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Does fiscal policy spur environmental issues? New evidence from selected developed countries

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Abstract

In this study, we investigate the effects of fiscal policies on the environment with annual frequency period from 1972 to 2017 data for countries such as Australia, Chile, Finland, the UK, and Sweden. This study leverages on second-generation unit root tests, bootstrap cointegrated test, and long-run coefficient estimators suitable for heterogeneous panels under review. Empirical results of the long-run coefficient estimators are consistent with economic-environmental intuition and extant literature. However, in terms of fiscal policy, these results do not provide any evidence of the expected mitigating effects on environmental pollution in any country. Our main findings show that revenue policy does not go beyond funding government expenditure in these countries. Based on these results, we propose two new concepts to the literature on carbon taxes. We call these concepts New Environmental Sin Taxes and Global Environmental Debts. We base this result on the argument that regional solutions to global problems are insufficient.

Keywords Cross-section dependence · Environmental tax · Fiscal policy · Heterogeneous panel

JEL Classification H2 · H23 · C1 · O13 · O23 · Q5

Introduction

Since the industrial revolution in the eighteenth century, the world economy has been on the rise with the increase in total production and is much more interconnected than ever before (WTO 2018). Countries rapidly industrializing with global economic growth needed more energy to get a share from this growth. The use of fossil fuels to fulfil the need for energy has created major environmental damage and climate change problems with the increase in greenhouse gas released to nature, but these negative effects have been noticed years later (CBO 2013; WMO 2020). Following industrialization, economic development increase of the world population, increasing technological innovations in recent years have led to increased demand of energy in the twenty-first century (Ike et al. 2020).

With the use of fossil fuels generated by energy demand and the damage to the environment, climate problems have started to attract the attention of researchers as they are among the primary problems of the economy (Yan and Crookes 2010). Environmental degradation is one of the factors that directly affect human health (Conservation Energy Future 2020). Melting glaciers, wildlife, precipitation, and indirectly agriculture are also affected by.these environmental degradations (Yuelan et al. 2019). Carson's (1962) remarkable novel, Silent Spring, environmental problems and sustainable development which was suggested as their solution have come to the fore and were first discussed and accepted at the 1972 Stockholm conference with the United Nations Conference on the Human Environment. In this

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conference, the common values of the world, the environment, and the principles emphasizing the integrity of the environment with development have been included.

The conference contains common principles to inspire and guide people in the protection and improvement of the environment (Sohn 1973; Basiago 1999). On the other hand, with the Rome Club report published in 1968, environmental pollution was emphasized. Similar way, in UNWCED (UNWCED 1987) and the Rio United Nations Framework Convention on Climate Change (UNFCCC 1992), it has been stated that human beings are at the center of sustainable development; on the other hand, Kyoto Protocol (KP 1997) (COP3) and United States Paris Agreement (PA 2015) (COP21) are international agreements in which targets to reduce greenhouse gas emissions in the process of combating global warming and climate change.

In the KP, which is valid until 2020, the responsibility for reducing greenhouse gas emissions has been undertaken only by developed countries. On the other hand, in the PA, which forms the basis of post-2020 policies, this responsibility belongs to all countries that are party to the agreement (Balı and Yaylı 2019; IMF 2019). Therefore, increasing awareness of reducing greenhouse gas emissions effective on environmental degradation and climate changes has brought along the production of policies that will solve this problem and policies to be implemented.

Researchers have conducted many studies which suggest that environmental degradation and economic variables are related. It has been submitted that environmental degradation has been originated from economic growth (Panayotou 1993; Grossman and Krueger 1995; Yan and Crookes 2010; Phimphanthavong 2013; Aye and Edoja 2017), energy consumption (Liu et al. 2018; Rauf et al. 2018), urbanization (Kasman and Duman 2015; Katircioğlu and Katircioğlu 2017; Wang et al. 2018; Ahmad et al. 2019), globalization (Shahbaz et al. 2017b; Akadiri et al. 2019; Hafeez et al. 2019; Rafindadi and Usman 2019), foreign direct investment (Abdouli and Hammami 2016), trade liberalization (Jalil and Feridun 2011; Yasmeen et al. 2018; Yao et al. 2019), financial markets (Jalil and Feridun 2011; Çetin and Ecevit 2017; Shahbaz et al. 2017a; Hafeez et al. 2018) tourism (Katircioglu 2014; Azam et al. 2018), and income inequality (Hailemariam and Dzhumashev 2019).

Some of these studies reveal that real income is the root cause of environmental degradation through increasing energy consumption (Yuelan et al. 2019). Along with the growth of the economy, energy consumption and carbon emission (CO_2) increase and environmental problems are arising (CBO 2013). That is why, countries must take the environment into account, although it is not the main target when implementing their fiscal policies. The desire of governments to increase their real incomes, on the one hand, and to ensure environmental quality in line with sustainable development targets, on the other hand, requires the creation of effective fiscal policy instruments (Halkos and Paizanos 2016). Also, the climate policies that policymakers will adopt with economic growth have to be well balanced with fiscal policies (Fischer and Fox 2012). At this point, carbon taxes applied by countries within the framework of their fiscal policies are an important issue. Examining the impact of taxation and expenditure policies, which are powerful fiscal policy tools, on the CO_2 level will provide an idea for the policies to be followed by countries in environmental problems. The features that make this study different from other studies are: (i) contributing to the literature with two new concepts; (ii) examining the countries applying carbon tax in the near and early period as a unique sample; (iii) and the econometric procedure that has been followed.

This study contributes to the literature in the following three perspectives. Firstly, there is a scarcity of studies, which relate fiscal policy to environmental degradation. The current study is the first to address the relationship between government expenditure, revenue, and carbon emissions in developed countries that were the first to implement carbon taxes. We believe that to understand the impact of fiscal policy this examination to be useful for policymakers in environmental degradation. Secondly, we employ augmented mean group (AMG) and common correlated effects (CCE) from advanced panel data estimation techniques to achieve effective results. These techniques can adequately address cross-sectional dependence (CD), heterogeneity, serial correlation, etc. Finally, a wide fiscal/environmental policy may not be convenient. Our estimates are the country-wise results that will enable policymakers to initiate current policies in line with each countries attribute.

Concordantly, in this study we have searched the effects of government expenditures, tax revenues, real GDP, and total energy supply on CO_2 in the period 1972–2017 for Australia, Chile, the UK, Finland, Sweden, which are some of the developed countries implementing a carbon tax, have been analyzed with panel cointegration and long-run coefficient estimators after preliminary tests. Following the introduction, in the second part of the study, we presented the theoretical framework of fiscal policies and the CO_2 relationship and some studies in the literature on the subject. In the third part of the study, we gave information about the data set and the econometric model, and in the fourth chapter, we list the empirical evidence and discussion. In the conclusion part, we included a general evaluation based on the findings and policy recommendations.

Theory and literature

Theoretical framework

In this study, we use two theoretical instruments. The first of these is the theoretical approach to the effects of fiscal policies on environmental pollution. The second instrument is that we propose two new concepts to the literature on fiscal policies and environmental pollution.

We explain the effectiveness of fiscal policies, which we consider as the first instrument, on the environment with two basic instruments. While the first of these is *expenditure policies* (henceforth government or public expenditure), the second is *income policy* (tax revenue or revenue policy). Green Keynesianism, in which Harris (2013) brought fiscal policies to the agenda for environmental policies, reveals a remarkable conceptual area in this regard. In general, Green Keynesianism can play a key role in preventing environmental degradation (Goldstein and Tyfield, 2017). However, here we brought Pigou's tax proposals in the government regulations and tax Metcalf (2019) recommendations of R. Coase (social cost of carbon) into the forefront. As Metcalf (2019) mentioned, pollution is a negative externality, so CO_2 is at the center of climate change, and "*Conservatives often talk about the power of markets and the way that Adam Smith's invisible hand leads us to efficient outcomes. Where pollution is involved, Pigou's insight ensures that the invisible hand has a green thumb.*"

The transmission mechanism of public expenditures on environmental pollution can be divided into two groups according to the source of the pollution. This classification is examined according to whether production or consumption determines the source of pollution (McAusland 2008; Halkos and Paizanos 2016), because the transmission mechanism of the fiscal policy for production and consumption differs on the environment.

