abdennadher (2022) examined the three-way relationships between REC, CO2 emissions and human development index (HDI) between 1990 and 2016. They used the three-stage least squares (3SLS) and seemingly unrelated regression (SUR) methods. The findings demonstrated that REC plays a significant role in improving economic conditions and levels of sustainable development. Similarly, the outcomes demonstrated that REC lowers CO2 emissions. Using panel data for a set of ASEAN countries, Islam *et al.* (2022) revealed that nonrenewable sources lessen the level of sustainable development and generate a significantly negative while, while renewable sources amplify it and produce a significantly positive influence.

Iftikhar, Pinglu, Ullah, and Ullah (2022) investigated the linkages between renewable energy, tourism and sustainable development for a set of 64 BRI nations. Based on the two-step system generalized method of moments (GMM), they found a statistically significant and positive dynamic association between sustainable development and its main drivers. Hosen, Siddik, Alam, Miah, and Kabiraj (2022) studied the link between biomass energy use and sustainable development in a set of 19 Asian countries during the period 1990–2019. To do this, they used the fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) techniques. They found that biomass energy generates a positive effect on sustainable development. This means that Asian countries should prioritize investments in the biomass energy industry to reach the SDGs targets. Usman and Radulescu (2022) examined the determinants of environmental sustainability measured by ecological footprint in a set of countries with the highest nuclear energy production between 1990 and 2019. Using panel data, they found that the consumption of nuclear and renewable energy significantly improves environmental quality. Conversely, technological innovations and nonrenewable energies considerably destroy environmental quality.

Sharif *et al.* (2023) used annual data from 1995 to 2020 to estimate the role of green technology, green energy and environmental taxes towards environmental sustainability in a set of five Nordic countries. They use the cross-sectional CS-ARDL method and the augmented mean group (AMG) and common correlated effects mean group (CCEMG) approaches for robustness checks. They revealed a significant contributory role of green technologies, environmental taxes and green energy in a sustainable environment.

2.2 Environmental taxation–sustainable development nexus

The effect of environmental taxation on sustainable development indicators is of little interest in the literature. For this reason, we will mention the studies that worked on topics concerning the effects of environmental taxation on environmental and economic dimensions of sustainable.

In the example of China, Lu, Tong, and Liu (2010) examined the effect of the carbon tax on CO2 emissions. The results of the simulation model indicated that the carbon price is a useful tool since it can reduce levels of pollution. For a sample of European countries and OECD countries, Abdullah and Morley (2014) examined the causality effect between environmental taxes and economic growth during the period 1995–2006. The results pointed out a long-run causality going from economic growth to environmental taxes, with also a short-run causality in the reverse direction.

The difference-in-difference (DID) technique was used by Lin and Li (2011) to study the effects of carbon prices in five northern European countries. According to the empirical results, the implementation of the carbon price in Finland significantly reduced CO2 emissions per capita. They found insignificant effects in the cases from Sweden, Denmark and the Netherlands. The consequences of the carbon tax have not been mitigated in Norway.

Vera and Sauma (2015) studied how the carbon tax affects CO2 emissions in the case of Chile from 2014 to 2024. The empirical results demonstrated that implemented carbon price results in a 1% reduction in emissions levels. He *et al.* (2019) examined the relationship between carbon taxes and CO_2 emissions in China, Finland and Malaysia between the years 1985 and 2014. The ARDL regression results showed that carbon taxes have long-term double-dividend effects in each of the three nations. Overall, the findings showed that air pollution may be reduced via environmental taxes.

In the same context, Ghazouani, Xia, Ben Jebli, and Shahzad (2020) employed the propensity score matching (PSM) model to investigate the role of the carbon tax on environmental degradation in European economies. The results of the estimation revealed a positive and significant relationship between the adoption of the carbon tax and CO_2 emissions.