The first group includes production-originated pollution. López et al. (2011) point to four different mechanisms by which the level of public expenditures can affect environmental quality. First of these, higher income levels due to public expenditure increase the demand for improved environmental quality (income effect). Moreover, increased public expenditures encourage human capital-intensive activities that are less harmful to the environment than capital-intensive physical activities (composition effect) (Ahmed et al. 2019; Yuelan et al. 2019).

Another choice that tends to reduce environmental pollution is increased labor productivity associated with higher public expenditure (technique effect) on the education and health sectors. Finally, depending on the relationship between fiscal expenditure and economic growth and the shape of the environmental Kuznets curve (EKC), increased government expenditure may lead to more pollution at some GDP levels (scale effect) (Halkos and Paizanos 2016; Ike et al. 2020). According to López et al. (2008), public expenditure can also facilitate pollution reduction by transforming the composition of consumer goods into less pollution-intensive goods. In other respects, increasing public expenditure can encourage investment in public transport and thus increase the use of these means of transport, which are considered to exert less environmental pressure than the use of private transport (Zimmerman 2005; Islam and López 2014).

In the second group, consumption sourced pollution is taken into consideration. Government expenditures on sectors such as health and education increase the current and future incomes of consumers. This situation may lead to the deterioration of the environmental quality that constitutes the income channel (Yuelan et al. 2019). On the other hand, higher levels of government expenditure help to form, enforce, and improve environmental planning. This can lead to the development of institutions that increase the environmental quality that represents the environmental regulation channel (Fullerton and Kim 2008). Consequently, the total impact on consumption pollution depends on the relative size of income and environmental regulatory effects. Especially in democratic governments compared to undemocratic governments, stricter environmental rules are more likely to be adopted, and a decrease in pollution levels have been found in such governments where income-related environmental regulations are effective (Carlsson and Lundström 2001; Galinato and Islam 2017; Lv 2017). All of the positive effects which we have been described are the namely *triple dividend* (Pereira et al. 2016; Freire-González 2017; Pigato 2019) hypothesis in the literature.

Fiscal policy is as important a policy tool as monetary policy to manage the demand side of the economy through government expenditure and taxation because governments in most countries around the world spend a large portion of the GDP through fiscal policy (Halkos and Paizanos 2013; Yuelan et al. 2019). After all, fiscal policy tools—revenue and expenditure—are directly linked to GDP growth, production level, energy use, and environmental quality, respectively.

The second tool that fiscal policies can use to prevent environmental degradation is the income policy. Many experts and international organizations propose tax reform to align fiscal policy with environmental targets (EEA 2016). Various fiscal instruments in income policy include tax incentives, new taxes or reforms in tax systems, struggle with tax havens, or canceling debts globally (Robinson et al. 2017; Cömert 2019). On the other hand, we argue that the most valid instrument among them is taxation. The greenhouse gas increase, which was brought to the agenda in the Rio Conference in 1992 and after the Kyoto Protocol in 1997, has been tried to be reduced through taxes called carbon tax (Vera and Sauma 2015; Sachs et al. 2018).

Here, we brought environmental taxes, which is one of the most common tools for environmental and climate change, into the forefront (Miller and Vela 2013; IMF 2019). The theoretical basis for environmental taxes was first developed by A. C. Pigou; therefore, environmental taxes are considered as Pigouvian tax (Ciocirlan and Yandle 2003; Stavins 2003; Shmelev and Speck 2018; Metcalf 2019) with the "polluter pays" principle (Hsu 2011). On the other hand, these taxes can be considered as a tool to correct market failures (OECD 2011). While environmental taxes are divided into various types, our focus is on carbon taxes. The purpose of carbon taxes is to control CO_2, which is considered the source of global warming and climate change (Ekins 1999; Goulder 2013; Beck et al. 2015). Moreover, environmental taxes are the lowest cost method in achieving this target (Uddin and Holtedahl 2013; Klenert and Mattauch 2016).

While carbon taxes have many favorable fiscal impacts (OECD 2015), they have not been found to have negatory effects on the economy (Beck et al. 2015), so it is claimed to be neutral (Goulder 2013; Filipović and Golušin 2015). However, there are also theoretical (Uddin and Holtedahl 2013; Aubert and Chiroleu-Assouline 2019) and empirical (Miller and Vela 2013) arguments that suggest that environmental taxes exacerbate current tax deterioration. Besides, carbon taxes, like all indirect taxes, can have adverse effects on relatively low-income groups. On the other hand, among its positive effects, providing revenue to the government (OECD 2011), reducing the tax burden on labor (Fullerton and Monti 2013; Jacobs and van der Ploeg 2019), reducing inequalities (Klenert et al. 2018), internalizing negative externalities (Speck 2007), reducing energy and natural resource consumption (Luìs et al. 2020) can be stated. However, along with these, debates continue about the effects of environmental taxes on the economy and the environment (Freire-González and Ho 2019).

Carbon tax levied depending on the unit emission amount is applied in many countries and local regions. While the emission level in these countries begin to decrease after the carbon tax was applied, it is noteworthy that countries such as Denmark, Sweden, Finland, and France (Freire-González and Ho 2019) are at the top of the sustainable development index (Sachs et al. 2018). Finally, we present two concepts that are closely related to income policy, which we call the second instrument in this study. The first of these is closely related to increases in public expenditures (Tanzi 2004), decrease in tax resources (United Nations 2002), and tax havens.

Policymakers' environmental degradation-driven tax source could be named as *New Environmental Sin Tax* (henceforth NEST), we do not know if this concept, which we call a new sin tax, is being used by us for the first time. However, we did not find such a concept and an explanation of its definition in the literature. We used NEST to name the taxes that are imposed or can be applied to limit human activities whose effects on environmental degradation are too much to be discussed, and we express that it is not too exaggerated. NEST can strengthen the perception of nation-states to prevent environmental degradation while partially compensating for tax losses. Of course, NEST will have various difficulties. On the other hand, we suggest that a conceptual discussion is needed to initiate for NEST. At this point, we propose a new second concept. This is *Ecological Debt*. With Ecological Debt (henceforth ED), we imply the environmental damage of human activities. There are ecological debts of the global system rather than the states, and we suggest the concept of *Global Ecological Debt* (henceforth GED) for this.

First and foremost, we state that the core of our offer below is the hypothesis that environmental degradation is a global problem and it's can be solved by global policies. The carbon taxes are applied on metric ton of carbon emission that has been emitted. We assume that total carbon emissions in a given period (t) Global Ecological Debt (GED_t) and $GED_t = CO_2$. Ecological Debt (ED_t) belonging to a certain country in a certain period be denoted by national ED_t (NED_t).

The New Environmental Sin Tax ($NEST_{t+1}$), which we bring about to compensate for the GED and reduce environmental degradation, has a progressive tax tariff. NEST is an example of global Pigovian tax, and its' taxpayer is the state. We assume that one of the tools we will use for calculating tariff rates, γ (fixed: payment amount in dollars per metric ton) is 15.[1] Tax rate is calculated as described in Eqs. 2 and 3.

$$\sum_{i=1}^{n} \mathrm{NED}_{ti} = \mathrm{GED}_t \tag{1}$$

$$\mathrm{NEST}_{ti}\ \mathrm{Rate} = \frac{\mathrm{NED}_{ti}}{\sum_{i=1}^{n} \mathrm{NED}_{ti}} \times \gamma \tag{2}$$

$$\mathrm{NEST}_{ti}\ \mathrm{Payment} = \frac{\left(\mathrm{NED}_{ti}\right)^2}{\sum_{i=1}^{n} \mathrm{NED}_{ti}} \times \gamma \tag{3}$$

where i is indicates each country and t is time dimension. Our proposal is brief to put a global tax system at the core of solving a global problem. The global solution necessitates

[1] γ is assumed that $15 per metric ton. For various values of γ, see also Ye (2021). Pricing carbon is not as simple a phenomenon as it seems because carbon price expresses a complex structure meaning of social and global costs.

global coordination. The global design of this system can also prevent possible tax havens in this area.

The two new concepts and their theory we have put forward, as in all discussions, points to varying attitudes depending on where you view events. We know that the challenges of Pigouvian taxation should not be dismissed. Nevertheless, we argue that ED, GED, and NEST could be notable for their potential positive impact on the environment, despite all the possible difficulties for the parties.

Literature review

Investigating the relationship between environmental degradation and fiscal policy has become important in recent years. The positive and negative effects of fiscal policy tools on environmental pollution with many mechanisms have been discussed in various studies. Considering that public expenditure is an important determinant of environmental degradation (McAusland 2008; López et al. 2011; Halkos and Paizanos 2013; Islam and López 2014; Yuelan et al. 2019), it has been suggested that when the expenditure is caused by the consumption, they cause environmental pollution and spending in the health and education sectors may also cause a pressure to increase environmental quality through the income channel (López et al. 2011). Taxes, another fiscal policy tool, also play a role (Katircioglu and Katircioglu 2017) in reducing environmental pollution (Ryan et al. 2009; Vera and Sauma 2015; Liu et al. 2017), as in economic growth and current account balance (Bolat et al. 2014). Moreover, improvements in the fiscal deficit increase the level of capital accumulation, economic activities, and energy demand within the economy (Dongyan 2009; Balcilar et al. 2016).

On the other hand, Liu et al. (2017) show that fiscal incentives play a role in reducing carbon emissions. Hafeez et al. (2019) suggested that energy consumption channels, fiscal policy instruments, taxes and revenues, and GDP are indirectly related to environmental quality and have a direct impact on environmental quality through real income and energy consumption channels (Halkos and Paizanos 2016; Jamel and Maktouf 2017; Katircioğlu and Katircioğlu 2017). There are lots of studies about time series in the literature. However, panel data analysis studies are quite limited (Carlsson and Lundström 2001; Bernauer and Koubi 2006; López et al. 2011; Halkos and Paizanos 2013; Adewuyi 2016) (see Table 1).

Finally, although the focus of the literature is on the effects of government expenditure, it can still be stated that the size of government revenues as well as the implementation of monetary policy, can play an important role in determining environmental quality. There are also signs of reverse causality from environmental pollution to macroeconomic policy (Rosenow et al. 2014). On the other hand, Halkos and Tzeremes (2013) pointed out the nonlinear relationships between carbon emissions and public indicators in the G-20 countries.

Materials and methods

Data

In this section, we present information about the variables we use in this study, their measurements, and data sources.

We have chosen variables that are widely preferred in the literature to explore possible relationships between fiscal policies and carbon emissions. We gave information about variables in Table 2.

Among the variables, in the literature, energy consumption (Katircioglu and Katircioglu 2017; Xu et al. 2018; Yuelan et al. 2019; Ike et al. 2020) and production (Malla 2009; Iwata et al. 2010; Qi et al. 2014; Ahmad and Du 2017; Chen et al. 2018; Sarkodie and Strezov 2018; Sinha and Shahbaz 2018; Amin et al. 2019; Khan et al. 2019) are preferred. But we use total primary energy supply because energy cannot be stock for now and energy supply, as it reflects the entire production–consumption process, has the trace of CO_2 emerging during the production phase. The variables for fiscal policy are by following (Halkos and Paizanos 2016; Katircioglu and Katircioglu 2017; Yuelan et al. 2019) the use of government expenditure and tax revenue. The abbreviation *ln* in the representations of the variables refers to the natural logarithms of the series. The logarithmic form not only smooths the data but also overcomes the issue of heteroscedasticity.

Table 3 shows the descriptive statistics of the variables used in this study in 1972 and 2017. Descriptive statistics were used to determine the measures of central tendency and dispersion of the results of the questionnaires. Accordingly, the results show that the CO_2 min value is 2.5172 and the max value is 5.5951, the min value of Rgdp is 24.4330, and the max value is 28.6753. CO_2 and Rgdp are positively skewed, while other data are negatively skewed. In addition, the failure to reject the null hypothesis of normal distribution from the Jarque–Bera test statistic indicates that the variables are normally distributed.

Table 4 shows the correlations between all variables at each of the times in the study. Accordingly, there is a significant positive relationship between CO_2 and real GDP. However, it is noteworthy that there is a positive relationship between carbon dioxide emissions and both tax revenues and government expenditures. On the other hand, correlation coefficients alone are not sufficient to validate any result of predictive analysis.

Table 1 Literature review

Author(s)	Countries	Period	Variables	Methods	Findings
Panel data analyses					
Carlsson and Lundström (2001)	77 countries	1977–1996	Govt. size, CO_2	FEM, REM	G. size = > (−) CO_2 G. size = > (+) CO_2 (low-income countries)
Bernauer and Koubi (2006)	42 countries	1971–1996	Govt. size, SO_2	POLS	G. size = > (+) SO_2
Hotunğlu and Tekeli (2007)	18 European Countries	1995–2013	CO_2, Carbon Tax	POLS	Carbon tax = > (−) CO_2(D. effect)
López et al. (2011)	38 countries for air pollution, 47 countries for water pollution	1986–1999	Share of public goods in govt. expenditure, Govt. size, SO_2, lead, BOD	OLS, FEM	Fiscal measures = > (−) SO_2, lead, BOD
Morley (2012)	EU	1995–2006	GDP, CO_2, Fuel tax, Fossil fuel	GMM	(−) Direct effects for CO_2
Halkos and Paizanos (2013)	77 countries	1980–2000	Govt. size SO_2, CO_2	FEM, DFEM	G. size = > (−)SO_2 (D. effect) G. size = > CO_2 (insignificant d. effect) G. size = > SO_2 (non-linear indirect effect) G. size = > (−) CO_2 (indirect effect)
Adewuyi (2016)	World economies	1990–2015	Total government expenditure, CO_2	CCEMG, PMG, DFEM	G. Exp. = > (+) CO_2 (total effect LR)
Aydin and Esen (2018)	15 EU	1995–2013	CO_2, Env. Taxes, R&D, GDP, Industry, Urbanization, Energy Price	DPTA	Env. Tax = > (−) CO_2 (D. effect) (above threshold)
He et al. (2019)	China, Finland, Malaysia	1985–2014	CO_2, GDP, Energy cons., Env. tax	Panel ARDL	Env. tax = > (−) CO_2 (direct effect)

DPTA: dynamic panel threshold analysis, FEM: fixed effects model, REM: random effects model, POLS: pooled ordinary least square, DFEM: dynamic fixed effects model, CCEMG: common correlated effects mean group, PMG: pooled mean group, GMM: generalized method of moments, BOD: biological oxygen demand, LR: long run, GOV: governess of indicators, INS: institution, = > indicates the direction of the impact

Table 2 Definition of data and source

Variables	Symbol	Data sources	Data period
Carbon dioxide emission (in metric ton per capita)	$lnCo_2$	IEA	1972–2017
Real GDP (US dollar with 2010 prices)	lnrgdp	WDI	1972–2017
Tax revenue (%GDP)	lntr	WDI	1972–2017
Government expenditure (%GDP)	lngex	WDI	1972–2017
Total primary energy supply (million tons of oil equivalent)	*lntes*	IEA	1972–2017

Our sample consists of Australia (first carbon taxes; in 2010–2013), Chile (first carbon taxes; in 2014), Finland (first carbon taxes in 1990), UK (first carbon taxes; in 1996–2000), and Sweden (first carbon taxes; in 1991). With this sample, we hope to observe the differences between relatively late starters in carbon tax practices (Australia and Chile) and early starters.

Models

We have seen that there are three types of modeling in the literature in examining the relationships between fiscal policies and carbon emissions. The first of these are conventional models in the context of the environmental Kuznets curve (EKC). Examples of these are (Danish and Wang 2019; Ike et al., 2020; Katircioglu and Katircioglu, 2017a, 2017b). The other is non-EKC-based models, and examples of these are Halkos and Paizanos (2016) and Yuelan et al.