Wang and Yu (2021) evaluated the effects of environmental policies (EP) and carbon pricing (CTAX) on GHGs and PM2.5 for a number of nations in Central and Eastern Europe from 2000 to 2018. By using a dynamic panel data model, the results show that EP reduces emissions by 2.7% and 17.4% in the short term and long term, respectively. Likewise, CTAX reduces GHGs by 8.6% in the short run and PM2.5 by 0.9% in the short term and 5.7% in the long term. In a group of five island economies chosen between 2001 and 2020, Yue *et al.* (2022) examined how a carbon tax and renewable energy sources affect the reduction of carbon pollution. Based on a panel quantile regression, they found that carbon pricing reduces carbon pollution at the 30th and 40th quantiles, with an elasticity value of 0.042% and 0.035%, respectively.

Dogan *et al.* (2022) used the novel quantile regressions to estimate the effects of environmental taxes on carbon emissions by including sustainable indicators for a set of environmentally friendly countries during the period 1994–2018. The results showed that environmental taxes are key determinants in decreasing carbon emissions.

Wolde-Rufael and Mulat-Weldemeskel (2022) investigated the effectiveness of renewable energy and environmental tax in reducing carbon emissions in a set of 18 Latin America and the Caribbean countries during 1994–2018. They used different panel methods such as the method of moments quantile regression (MMQR) and other conventional techniques (the AMG and the DOLS). The findings from MMQR together with the other techniques pointed out that environmental tax and renewable energy can minimize carbon emissions.

The study by Shayanmehr *et al.* (2023) explored the direct and indirect effects of renewable energy and environmental tax on environmental sustainability (measured by ecological footprints). By using several techniques including the MMQR, DOLS, FMOLS and panel GMM, the empirical findings showed that renewable energy and environmental tax promote sustainability by reducing the ecological footprints.

3. Model specification and variables selection

3.1 Model specification

Our study aims to scrutinize empirically the effects of environmental taxation and energy transition on sustainable development for a sample of 24 OECD countries [2], over 25 years, from 1994 to 2018. Due to the lack of recent data for the other countries of the region, only 24 countries were included in this analysis. The different data are extracted from the World Bank database (WDI) and the OECD are the sources of information.

The general empirical model of current study is constructed as follows:

$$ANS = f(REN, EVTAX, INF, RENT)$$

Our empirical model is represented in linear form as follows:

$$ANS_{i,t} = \beta_0 + \beta_1 REN_{i,t} + \beta_2 EVTAX_{i,t} + \beta_3 INF_{i,t} + \beta_4 RENT_{i,t} + \varepsilon_{i,t}$$

Where (ANS) the dependent variable is the adjusted net savings refers to the annual sustainable development level. β_0 designates the constant term; $\beta_1\beta_2$, and β_3 and β_4 term the long-run elasticities, which represent the impacts of renewable energy consumption (REN), environmental taxation ($EVTAX$), inflation rate (INF) and natural resources rents ($RENT$) on sustainable development; $\varepsilon_{i,t}$ denotes the error terms. The number of countries is represented by i and t denotes the period. Table 1 lists the definitions of the various variables, labels, measurements and datasets' sources.

After presenting the different model variables, an overview of descriptive statistics and partial correlation coefficients between variables will be presented in the table below. Clearly, the standard deviation results reveal that REN, INF and ANS are greater than the standard deviation of EVTAX and RENT. On the other hand, the findings of the correlation matrix indicate that REN and EVTAX are positively correlated with sustainable development, the viability of which assists countries in moving toward sustainable development. Similarly, the RENT is positively correlated with sustainable development is obtained (r = 0,001), but a negative correlation between sustainable development and INF is obtained, with a correlation coefficient value of (r = −0.146).

3.2 Variables selection

3.2.1 Dependent variable. The dependent variable in this paper is sustainable development measured by ANS [3] as a percentage of Gross National Income (GNI). It goes beyond the traditional definition of (net) saving by adding the accumulation of human capital and subtracting the depletion of natural resources, earning it the name "Genuine Savings." It aims to understand the dimensions of physical capital, human capital and natural capital. As the classical measure, GDP ignores the human welfare dimensions and cannot define sustainable development. Therefore, in this study, we provide the adjusted net savings as a more appropriate indicator of countries' sustainable development. This is in accordance with the recent studies of (Güney, 2021; Islam *et al.*, 2022; Hosen *et al.*, 2022).