Table 3 Descriptive statistics

	$\ln CO_2$	lnRgdp	LnTr	*LnTes*	LnGex
Mean	4.0058	26.6611	3.0627	3.9789	2.9177
Median	3.8042	26.5109	3.0875	3.8824	2.9398
Maximum	5.5951	28.6753	3.4113	5.4192	3.3230
Minimum	2.5172	24.4330	2.5883	2.0325	2.2686
SD	0.8410	1.0825	0.1686	0.9198	0.2641
Skewness	0.2041	0.0577	−0.4777	−0.0186	−0.6856
Kurtosis	1.8571	2.1975	2.5995	2.2423	2.8462
Jarque–Bera (Prob.)	14.1149 (0.0009)	6.2989 (0.0429)	10.2860 (0.0058)	5.5151 (0.0634)	18.2441 (0.0001)
Observations	230	230	230	230	230

Table 4 Correlation matrix

	$\ln CO_2$	lnRgdp	LnTr	LnTes	LnGex
$\ln CO_2$	1				
lnRgdp	0.9014	1.0000			
LnTr	0.3837	0.5716	1.0000		
LnTes	0.9469	0.9819	0.5441	1.0000	
LnGex	0.1850	0.3451	0.5648	0.3422	1

(2019). Finally, there are models that differ due to the choice of variable regarding fiscal policies, and these have preferred the fiscal policy index variable; Katircioglu and Katircioglu (2017b) and Ike et al. (2020) are examples of this group.

Since we have aimed to give a point to the effects of fiscal policies on carbon emissions in this study, we use two models. These models build on the study of Yuelan et al. (2019) for empirical support by the inclusion of fiscal variables as presented in Eqs. 4 and 5. However, our model differs from theirs in at least two aspects. Firstly, we adapted these models to the panel data form and focused only on long-run relationships. Secondly, we chose energy production series like Ahmad and Du (2017) and Danish et al. (2018). These models are written below:

$$\ln \text{co}_2 = a_0 + \beta_1 \ln rgdp + \beta_2 \ln tr + \beta_3 \ln tes + \varepsilon_{it} \quad (4)$$

$$\ln \text{co}_2 = a_0 + \beta_4 \ln rgdp + \beta_5 \ln gex + \beta_6 \ln tes + \varepsilon_{it} \quad (5)$$

where t is period, i is unit of panel, and ε_{it} is the error disturbance in Eqs. 4 and 5. While β_1, β_2 and β_3 are the coefficients of regressors in Eq. 4, β_4, β_5 and β_6 are the coefficients of regressors in Eq. 5.

Methods

In this section, we present summary information about the econometric approaches that we use in this study. Firstly, we use preliminary analysis, which has an important role in determining the tests to be used in panel data econometrics. These preliminary analyses are cross-section dependency and slope homogeneity tests. Whether a shock occurring in each unit in the panel affects other units of the panel (vice versa) is investigated in the literature with cross-section dependence tests. Besides, these tests have an important role in determining the following tests (unit root tests, cointegration tests, and long-run coefficient estimator).

Cross-section dependency tests (CD): Lagrange multiplier (LM) test statistic (LM_{BP}) developed by Breusch and Pagan (1980) (BP), the pioneer of cross-section dependency tests (LM_{BP}). This test is applied to test cross-section dependency in heterogeneous panels when N (sample number) is constant and time is (T), $T \to \infty$. However, the LM_{BP} test is not applicable for $N \to \infty$. For $N \to \infty$, a scale of the LM_{BP} test has been prepared by Pesaran (2004, 2020) (CD_{LM1}). Pesaran (2004) showed the asymptotic distribution of results (N, 0) when $N \to \infty$ and $T \to \infty$ (Baltagi 2021). In time, the necessity of cross-section dependency tests for N˃T cases has emerged, and it has been understood that these tests are not suitable for this situation. In this context, the CD_{LM2} test was developed by Pesaran (2004, 2020) for cases where the number of countries (N˃T) is greater than the time series. Finally, because of CD_{LM2} is not suitable for $N > T$ and its mean is shown incorrectly, Pesaran et al. (2008a, b) (PUY) suggested a corrected LM test (Baltagi 2021). This test can be expressed as PUY_{LM}. Although these tests are widely used in the literature, LM_{BP} test; $T > N$, PUY_{LM} test; T ˃ N or N ˃T, CD_{LM1} and CD_{LM2} tests are preferred for N ˃T.

Slope homogeneity tests (HT): In panel data studies, it is a realistic assumption that each of the cross sections has different economic and fiscal conditions. Therefore, as an economic or financial shock occurring in one of the cross sections may affect another unit, effects may differ according to the units. Besides, in panels consisting of large N and large T, generally the slope coefficients are not homogeneous (Blackburne III and Frank 2007). Slope homogeneity (Delta) tests developed by Pesaran and Yamagata (2008) are widely used in the literature to investigate the homogeneity of slope coefficients. Pesaran and Yamagata (2008) suggested the $\tilde{\Delta}$ test for large samples, and they stated that $\tilde{\Delta}_{adj}$ test can be used for small samples.

Unit root test: In this study, we used the second-generation unit root test in line with the findings of the preliminary analysis. The unit root test in question which is developed by Pesaran (2007) presents two separate unit root findings. While the individual unit root test results of the series belonging to each unit in the panel are calculated with CADF statistics, unit root results for the overall panel are evaluated according to CIPS statistics. As the CADF test results are determined by comparing them with the critical values in Pesaran (2007), whether the series is stationary for the panel, in general, is determined with the help of CIPS test statistics obtained from the average of CADF statistics (Baltagi 2021).

Cointegration test: Whether two variables, which are claimed to act together according to the theory in the long run, are investigated by cointegration tests in the econometrics literature. As determining the cointegration tests, we also considered the CD and HT test results and we preferred two cointegration tests that take these criteria into account.

The first of these is Westerlund (2008) cointegration (DH) test. While this test can also be used in cases of T > N, it requires the dependent variable to contain unit root and has two statistical calculations. These are Durbin–Hausman group (Durbin-H_g) and Durbin–Hausman panel (Durbin-H_p) statistics. While the DH_g statistic moves from the assumption of the heterogeneity of the autoregressive parameter, the DH_p statistic moves with the assumption of the homogeneity of the autoregressive parameter (Westerlund 2008). On the other hand, it is also important to test the null hypothesis (there is cointegration) for the reliability of the results in investigating the cointegration relationship between variables. For this purpose, we investigate the second cointegration test with bootstrap LM cointegration (LM) test developed by Westerlund and Edgerton (2007).

Long-run coefficient estimator: We preferred cointegration coefficient estimation methods augmented mean group (AMG) developed by Eberhardt and Bond (2009), Eberhardt and Teal (2011, 2010), and common correlated effects (CCE) developed by Pesaran (2006) for estimation of coefficients in Eqs. 4 and 5. AMG and CCE estimators consider cross-sectional dependency and heterogeneity. With these estimators, the cointegration estimation coefficients of the panel can be an estimate as well as individual coefficients. As the AMG estimator can be applied if the I (1) or integration degrees of the series are different (Eberhardt 2012), the CCE estimators assume that the independent variables and unobservable common effects are stationary and exogenous, and these are stationary (I (0)), first-order integrated (I (I)), and/or provide consistent results in cases where they are cointegrated (Pesaran 2006).

Table 5 Result of CD and HT

Tests	Equation 4		Equation 5	
	Stat	P value	Stat	P value
Cross-section dependency tests				
CD_{BP} (BP 1980)	44.148[a]	0.000	48.796[a]	0.000
CD_{LM1} (Pesaran 2004)	7.636[a]	0.000	8.675[a]	0.000
CD_{LM1} (Pesaran 2004)	5.532[a]	0.000	6.073[a]	0.000
PUY_{LM} (PUY 2008)	3.290[a]	0.001	4.200[a]	0.000
Slope homogeneity tests				
$\tilde{\Delta}$	5.230[a]	0.000	4.947[a]	0.000
$\tilde{\Delta}_{adj}$	5.474[a]	0.000	5.177[a]	0.000

[a]Denotes statistical significance at 1% level, respectively. All models are tested with intercept and trend

Table 6 Result of unit root test (CIPS)

Series	Level	Δ	Critical value		
	Specification without trend	Specification without trend	1%	5%	10%
$lnco_2$	−0.511	−4.736[a]	−2.55	−2.33	−2.21
lntr	−2.031	−4.775[a]			
lngex	−2.063	−3.912[a]			
lntes	−2.506	−5.190[a]			
lnrgdp	−2.307	−4.218[a]			

The maximum lag length has been set to 3. CIPS critical values are compiled from Pesaran (Pesaran 2007) for T: 50 and N: 10. [a] refers to significance level at 1%. Δ shows the first difference of the series

Results and discussion

Empirical results

Table 5 shows that cross-section dependency tests and slope homogeneity tests result for models.