3.2.2 Independent variables. The first independent variable is the environmental tax (EVTAX) measured as a % of GDP. It is defined as any tax, which has a physical unit as its base and which has specific results on the environment and on the economy. Therefore, to transition to a low-carbon and climate-resilient economy in a cost-effective and economically efficient way, it is important that the trade-offs between the sustainable development goals (SDGs) are effectively managed. Therefore, given that the challenges of development oblige the most developed countries to make an increased effort to reduce global carbon emissions, the carbon tax should be gradually introduced. Several studies that have adopted this variable include; Ghazouani *et al.* (2020), Bragagni, Xhaferraj, Mazza, and Concetti (2021), Romero-Castro, López-Cabarcos, and Piñeiro-Chousa (2022) and Wang *et al.* (2022).

As a basic variable, renewable resources are essential for satisfying basic economic needs (e.g. growth, human well-being, clean environment, etc.). Therefore, for a sustainable development path, their adoption is necessary and it is a strategic issue for the future of our planet. All over the world, the access to renewable sources of energy is a necessary to achieve sustainable development targets. This is pursuant to the recent papers of (Tiba and Belaid, 2021; Islam *et al.*, 2022; Meng, Sun, & Guo, 2022; Hosen *et al.*, 2022).

The literature review highlighted a certain number of variables that can explain sustainable development. We introduce the inflation rate as one of the most important macroeconomic factors because it can engender negative effects on the structure of production costs and the well-being level. This is pursuant to the studies of (Yolanda, 2017; Pardi, Abd Majid, & Junos, 2021). Besides, natural resource rents (% of GDP) are also a

Variables	Labels	Measure	Source
Adjusted net savings	ANS	including particulate emission damage (% of GNI)	WDI (2020)
Renewable energy consumption	REN	% of total final energy consumption	WDI (2020)
Environmental tax	EVTAX	% of GDP	OECD (2020)
Infation, GDP defator	INF	Annual %	WDI (2020)
Total natural resources rents	RENT	% of GDP	WDI (2020)

Source(s): Table by the author

Table 1. Definition, symbol, measure and source of variables

significant determinant for adjusted net savings. It defines the degree to which an economy can depend on natural resources to produce income which is an essential part of the sustainability debate. It is expected that raised percentage of natural rents in GDP decreases sustainable development and various studies that have employed this variable include Koirala and Pradhan (2020) and Romero-Castro *et al.* (2022).

4. Econometric strategy and results

To address the validity of the specification of our model, we perform several tests, including descriptive statistics and correlation matrix, VIF, heteroskedasticity, serial correlation and normality tests. The different results are displayed in Appendix A1 - A4.

4.1 Cross-sectional dependence (CSD)

The selection of a relevant econometric model for panel data hinges on the findings of the CSD test, which should be tested before estimating the model. As a first step, we check the problem of CSD by implying the CD test of Pesaran, Schuermann, & Weiner (2004). It is a key step and helps in choosing the stationarity tests. To do this, we calculated the statistics for the CD test using the infra equation:

$$CD = \sqrt{\frac{2T}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\rho_{ij}$$

Where N design the number of countries, T represents the time dimension, ρ_{ij} denotes the estimation of the CSD of country i and j. The null hypothesis (H0) confirms the absence of CSD, while the alternative hypothesis (H1) advocates for the absence of CSD.

The findings illustrated in Table 2 confirmed the reject the null hypothesis of the CD test. This implies that there is a sufficient CSD condition across all countries involved in this study.

4.2 Panel unit root tests

After checking the issue of CSD, we move on to the next step, checking the unit root property of the different series in the model. At this stage, we employ Pesaran's (2007) second-generation tests, such as the cross-sectionally augmented IPS (CIPS) and the augmented Dickey–Fuller (CADF) tests. The following table lists the findings.

Based on the CIPS test, the results reveal that the ANS, RENT and EVTAX are non-stationary at the level form but become stationary in the first difference at a 1% significance level. However, INF and RENT are stationary at a level. Furthermore, in Table 3, we show that the CADF test reveals the same results of stationarity.

4.3 Panel cointegration tests

After establishing the stationarity of the series, we then perform panel cointegration test to verify the long-term relationship between the variables. Traditional tests to such as Pedroni's

Table 2.
Results of CSD test

Cross-sectional dependence test analysis

	ANS	Evtal-tax	REN	RENT	INF
CD test	4.748*	13.671*	28.700*	22.873*	20.307*

Note(s): Symbol * denote significant at 1%
Source(s): Table by the author

test (Pedroni, 1999) and Kao's test (1999) ignore CSD. We will use the test of Westerlund (2007), which takes into account the problem of CSD.

The results in Table 4 lead to the conclusion that the variables have a long-term connection. Overall, the cointegration of all panel variables is validated.

4.4 Panel quantile regression

We must choose the proper econometric methods before estimating the panel quantile regression. To do this, we conduct the Hausman test–based fixed-effects and random-effects models. The random-effects model is adequate in our situation based on the Hausman test results shown in Table 5.

To peruse these findings, we employ the approach suggested by Koenker (2004) for defining the conditional quantile functions. Alsayed, Isa, Kun, and Manzi (2020) checked that quantile regression (QR) is an effective and well-established method that could furnish a

	CIPS test statistics		CADF test statistic	
Variables	Level	First difference	Level	First difference
ANS	−1.856	−4.713*	−1.702	−3.194*
REN	−1.775	−4.674*	−1.610	−3.446*
EVTAX	−1.857	−4.477*	−1.861	−2.995*
RENT	−2.383*	−4.652*	−2.175**	−3.808*
INF	−3.398*	−5.234*	−2.813*	−4.064*

Note(s): Symbol * and **denote significant at 1% and 5%, respectively
Source(s): Table by the author

Table 3. Results of unit root tests

Statistic	Value	*Z*-value	*P*-value
Gt	−2.176	−2.231	0.013**
Ga	−4.920	2.267	0.988
Pt	−9.016	−1.957	0.025**
Pa	−4.950	−0.528	0.299

Note(s): Symbols** significant at 5 level of significance
Source(s): Table by the author

Table 4. Panel cointegration test results

	Fixed	Random
Variables	ANS	ANS
REN	0.150* (0.000)	0.133* (0.000)
EVTAX	1.645* (0.000)	1.558* (0.000)
INF	−0.034*** (0.055)	−0.036** (0.041)
RENT	−0.065 (0.603)	−0.082 (0.503)
Constant	3.635* (0.006)	4.164* (0.012)
Observations	600	
Hausman FE-RE	1.80 (0.772)	

Note(s): Symbol *, ** and ***denote significant at 1, 5 and 10%, respectively
Source(s): Table by the author

Table 5. Fixed- and random-effect estimation

meaningful debate on the environmental linkages. One of its advantages compared with OLS regression is to provide various estimators for each quantile. Therefore, many scientists began employing QR to avoid the abovementioned issues. The τ represents the quantile of a random variable Y is specified by a quantile function:

$$Q_Y(\tau) = F_Y^{-1}(\tau) = inf\{y: F_Y(y) \geq \tau\}$$

Where $\tau \in (0,1)$ and $F_Y(y) = P(Y \leq y)$

To take into account the effects and the unobserved individual heterogeneity, we carry out the following model:

$$Q_{Y_{i,t}}\left(\tau/X_{i,t}\right) = \alpha(\tau)' X_{i,t} + \beta_i, i = 1, \ldots, N, t = 1, \ldots, T$$

Where $Y_{i,t}$ and $X_{i,t}$ indicate the adjusted net savings and corresponding determinants in the country i at time t, and β_i designate the unobserved individual effects. $\alpha(\tau)$ denotes a vector of estimated parameters which are varying on different quantile τ

Furthermore, in this paper, we study the impacts of energy transition, environmental taxation, inflation rate and natural resource rents on the adjusted net savings in OECD countries. We perform our analysis using the model to allow our study specifications to be distinguished from the previous studies.