These findings indicate that there is no dependence between the cross sections for both models and the null hypothesis is rejected. On the other hand, HT results in Table 5 reject the null hypothesis that the cross sections are homogeneous for both models and show that each unit is heterogeneous.

Table 6 shows the unit root test results for the series in the model. Accordingly, all the series are first difference stationary I (1). We run the DH and LM cointegration test to investigate whether these series, which become stable in the first difference, act together in the long run. Findings are present in Tables 7 and 8.

Durbin-H_g, one of the findings we provide in Table 7, is recommended for heterogeneous panels, and according to

Table 7 Results of cointegration test (Durbin–Hausman)

Tests	Equation 4		Equation 5	
	t-Stat	P value	t-Stat	P value
Durbin-H_g	−1.860[b]	0.031	−1.861[b]	0.034
Durbin-H_p	−1.583[c]	0.057	−1.598[c]	0.055

The maximum lag length has been set to 2, and optimal lags included in the models are selected with the AIC and are determined according to Bandwith $4(T/100)^{2/9}$. [b] and [c] refer to significance level at 5% and 10%, respectively

Table 8 Results of cointegration test (LM bootstrap)

Tests	Equation 4		Equation 5	
	Lm Stat	Bootstrap p-value	Lm Stat	Bootstrap p-value
LM_N^+	1.014[a]	0.840	0.760[a]	0.815

The bootstrap test statistics have been calculated using 1000 replications. H_0: cointegration in the panel for all units. a refers to significance level at 1%

the test findings, the null hypothesis “there is no cointegration for all cross sections” is rejected.

The LM findings in Table 8 (*H_0: there is cointegration for all cross sections*) also confirm the Durbin-H_g findings. These results show that the variables included in both models act together in the long run.

We estimated the long-run coefficient estimates of the series, which we found to act together in the long run with two different estimators. AMG results are shown in Table 9, and CCE results are shown in Table 10.

We interpret the findings in Table 9 for Eq. 4 first and then for Eq. 5. In Eq. 4, the *lnrgdp* coefficient estimation findings of Australia, Chile, and Finland except for Sweden and the U. K. are marked positively. Sweden’s lnrgdp coefficient is negative, but not statistically significant. These results show that lnrgdp has a positive impact on $lnco_2$ in Australia, Chile, Finland, and 1% increase in lnrgdp leads to an increase by 0.86, 0.69, and 0.37% in $lnco_2$ for these countries. The coefficients of the lntes are not statistically significant only in Australia.

On the other hand, all the coefficients and statistically significant for lntes are positively signed. Finally, the coefficient estimation findings of the lntr variable are statistically significant for only two countries. For the lntr variable, the coefficient estimation findings of Finland and Sweden are marked positive. This result shows that lntr has an impact on the positive of $lnco_2$ in Finland and Sweden also 1% increase in lntr leads to an increase by 0.22% and 0.21% in $lnco_2$.

For Eq. 5, the *lnrgdp* and lntes coefficient estimation findings are consistent with Eq. 4 estimates. For Australia, Chile, and Finland, *lnrgdp* indicates positive effects on $lnco_2$. A similar situation is valid for the *Intes* coefficient estimation findings of Chile, Finland, the UK, and Sweden. On the other hand, in Eq. 5, coefficient estimation findings of *lngex* are statistically significant only in Australia. This result shows that *lngex* has an impact on the positive of $lnco_2$ in Australia; 1% increase in *lngex* leads to an increase by 0.48% in $lnco_2$.

Some of the CCE findings in Table 10 are consistent with AMG results. Among the consistent results, the coefficient estimates of *lnrgdp* draw attention. For example, in Eq. 4, *lnrgdp* coefficient estimates for Australia, Chile, and Finland are marked positively. Apart from these, the *lnrgdp* coefficient estimation of UK is statistically significant and positively marked, unlike AMG.

For lntes, the coefficient estimate we obtained with the CCE method is different from AMG and is not statistically significant in countries other than Australia and Finland. Coefficient estimation findings of lntr confirm AMG results for Finland only. On the other hand, in the estimates of Eq. 5, *lnrgdp* coefficient estimation findings are consistent with Eq. 4 in other countries except for Australia. Among the coefficient estimates belonging to lntes in Eq. 5, only the one that belongs to Finland is consistent with Eq. 4, positively signed and significant. Finally, none of the *lngex* coefficient estimates for the countries in Eq. 5 are statistically significant.

Table 9 Results of AMG

Countries	Equation 4			Equation 5		
	lnrgdp	lntes	lntr	lnrgdp	lntes	lngex
Australia	0.86[a]	−0.15	0.13	1.00[a]	−0.09	0.48[a]
Chile	0.69[a]	0.35[b]	−0.11	0.71[a]	0.35[b]	−0.09
Finland	0.37[a]	0.37[a]	0.22[b]	0.27[a]	0.37[a]	−0.04
UK	0.07	0.40[a]	−0.22	0.11	0.29[b]	−0.10
Sweden	−0.09	0.81[a]	0.21[a]	0.21	1.03[a]	0.15
Panel	0.38[b]	0.38[a]	0.04	0.46[a]	0.39[c]	0.07

UK: United Kingdom, [a] and [b] refer to significance level at 1% and 5%

Table 10 Results of CCE

Countries	Equation 4			Equation 5		
	lnrgdp	lntes	lntr	lnrgdp	lntes	lngex
Australia	1.23[a]	0.46[b]	0.17	0.59	0.26	0.13
Chile	0.59[b]	0.31	−0.07	0.63[b]	0.40	−0.12
Finland	0.46[b]	0.67[a]	0.23[b]	0.49[a]	0.59[a]	0.04
UK	1.51[a]	0.46	0.24	0.96[b]	0.27	0.08
Sweden	−0.46	0.22	−0.02	0.45	0.03	0.01
Panel	0.67[c]	0.43[a]	0.10	0.62[a]	0.31[a]	0.01

UK: United Kingdom, [a, b] and [c]refer to significance level at 1%, 5%, and 10%

Discussion

Findings of coefficient estimation point to the inadequacy of fiscal policies in reducing carbon emissions for the sample and period we have considered. For Finland and Sweden, the increasing effects of tax cuts on carbon emissions strengthen the impressions of the negative effects of these tax practices on environmental regulations. According to the results, the most striking point among the long-run coefficient estimation findings of this study is the findings obtained for Finland. Coefficient findings of electricity supply, real GDP, and tax revenues for Finland are affirmative. These results on the impact of Finland's tax revenues on CO_2 may indicate their tendency to generate tax revenue, which the OECD (2011) emphasized, as well as the validity of Green Keynesianism.

In our sample, real GDP and electricity supply have negative effects on the environment. These results strengthen the arguments that the countries in the sample prefer economic performance against the environmental issue. It can be argued that energy policies bring limited policy choice to the agenda. On the other hand, our findings may point to the results that income policies are effective in generating income—the most pragmatist of the theoretical effects—and that policymakers use their choices in this direction. Moreover, these results provide no evidence for the expected theoretical effects of expenditure policies. Besides, both long-run coefficient estimation results are in the same direction for Finland regarding energy policies. These results support the view that high energy taxation will not prevent environmental degradation.

Contrary to theoretical approaches, studies that we can access from empirical literature have obtained findings regarding the positive effects of public expenditures on CO_2. Our findings for Australia in terms of public expenditures are consistent with the findings of Carlsson and Lundström (2001), Bernauer and Koubi (2006), López et al. (2011), and Adewuyi (2016) and while confirming the *scale effect,* they are inconsistent with the results for negative effects on CO_2 with increased income in Halkos and Paizanos (2013). For Australia, these findings may point to consumption-induced public spending, as stated by McAusland (2008), López et al. (2011), Islam and López (2014), and Yuelan et al. (2019).

Conclusion

In this study, we investigated the effects of fiscal policies on the environment with two different models based on the models in the literature. Countries in our sample (Australia, Chile, Finland, the UK, and Sweden) take first place in the implementation of carbon taxes. In econometric research, we used cointegration and long-run coefficient estimators that consider the second-generation unit root test and preliminary analysis, depending on the results of cross-section dependence and homogeneity tests.