$$Q_{Y_{i,t}}\left(\tau/X_{i,t}\right) = \alpha_{1,\tau} REN_{i,t} + \alpha_{2,\tau} EVTAX_{i,t} + \alpha_{3,\tau} INF_{i,t} + \alpha_{4,\tau} RENT_{i,t} + \beta_i$$

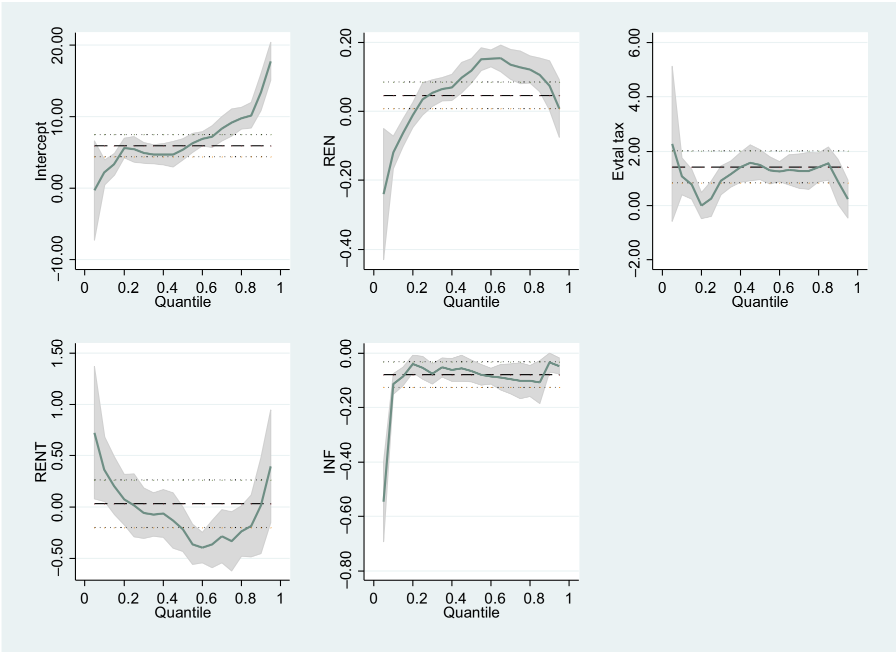
In this equation, the countries and the time is indicated by i and t, respectively.

The different empirical results of OLS and quantile regressions are shown in Table 6. We start by showing the OLS estimates. It can be concluded that renewable energy consumption (REN) and environmental tax (EVTAX) affect positively and significantly ANS. In other words, by increasing REN or EVTAX by 1%, ANS are expected to increase by 0.046% and 1.422, respectively. From the presented observations, natural resource rents have a positive and insignificant effect on ANS and the inflation rate is negative and significantly correlated with the ANS. According to the panel quantile regression, the results are reported for the different percentiles. Overall, we may conclude that the empirical results shown in Table 6 and Figure 1 are more interesting and contain more details than the OLS results. Likewise, the

Table 6.
Panel quantile regression results

		Variables			
	Constant	REN	Evatax	RENT	INF
OLS	5.946 (0.000)	0.046 (0.017)	1.422 (0.000)	0.030 (0.798)	−0.079 (0.000)
q05	5.403 (0.000)	−0.240 (0.020)	2.272 (0.066)	0.723 (0.085)	−0.546 (0.016)
q10	2.220 (0.225)	−0.119 (0.006)	1.077 (0.082)	0.364 (0.000)	−0.113 (0.400)
q20	5.600 (0.000)	−0.010 (0.790)	0.001 (0.998)	0.071 (0.563)	−0.039 (0.453)
q30	4.938 (0.000)	0.053 (0.011)	0.921 (0.046)	−0.059 (0.457)	−0.076 (0.112)
q40	4.722 (0.000)	0.069 (0.025)	1.409 (0.000)	−0.064 (0.542)	−0.061 (0.000)
q50	5.403 (0.000)	0.117 (0.000)	1.501 (0.000)	−0.217 (0.056)	−0.065 (0.001)
q60	6.906 (0.000)	0.153 (0.000)	1.248 (0.000)	−0.397 (0.000)	−0.085 (0.000)
q70	8.308 (0.000)	0.136 (0.000)	1.274 (0.000)	−0.286 (0.006)	−0.094 (0.002)
q80	9.740 (0.000)	0.121 (0.000)	1.407 (0.000)	−0.236 (0.070)	−0.101 (0.023)
q90	−13.392 (0.000)	0.008 (0.811)	0.233 (0.747)	0.395 (0.016)	−0.076 (0.112)

Source(s): Table by the author



Source(s): Figure by the authors

Figure 1.
Results from quantile regression

empirical results indicate that the impacts of various factors on ANS are clearly heterogeneous.

Regarding the REN variable, we can observe that at the 5th, 30th, 40th, 50th, 60th 70th and 80th quantiles, the coefficients are positive and significant at the 5% level. However, we fund a negative effect and significant at the 10th and 20th quantiles. The empirical findings show that to achieve the sustainability target, the OECD governments should promote investment in clean sources of energy. These results are consistent with recent research that has demonstrated the vital role that renewable energy plays in promoting sustainable development, particularly the studies developed by (Güney & Kantar, 2020; Dradra & Abdennadher, 2022).

According to the EVTAX variable, the coefficients have a positive sign and are highly significant at various quantiles except for 20th and 90th quantiles. The elasticity estimates indicate that the minimum value is at the 20th quantile (0.001, $p = 0.998$) and the maximum value is at the 10th percentile (2.272*, $p = 0.066$). The findings of our study are consistent with those reported in earlier empirical studies (e.g. Hassoun & Hicham, 2020; Wolde-Rufael & Mulat-Weldemeskel, 2022; Yue *et al.*, 2022; Dogan *et al.*, 2022). These studies revealed that environmental taxation presumed advantages for sustainable development goals. Furthermore, they confirmed that over time, environmental taxes have a double-dividend effect in all of the set of countries.

The other results for the control variables included (INF and RENT) in the model are also informative. First, we can observe the impact of the INF on sustainable development. The coefficient is clearly highly significant and negative at various quantiles except for the 10th, 20th, 30th and 90th quantiles. These results are consistent with those of the research by Iftikhar *et al.* (2022), which revealed that the increase of the inflation by 1% led to a decrease in adjusted net savings by 0.625%. Finally, we can reveal that the effect of RENT is a heterogeneous effect that can be easily seen. It is significant and positive at the 5th and 10th quantiles, and positive and not significant at the 20th quantile. From the 30th quantile level to the 80th quantile level, RENT generates a significant and negative effect. At a higher quantile level (90th), it becomes positive and significant (0.395**). These different outcomes are confirmed by the results shown in Figure 1.

4.5 Panel causality test

In order to perform the causality between the described variables, we use the panel test proposed by Dumitrescu and Hurlin (DH) [2012]. It is founded on the individual Wald statistic of Granger non causality averaged over cross-sectional units. The following is the linear panel regression model used by DH:

$$\Delta Y_{i,t} = \alpha_i + \sum_{k=1}^{K} \theta_{ik} Y_{i,t-k} + \sum_{k=1}^{K} \beta_{ik} X_{i,t-k} + \varepsilon_{i,t}$$

where θ_{ik} and β_{ik} denote the coefficients of $Y_{i,t-k}$ and $X_{i,t-k}$ for cross-sectional dimensions $(i = 1, 2, \ldots, N)$, respectively, and t represents the time period dimensions $(t = 1, 2 \ldots; T)$ of the panel.

The hypotheses are defined in the following:

H0. $\beta_{i1=\ldots\beta_{ik}=0}$

H1. $\beta_{i1=\ldots\beta_{ik}=0}, \forall i = 1 \ldots N_1$

$$\beta_{i1} \neq 0, or \beta_{i1} \neq 0, \forall i = N_1 + 1, \ldots, N$$

Or $0 \leq \frac{N_1}{N}$

The null hypothesis (H0) presents a homogeneous result, while the alternative hypothesis (H1) presents a heterogeneous result.