CD test results showed that countries are more likely to be influenced by or influence each other, and HT tests showed that interactions were also different. Unit root test results, considering CD and HT, showed that series of countries were permanently affected by shocks. Cointegration tests point out that the variables in the models moved together in the long run. In another way, long-run estimation result showed that fiscal policies are different but effective on countries' carbon emissions. The coefficient estimation results provided no evidence of the reducing effects of fiscal policies on carbon emissions. For the income policy (tax revenues), the coefficient estimation results for Finland for both models showed positive effects on CO_2. Besides, the expenditure policy (government expenditure) is only significant for Australia in the AMG estimator and has a positive sign.

We focused on fiscal and special revenue policy and we concentrated our suggestions at this point. Findings strengthen the possibility that regional efforts to reduce carbon emissions are weak. NEST and GED, which we named in the theoretical section, gain importance in this sense. "Classic" carbon taxes taken mostly from the consumers are insufficient in the fight against environmental degradation; in this context, carbon taxes can be expanded with NEST based on GED and made as effective as tax incentives on production. Because global problems require global solutions, NEST and GED should not be considered only conceptually as they are also open to extensive theoretical discussions.

Appendix

$$\text{NEST}_{ti}\ \text{Rate} = \frac{\text{NED}_{ti}}{\sum_{i=1}^{n} \text{NED}_{ti}} \times \gamma \tag{6}$$

$$\text{NEST}_{ti}\ \text{Payment} = \text{NEST}_{ti}\ \text{Rate} \times \text{NED}_{ti} \tag{7}$$

$$\text{NEST}_{ti}\ \text{Payment} = \frac{\text{NED}_{ti}}{\sum_{i=1}^{n} \text{NED}_{ti}} \times \text{NED}_{ti} \tag{8}$$

$$\text{NEST}_{ti}\ \text{Payment} = \frac{\left(\text{NED}_{ti}\right)^2}{\sum_{i=1}^{n} \text{NED}_{ti}} \times \gamma \tag{9}$$

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Declarations

Conflict of interest Both authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Consent to participate Not applicable.

Consent to publish Applicable.

References

Abdouli M, Hammami S (2016) Investigating the causality links between environmental quality, foreign direct investment and economic growth in MENA countries. Int Bus Rev 26:264–278. https://doi.org/10.1016/j.ibusrev.2016.07.004

Adewuyi AO (2016) Effects of public and private expenditures on environmental pollution: a dynamic heterogeneous panel data analysis. Renew Sustain Energy Rev 65:489–506. https://doi.org/10.1016/j.rser.2016.06.090

Ahmad M, Zhao ZY, Li H (2019) Revealing stylized empirical interactions among construction sector, urbanization, energy consumption, economic growth and CO2 emissions in China. Sci Total Environ 657:1085–1098. https://doi.org/10.1016/j.scitotenv.2018.12.112

Ahmad N, Du L (2017) Effects of energy production and CO2 emissions on economic growth in Iran: ARDL approach. Energy 123:521–537. https://doi.org/10.1016/j.energy.2017.01.144

Ahmed Z, Wang Z, Mahmood F et al (2019) Does globalization increase the ecological footprint? Empirical evidence from Malaysia. Environ Sci Pollut Res 26:18565–18582. https://doi.org/10.1007/s11356-019-05224-9

Amin SB, Kabir F Al, Khan F (2019) Tourism and energy nexus in selected South Asian countries: a panel study. Curr. Issues Tour

Aubert D, Chiroleu-Assouline M (2019) Environmental tax reform and income distribution with imperfect heterogeneous labour markets. Eur Econ Rev 116:60–82. https://doi.org/10.1016/j.euroecorev.2019.03.006

Aydin C, Esen Ö (2018) Reducing CO 2 emissions in the EU member states: do environmental taxes work? J Environ Plan Manag 1–26. https://doi.org/10.1080/09640568.2017.1395731

Aye GC, Edoja PE (2017) Effect of economic growth on CO2 emission in developing countries: evidence from a dynamic panel threshold model. Cogent Econ Financ 5:1379239. https://doi.org/10.1080/23322039.2017.1379239

Azam M, Alam MM, Haroon Hafeez M (2018) Effect of tourism on environmental pollution: further evidence from Malaysia, Singapore and Thailand. J Clean Prod 190:330–338. https://doi.org/10.1016/j.jclepro.2018.04.168

Balcilar M, Çiftçioğlu S, Güngör H (2016) The effects of financial development on invesment in Turkey. Singapore Econ Rev 61:1650002. https://doi.org/10.1142/S0217590816500028

Balı S, Yaylı G (2019) Karbon Vergisinin Türkiye'de Uygulanabilirliği. 3 Sektör Sos Ekon Dergisi 43:302–319. https://doi.org/10.15659/3.sektor-sosyal-ekonomi.19.03.1104

Baltagi BH (2021) Econometric Analysis of Panel Data, Sixth Edit. Springer Texts in Business and Economics, Cham

Basiago AD (1999) Economic, social, and environmental sustainability in development theory and urban planning practice. Environmentalist 19:145–161. https://doi.org/10.1023/A:1006697118620

Beck M, Rivers N, Wigle R, Yonezawa H (2015) Carbon tax and revenue recycling: impacts on households in British Columbia. Resour Energy Econ 41:40–69. https://doi.org/10.1016/j.reseneeco.2015.04.005

Bernauer T, Koubi V (2006) States as providers of public goods: how does government size affect environmental quality?

Blackburne EF III, Frank MW (2007) Estimation of nonstationary heterogeneous panels. Stata J 7:197–208. https://doi.org/10.1177/1536867X0700700204

Bolat S, Emirmahmutoglu F, Belke M (2014) The dynamic linkages of budget deficits and current account deficits nexus in EU countries: Bootstrap panel Granger causality test. Int J Econ Perspect 8:16–26

Breusch TS, Pagan AR (1980) The Lagrange multiplier test and its applications to model specification in econometrics. Rev Econ Stud 47:239–253

Carlsson F, Lundström S (2001) Political and economic freedom and the environment: the case of CO2 emissions. Göteborg

Carson R (1962) Silint spring. Crest Book, Greenwich

CBO (2013) Effects of a carbon tax on the economy and the environment

Çetin M, Ecevit E (2017) The impact of financial development on carbon emissions under the structural breaks: Empirical evidence from Turkish economy. Int J Econ Perspect 11:64–78

Chen Y, Wang Z, Zhong Z (2018) CO2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China. Renew Energy 131:208–216. https://doi.org/10.1016/j.renene.2018.07.047

Ciocirlan CE, Yandle B (2003) The political economy of green taxation in OECD countries. Eur J Law Econ 15:203–218. https://doi.org/10.1023/A:1023390126187