The different results are presented in Table 7. It highlights the existence of feedback causality between environmental taxes and sustainable development. The findings also ascertain unidirectional causal links from renewable energy to sustainable development, from sustainable development to inflation rate, from environmental taxes to renewable energy, from resource rents to renewable energy and from inflation rate to renewable energy. Finally, the evidence shows no causal link between resource rents and sustainable development, between resource rents and environmental taxes and between inflation rate and resource rents.

5. Conclusion and policy implications

Several environmental policies, and more broadly those claiming sustainable development, always has been recognized in the area of sustainable development. Around this idea, the current research is an attempt to check the performance of environmental regulations (taxation) and transition to renewable energy in achieving the sustainability target and fulfilling the research gap. This study focused on a sample of 24 OECD countries over the period 1994–2018. Firstly, the results obtained from CSD tests imply that there is a sufficient CSD condition across all countries involved in this study. Secondly, the CADF and CIPS panel unit root tests indicate that all variables are incorporated at level I (1) integrated at the first difference; however, INF and RENT are stationary at level. Thirdly, we used the cointegration test of Westerlund (2007), which takes into account the problem of CSD. The results show that the variables are cointegrated. Proceeding in the same way, results obtained from the quantile

Hypothesis	*F*-statistic	Prob	Result	Conclusion
REN→ANS	3.618	0.027	Yes	Unidirectional causality from REN to ANS
ANS→REN	1.050	0.350	No	
EVTAX→ANS	4.715	0.009	Yes	Bidirectional causality between EVTAX and ANS
ANS→EVTAX	4.566	0.010	No	
INF→ANS	0.112	0.893	No	Unidirectional causality from ANS to INF
ANS→INF	3.794	0.023	Yes	
RENT→ANS	1.726	0.178	No	No causality between RENT and ANS
ANS→RENT	1.023	0.359	No	
EVTAX→REN	3.791	0.023	Yes	Unidirectional causality from EVTAX to REN
REN→EVTAX	1.022	0.360	No	
RENT→REN	6.784	0.001	Yes	Unidirectional causality from RENT to REN
REN→RENT	2.293	0.101	No	
INF→REN	7.270	0.000	Yes	Unidirectional causality from INF to REN
REN→INF	1.624	0.198	No	
RENT→EVTAX	0.771	0.462	No	No causality between RENT and EVTAX
EVTAX→RENT	0.400	0.670	No	
INF→EVTAX	10.545	0.000	Yes	Unidirectional causality from INF to EVTAX
EVTAX→INF	0.087	0.916	No	
INF→RENT	1.037	0.354	No	No causality between INF and RENT
RENT→INF	0.631	0.532	No	

Source(s): Table by the author

Table 7.
Causality test results

regression demonstrate estimates show that access to renewable energy and environmental taxation generate positive and significant effects in increasing the adjusted net savings. That means that it is important to enact environmental taxation and furnish incentives for using renewable energy sources.

Based on the different findings, our study serves as a groundbreaking attempt to show the effects of renewable energy and environmental taxes on sustainable development. Thus, several policy recommendations are proposed for the OECD policymakers. First, the positive link between sustainable development and renewable energy enhances the governments to amplify their share of clean and renewable energy funding and develop their subsidy portfolio. Second, the positive association between environmental taxation and sustainable development confirms that this policy must be prioritized and it is not only effective and necessary to impede pollution but also to ameliorate environmental quality while promoting economic growth.

Further research can include the main ideas. First, address the institutional scope that affects environmental and energy policies, such as environmental legislation, energy structure and economic development. Second, additional research can also address issues such as the effects of green finance in promoting the transition to renewable energy and sustainability goals. Finally, use new methodologies such as the nonlinear autoregressive model (NARDL) and wavelet-based estimation to verify asymmetric behavior between environmental policies and sustainability.

Notes

1. This concept was first suggested by Solow (1974) and extends to what an economy should support, growth linked to an overall development that ensures wealth for future generations.
2. Namely Australia, Chile, Czech Republic, Denmark, France, Finland, Hungary, Germany Spain, Sweden, Switzerland, Israel, Italy, Portugal, Japan, Korea, Lithuania, the Netherlands, Republic of Latvia, Norway, Turkey, Mexico, UK and USA.