Cömert M (2019) Revival of Keynesian economics or greening capitalism: "Green Keynesianism". Sosyoekonomi 27:129–144. https://doi.org/10.17233/sosyoekonomi.2019.04.07
Conservation Energy Future (2020) Environmental impact of the aviation industry. https://www.conserve-energy-future.com/category/pollution. Accessed 1 Mar 2020
Danish BMA, Wang B (2019) Analyzing the role of governance in CO2 emissions mitigation: the BRICS experience. Struct Chang Econ Dyn 51:119–125. https://doi.org/10.1016/j.strueco.2019.08.007
Danish ZB, Wang Z, Wang B (2018) Energy production, economic growth and CO2 emission: evidence from Pakistan. Nat Hazards 90:27–50. https://doi.org/10.1007/s11069-017-3031-z
Dongyan L (2009) Fiscal and tax policy support for energy efficiency retrofit for existing residential buildings in China's northern heating region. Energy Policy 37:2113–2118. https://doi.org/10.1016/j.enpol.2008.11.036
Eberhardt M (2012) Estimating panel time-series models with heterogeneous slopes. Stata J 12:61
Eberhardt M, Bond S (2009) Cross-section dependence in nonstationary panel models: a novel estimator. Munich
Eberhardt M, Teal F (2010) Aggregation versus heterogeneity in cross-country growth empirics
Eberhardt M, Teal F (2011) Econometrics for grumblers: a new look at the literature on cross-country growth empirics. J Econ Surv 25:109–155. https://doi.org/10.1111/j.1467-6419.2010.00624.x
EEA (2016) Environmental taxation and EU environmental policies
Ekins P (1999) European environmental taxes and charges: recent experience, issues and trends. Ecol Econ 31:39–62. https://doi.org/10.1016/S0921-8009(99)00051-8
Filipović S, Golušin M (2015) Environmental taxation policy in the EU - new methodology approach. J Clean Prod 88:308–317. https://doi.org/10.1016/j.jclepro.2014.03.002
Fischer C, Fox AK (2012) Climate policy and fiscal constraints: do tax interactions outweigh carbon leakage? Washington, DC
Freire-González J (2017) Environmental taxation and the double dividend hypothesis in CGE modelling literature: a critical review. J Policy Model 40:194–223. https://doi.org/10.1016/j.jpolmod.2017.11.002
Freire-González J, Ho MS (2019) Carbon taxes and the double dividend hypothesis in a recursive-dynamic CGE model for Spain. Econ Syst Res 31:267–284. https://doi.org/10.1080/09535314.2019.1568969
Fullerton D, Kim SR (2008) Environmental investment and policy with distortionary taxes, and endogenous growth. J Environ Econ Manage 56:141–154. https://doi.org/10.1016/j.jeem.2008.02.001
Fullerton D, Monti H (2013) Can pollution tax rebates protect low-wage earners? J Environ Econ Manage 66:539–553. https://doi.org/10.1016/j.jeem.2013.09.001
Galinato GI, Islam A (2017) The challenge of addressing consumption pollutants with fiscal policy. Environ Dev Econ 22:624–647. https://doi.org/10.1017/S1355770X17000237
Goldstein J, Tyfield D (2017) Green Keynesianism: bringing the entrepreneurial state back in(to question)? Sci Cult (lond) 27:74–97. https://doi.org/10.1080/09505431.2017.1346598
Goulder LH (2013) Climate change policy's interactions with the tax system. Energy Econ 40:S3–S11. https://doi.org/10.1016/j.eneco.2013.09.017
Grossman MG, Krueger AB (1995) Economic growth and the environment. Q J Econ 110:353–377. https://doi.org/10.2307/2118443
Hafeez M, Chunhui Y, Strohmaier D et al (2018) Does finance affect environmental degradation: evidence from One Belt and One Road Initiative region? Environ Sci Pollut Res 25:9579–9592. https://doi.org/10.1007/s11356-018-1317-7
Hafeez M, Yuan C, Yuan Q et al (2019) A global prospective of environmental degradations: economy and finance. Environ Sci Pollut Res 26:25898–25915. https://doi.org/10.1007/s11356-019-05853-0
Hailemariam A, Dzhumashev R (2019) Income inequality and economic growth: heterogeneity and nonlinearity. Stud Nonlinear Dyn Econ. https://doi.org/10.1515/snde-2018-0084
Halkos GE, Paizanos EA (2016) The effects of fiscal policy on CO2 emissions: evidence from the U.S.A. Energy Policy 88:317–328. https://doi.org/10.1016/j.enpol.2015.10.035
Halkos GE, Paizanos EA (2013) The Effect of government expenditure on the environment: an empirical investigation. Ecol Econ 91:48–56. https://doi.org/10.1016/j.ecolecon.2013.04.002
Halkos GE, Tzeremes NG (2013) Carbon dioxide emissions and governance: a nonparametric analysis for the G-20. Energy Econ 40:110–118. https://doi.org/10.1016/j.eneco.2013.06.010
Harris JM (2013) Green Keynesianism: beyond standard growth paradigms. Medford
He P, Ya Q, Chengfeng L et al (2019) Nexus between environmental tax, economic growth, energy consumption, and carbon dioxide emissions: evidence from China, Finland, and Malaysia based on a panel-ARDL approach. Emerg Mark Financ Trade. https://doi.org/10.1080/1540496X.2019.1658068
Hotunğlu H, Tekeli R (2007) Sosyo Ekonomi Karbon Vergisinin Ekonomik Analizi ve Etkileri: analysis and effects of carbon tax : does carbon tax reduce. Sosyoekonomi 2007–2:107–126
Hsu S-L (2011) The case for a carbon tax, 2011th edn. Island Press, Washington, D.C.
Ike GN, Usman O, Sarkodie SA (2020) Fiscal policy and CO2 emissions from heterogeneous fuel sources in Thailand: evidence from multiple structural breaks cointegration test. Sci Total Environ 702:134711. https://doi.org/10.1016/j.scitotenv.2019.134711
IMF (2019) Fiscal policies for paris climate strategies-from principle to practice. Washington, D.C.
Islam AM, López RE (2014) Government spending and air pollution in the US. Int Rev Environ Resour Econ 8:139–189. https://doi.org/10.1561/101.00000068
Iwata H, Okada K, Samreth S (2010) Empirical study on the environmental Kuznets curve for CO2 in France: the role of nuclear energy. Energy Policy 38:4057–4063. https://doi.org/10.1016/j.enpol.2010.03.031
Jacobs B, van der Ploeg F (2019) Redistribution and pollution taxes with non-linear Engel curves. J Environ Econ Manage 95:198–226. https://doi.org/10.1016/j.jeem.2019.01.008
Jalil A, Feridun M (2011) The impact of growth, energy and financial development on the environment in China: a cointegration analysis. Energy Econ 33:284–291. https://doi.org/10.1016/j.eneco.2010.10.003
Jamel L, Maktouf S (2017) The nexus between economic growth, financial development, trade openness, and CO2 emissions in European countries. Cogent Econ Financ 5:1341456. https://doi.org/10.1080/23322039.2017.1341456
Kasman A, Duman YS (2015) CO2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: a panel data analysis. Econ Model 44:97–103. https://doi.org/10.1016/j.econmod.2014.10.022
Katircioglu S, Katircioglu S (2017) Testing the role of fiscal policy in the environmental degradation: the case of Turkey. Environ Sci Pollut Res 25:5616–5630. https://doi.org/10.1007/s11356-017-0906-1
Katircioğlu S, Katircioğlu S (2017) Testing the role of urban development in the conventional environmental Kuznets curve: evidence from Turkey. Appl Econ Lett 25:741–746. https://doi.org/10.1080/13504851.2017.1361004
Katircioglu ST (2014) International tourism, energy consumption, and environmental pollution: the case of Turkey. Renew Sustain

Energy Rev 36:180–187. https://doi.org/10.1016/j.rser.2014.04.058
Khan MWA, Panigrahi SK, Almuniri KSN et al (2019) Investigating the dynamic Impact of CO2 emissions and economic growth on renewable energy production: evidence from FMOLS and DOLS tests. Processes 7:496. https://doi.org/10.3390/pr7080496
Klenert D, Mattauch L (2016) How to make a carbon tax reform progressive: the role of subsistence consumption. Econ Lett 138:100–103. https://doi.org/10.1016/j.econlet.2015.11.019
Klenert D, Schwerhoff G, Edenhofer O, Mattauch L (2018) Environmental taxation, inequality and Engel's law: the double dividend of redistribution. Environ Resour Econ 71:605–624. https://doi.org/10.1007/s10640-016-0070-y
KP (1997) KYOTO protocol to the united nations framework convention on climate change
Liu Y, Han L, Yin Z, Luo K (2017) A competitive carbon emissions scheme with hybrid fiscal incentives: the evidence from a taxi industry. Energy Policy 102:414–422. https://doi.org/10.1016/j.enpol.2016.12.038
Liu Y, Li Z, Yin X (2018) The effects of three types of environmental regulation on energy consumption—evidence from China. Environ Sci Pollut Res 25:27334–27351. https://doi.org/10.1007/s11356-018-2769-5
López R, Gregmar IG, Asif I (2011) Fiscal spending and the environment: theory and empirics. J Environ 62:180–198. https://doi.org/10.1016/j.jeem.2011.03.001
López RE, Thomas V, Wang Y (2008) The quality of growth: fiscal policies for better results. Washington, D.C.
Luìs G, Giulio G, Gabriel P (2020) Environmental innovations, income distribution, international competitiveness and environmental policies: a Kaleckian growth model with a balance of payments constraint. Struct Chang Econ Dyn 53:16–25. https://doi.org/10.1016/j.strueco.2020.01.002
Lv Z (2017) The effect of democracy on CO2 emissions in emerging countries: does the level of income matter? Renew Sustain Energy Rev 72:900–906. https://doi.org/10.1016/j.rser.2017.01.096
Malla S (2009) CO2 emissions from electricity generation in seven Asia-Pacific and North American countries: a decomposition analysis. Energy Policy 37:1–9. https://doi.org/10.1016/j.enpol.2008.08.010
McAusland C (2008) Trade, politics, and the environment: Tailpipe vs. smokestack. J Environ Econ Manage 55:52–71. https://doi.org/10.1016/j.jeem.2007.08.002
Metcalf GE (2019) On the economics of a carbon tax for the United States. Washington, D.C
Miller S, Vela MA (2013) Are environmentally related taxes effective?
Morley B (2012) Empirical evidence on the effectiveness of environmental taxes. Appl Econ Lett 19:1817–1820. https://doi.org/10.1080/13504851.2011.650324
OECD (2011) Environmental taxation a guide for policy makers
OECD (2015) Environmental taxation. http://www.oecd.org/environment/tools-evaluation/environmentaltaxation.htm. Accessed 1 Mar 2020
PA (2015) Paris agreement
Panayotou T (1993) Empirical tests and policy analysis of environmental degradation at different stages of economic development. International Labour Organization, Geneva
Pereira AM, Pereira RM, Rodrigues PG (2016) A new carbon tax in Portugal: a missed opportunity to achieve the triple dividend? Energy Policy 93:110–118. https://doi.org/10.1016/j.enpol.2016.03.002
Pesaran MH (2020) General diagnostic tests for cross-sectional dependence in panels. Empir Econ. https://doi.org/10.1007/s00181-020-01875-7
Pesaran MH (2006) Estimation and inference in large heterogeneous panels with a multifactor error structure. Econometrica 74:967–1012. https://doi.org/10.1111/j.1468-0262.2006.00692.x
Pesaran MH (2004) General diagnostic tests for cross section dependence in panels
Pesaran MH (2007) A simple panel unit root test in the presence of cross-section dependence. J Appl Econom 22:265–312. https://doi.org/10.1002/jae951
Pesaran MH, Ullah A, Yamagata T (2008a) A bias-adjusted LM test of error cross-section independence. Econom J 11:105–127. https://doi.org/10.1111/j.1368-423X.2007.00227.x
Pesaran MH, Yamagata T (2008) Testing slope homogeneity in large panels. J Econom 142:50–93
Phimphanthavong H (2013) The impacts of economic growth on environmental conditions in laos. Int J Bus Manag Econ Res 4:766–774
Pigato MA (2019) Fiscal policies for development and climate action. International Development in Focus. World Bank, Washington, DC:
Qi T, Zhang X, Karplus VJ (2014) The energy and CO2 emissions impact of renewable energy development in China. Energy Policy 68:60–69. https://doi.org/10.1016/j.enpol.2013.12.035
Rafindadi AA, Usman O (2019) Globalization, energy use, and environmental degradation in South Africa: startling empirical evidence from the Maki-cointegration test. J Environ Manage 244:265–275. https://doi.org/10.1016/j.jenvman.2019.05.048
Rauf A, Liu X, Amin W et al (2018) Testing EKC hypothesis with energy and sustainable development challenges: a fresh evidence from belt and road initiative economies. Environ Sci Pollut Res 25:32066–32080. https://doi.org/10.1007/s11356-018-3052-5
Robinson D, Keay M, Hammes K (2017) Fiscal policy for decarbonisation of energy in Europe
Rosenow J, Platt R, Demurtas A (2014) Fiscal impacts of energy efficiency programmes-the example of solid wall insulation investment in the UK. Energy Policy 74:610–620. https://doi.org/10.1016/j.enpol.2014.08.007
Ryan L, Ferreira S, Convery F (2009) The impact of fiscal and other measures on new passenger car sales and CO2 emissions intensity: evidence from Europe. Energy Econ 31:365–374. https://doi.org/10.1016/j.eneco.2008.11.011
Sachs J, Schmidt-Traub G, Kroll C, et al (2018) SDG index and dashboards report global responsibilities implementing the goals
Sarkodie SA, Strezov V (2018) Assessment of contribution of Australia's energy production to CO2 emissions and environmental degradation using statistical dynamic approach. Sci Total Environ 639:888–899. https://doi.org/10.1016/j.scitotenv.2018.05.204
Shahbaz M, Van HTH, Mahalik MK, Roubaud D (2017a) Energy consumption, financial development and economic growth in India: new evidence from a nonlinear and asymmetric analysis. Energy Econ 63:199–212. https://doi.org/10.1016/j.eneco.2017.01.023
Shahbaz M, Khan S, Ali A, Bhattacharya M (2017) The impact of globalization on Co2 emissions in China. Singapore Econ Rev 62:1740033. https://doi.org/10.1142/S0217590817400331
Shmelev SE, Speck SU (2018) Green fiscal reform in Sweden: econometric assessment of the carbon and energy taxation scheme. Renew Sustain Energy Rev 90:969–981. https://doi.org/10.1016/j.rser.2018.03.032
Sinha A, Shahbaz M (2018) Estimation of environmental Kuznets curve for CO2 emission: role of renewable energy generation in India. Renew Energy 119:703–711. https://doi.org/10.1016/j.renene.2017.12.058
Sohn LB (1973) Stockholm declaration on the human environment. Harvard Int Law J 14:423–515
Speck S (2007) Overview of environmental tax reforms in EU member states

Stavins R (2003) Prepared for handbook for environmental economics. In: Mäler K-G, Vincent J (eds) Handbook of environmental economics, 2003rd edn. Elsevier Science, Amsterdam, pp 355–435
Tanzi V (2004) Globalization, social protection and public finance current affiliation consultant for the inter-American development bank paper prepared for the united nations development program
Uddin N, Holtedahl P (2013) Emission trading schemes - avenues for unified accounting practices. J Clean Prod 52:46–52. https://doi.org/10.1016/j.jclepro.2013.03.017
UNFCCC (1992) Gender, climate change and the United Nations Framework Convention on Climate Change
United Nations (2002) Globalization and new challenges of public finance: New York
UNWCED (1987) Our common future. Oslo
Vera S, Sauma E (2015) Does a carbon tax make sense in countries with still a high potential for energy efficiency? Comparison between the reducing-emissions effects of carbon tax and energy efficiency measures in the Chilean case. Energy 88:478–488. https://doi.org/10.1016/j.energy.2015.05.067
Wang Q, Su M, Li R (2018) Toward to economic growth without emission growth: the role of urbanization and industrialization in China and India. J Clean Prod 205:499–511. https://doi.org/10.1016/j.jclepro.2018.09.034
Westerlund J (2008) Panel cointegration tests of the fisher effect. J Appl Econom 23:193–233. https://doi.org/10.1002/jae967
Westerlund J, Edgerton DL (2007) A panel bootstrap cointegration test. Econ Lett 97:185–190
WMO (2020) WMO statement on the status of the global climate in 2019. World Meteorological Organization, Geneva
WTO (2018) Making trade work for the environment, prosperity and resilience
Xu X, Xu X, Chen Q, Che Y (2018) The impacts on CO2 emission reduction and haze by coal resource tax reform based on dynamic CGE model. Resour Policy 58:268–276. https://doi.org/10.1016/j.resourpol.2018.05.015
Yan X, Crookes RJ (2010) Energy demand and emissions from road transportation vehicles in China. Prog Energy Combust Sci 36:651–676. https://doi.org/10.1016/j.pecs.2010.02.003
Yao X, Yasmeen R, Li Y et al (2019) Free trade agreements and environment for sustainable development: a gravity model analysis. Sustain 11:1–17. https://doi.org/10.3390/su11030597
Yasmeen R, Li Y, Hafeez M, Ahmad H (2018) The trade-environment nexus in light of governance: a global potential. Environ Sci Pollut Res 25:34360–34379. https://doi.org/10.1007/s11356-018-3390-3
Ye J (2021) Center for climate and energy solutions. In: Carbon pricing proposal 117th congress. Center for Climate and Energy Solutions, pp 1–17
Yuelan P, Akbar MW, Hafeez M et al (2019) The nexus of fiscal policy instruments and environmental degradation in China. Environ Sci Pollut Res 26:28919–28932. https://doi.org/10.1007/s11356-019-06071-4
Zimmerman R (2005) Mass transit infrastructure and urban health. J Urban Heal 82:21–32. https://doi.org/10.1093/jurban/jti005