3. According to the World Bank, ANS is calculated as net national saving plus government spending on education minus net energy, mineral depletion, net forest loss and carbon dioxide damage carbon.

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Appendix 1
Descriptive statistics and correlation matrix

	ANS	REN	EVTAX	INF	RENT
Min	−24.002	0.441	−1.53	−9.666	0.0008
Max	27.344	61.111	5.372	143.639	1.338
Mean	9.836	16.407	2.406	4.269	17.239
Std.Dev	6.3190	14.708	0.899	10.558	2.504
Obs	600	600	600	600	600
ANS	1.000				
REN	0.126	1.000			
EVTAX	0.221	0.088	1.000		
INF	−0.146	0.037	−0.093	1.000	
RENT	0.001	0.452	−0.267	0.039	1.000

Source(s): Table by the author

Table A1. Descriptive statistics

Appendix 2
Predictors variance inflation factors (VIF)

Table A2 Shows that all the VIF values are less than 5, with an average value of 1.3

Variables	VIF	1/VIF
REN	1.34	0.747
EVTAX	1.16	0.865
INF	1.01	0.989
RENT	1.43	0.699
Mean VIF	1.23	

Note(s): This means that there are no autocorrelation problems in our model
Source(s): Table by the author

Table A2. Predictors variance inflation factors (VIF)

Appendix 3
Normality test

Figure A1 Presents the distributions of the residuals. The shape is quite normal. Thus, this will confirm the robustness of our results

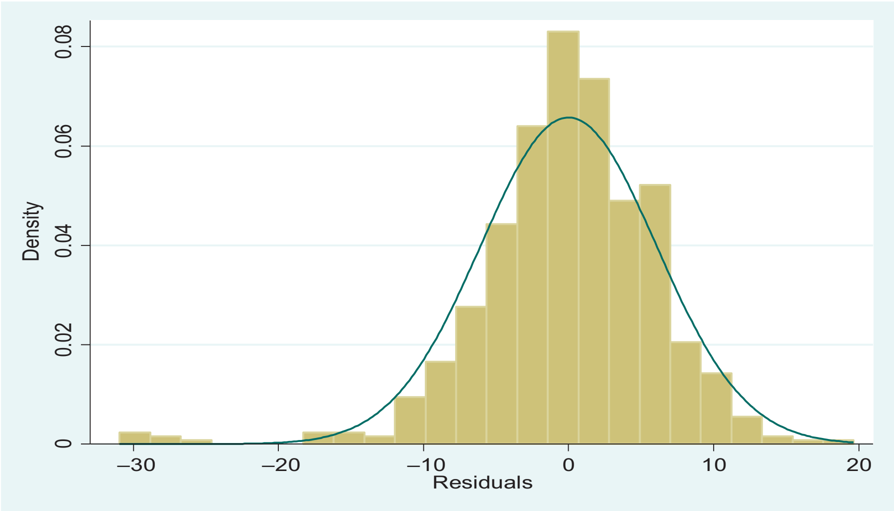

Figure A1.

Source(s): Authors

Appendix 4
The Breusch–Pagan heteroskedasticity test

We employ the Breusch–Pagan test to address the issue of heteroskedasticity in the model. The results exhibited in Table A4 suggest that the residuals are homoscedastic.

Table A3. Normality test

The Breusch–Pagan test output

H0: no first-order autocorrelation
χ^2 (1) = 0.02 Prob > χ^2 = 0.9013

Source(s): Table by the author

Appendix 5

Panel autocorrelation test

It is important to look into the issue of autocorrelation in panel data. According to the results displayed in table A5, the null hypothesis of no serial correlation is strongly rejected with a 5% level of significance.

Wooldridge test for autocorrelation results

H0: no first-order autocorrelation
F (1, 23) = 178.361
Prob > F = 0.0000

Source(s): Table by the author

Table A4. The Breusch–Pagan heteroskedasticity test

Corresponding author
Zohra Dradra can be contacted at: dradra.zohra@yahoo.fr