The impact of renewable energy policies on deaths from outdoor and indoor air pollution: Empirical evidence from Latin American and Caribbean countries

Matheus Koengkan *,[1], José Alberto Fuinhas [2], Emad Kazemzadeh [3], Nooshin Karimi Alavijeh [3], and Saulo Jardim de Araujo [4]

[1]GOVCOPP-DEGEIT, University of Aveiro, Aveiro, Portugal
[2] CeBER and University of Coimbra, Faculty of Economics, Coimbra, Portugal
[3] Department of Economics, Faculty of Economics and Administrative Sciences, Ferdowsi University of Mashhad, Mashhad, Iran
[4] Department of Economics, Federal Fluminense University, Niteroi, Brazil

Abstract

This investigation analysed the effect of renewable energy policies (e.g., economic instruments-fiscal/financial incentives policies, such as feed-in tariffs/premiums, grants and subsidies, loans, tax relief, taxes, and user charges) on deaths caused by outdoor and indoor air pollution in fifteen countries from Latin America and the Caribbean (LAC) region from 1990 to 2017. The results from the panel quantile model regression showed that in the 0.10, 0.25, 0.5, 0.75, and 0.90 quantiles, the variables carbon dioxide emissions, electricity consumption from new renewable energy sources, economic instruments-fiscal/financial incentives policies to enable renewable energy deployment and use, economic growth, and social globalisation reduces the air pollution deaths. In contrast, the variables electricity consumption from non-renewable energy sources, urbanisation, and economic globalisation encourages the increase of these deaths caused by outdoor and indoor air pollution in the LAC region.

Keywords: Air pollution death; Financial incentives; Fiscal incentives, Latin America and the Caribbean region; Renewable energy policies.

Acknowledgements: This work was financially supported by the research unit on Governance, Competitiveness and Public Policy UIDB/04058/2020 and UIDP/04058/2020, funded by national funds through FCT - Fundação para a Ciência e a Tecnologia; and CeBER R&D unit funded by national funds through FCT – Fundação para a Ciência e a Tecnologia, I.P., project UIDB/05037/2020.

1. Introduction

In recent years, the emission of greenhouse gases such as CO_2, SO2, NO, $PM_{2.5}$, etc., have intensified environmental pollution. Based on experimental evidence, carbon dioxide gas has the highest emission rate among greenhouse gases and is considered an indicator of air pollution in most studies (e.g., Salehnia et al., 2020; Nathaniel et al., 2021). Air pollution is capable of causing damage not only to fauna and flora but also to people's health. Thus, air pollution is responsible for a significant death rate in some

* Corresponding Author: *matheuskoengkan@ua.pt*, GOVCOPP-DEGEIT, University of Aveiro, Aveiro, Portugal.

countries. In addition, adverse effects on the population's health have also been observed in nations where air pollution is below the levels determined by legislation. Therefore, it can be seen through this scenario that even at lower levels, air pollution can cause severe respiratory and cardiovascular diseases (Dapper et al., 2016).

In this sense, the replacement of conventional sources of energy generation by renewable sources, in which the latter is usually driven by the use of economic instruments, such as tax incentive policies, is seen as a viable and efficient alternative for reducing the levels of atmospheric pollution, and consequently a reduction in mortality rates in several countries.

There are no investigations that approach the impact of renewable energy policies on mortality caused by air pollution in the literature. Most of the studies related to this theme approach the impact of renewable energy consumption on the mortality rate caused by air pollution. In the literature, several investigations have been carried out in the last decades to analyse the impact of renewable energy sources on the mortality rate caused by air pollution, such as Koengkan et al. (2021a), Kim et al. (2011), Nordhaus (2007), and Blackman and Harrington (2000). Indeed, most of these authors mentioned above, such as Koengkan et al. (2021a) and Kim et al. (2011), indicated that the capacity of renewable energy sources to reduce the mortality rate caused by air pollution is related to the capacity and existence of effective renewable energy policies that encourage the development and consumption of this kind of source. However, the evidence that the renewable energy policies can help the mitigation of mortality rate caused by air pollution via renewable energy consumption was not proved and investigated by the authors. Therefore, exist a gap in the literature that needs to be filled regarding the possible effects of renewable energy policies on deaths from outdoor and indoor air pollution.

Due to the existence of a gap in the literature regarding the impact of renewable energy policies (e.g., economic instruments-fiscal/financial incentives policies, such as feed-in tariffs/premiums, grants and subsidies, loans, tax relief, taxes, and user charges) on deaths from outdoor and indoor air pollution, this investigation elaborated the following central question – **Can the renewable energy policies reduce the deaths from outdoor and indoor air pollution in the Latin American and Caribbean (LAC) countries?** To answer this central question, this research will conduct an empirical analysis using macroeconomic panel data with fifteen LAC countries between 1990-2017. The panel quantile model approach developed by Machado and Silva (2019) will be used to realise this empirical analysis.

The realisation of this analysis will provide advances in the literature to strengthen the global debate favouring public policies that significantly influence the death rate. Also, LAC countries were selected for this study, as it is a region: (1) rich in natural resources with sustainable energy potentials; (2) it has a structurally fragile health system, making it difficult to treat diseases caused by air pollution; (3) with high potential for economic growth, and therefore will need new energy sources in the future; (4) which has the potential to meet all future energy demands, through the installation of non-conventional renewable generation sources (Alatorre et al., 2013).

Moreover, this investigation is innovative and will contribute to the literature for several reasons, first, by introducing a new analysis related to the effect of renewable energy policies on deaths from outdoor and indoor air pollution in the LAC region. Second, this investigation will introduce new econometric models in this topic of investigation (e.g., panel quantile model). Moreover, this can also be considered the innovation of this study, where a new econometric approach is being used in a new case of study. Finally, this investigation will support policymakers in developing consistent initiatives that promote the development of renewable energy policies in the LAC region to reduce the consumption of fossil fuels and environmental degradation.

This study is organised as follows. **Section 2** presents the literature review regarding the effect of renewable energy policies (e.g., economic instruments-fiscal/financial incentives policies, such as feed-in tariffs/premiums, grants and subsidies, loans, tax relief, taxes, and user charges) to enable renewable energy deployment and use. **Section 3** provides the Method and data approach. **Section 4** presents the results and a brief discussion. **Section 5** presents the conclusions and policy implications.

2. Literature review

Rising Greenhouse Gas emissions have led to an increase in deaths from air pollution, and governments are trying to use different economic instruments to increase renewable energy use and reduce pollution. Among these, carbon taxes, tax incentives, subsidies, loans and tariffs have more benefits than other policies (Kim et al., 2011).

Blackman and Harrington (2000), in a study examining the effectiveness of economic incentives on reducing industrial air pollution in developing countries, stated that both design shortcomings and limitations in monitoring and implementation hinder the effectiveness of financial instruments in developing countries. Harring (2014) found in a study for the European Union that people in Nordic and Benelux countries consider the effectiveness of economic instruments to protect the environment from being effective, while people in southern and eastern Europe are less aware of this effectiveness. According to Stelling (2014), economic instruments are effective for the Swedish freight transport sector in the short term and until new techniques are implemented. At the same time, the study of the effectiveness of economic instruments for the development of photovoltaics (PV) and wind energy in the European Union (EU) by Li et al. (2017) showed that feed-in tariffs are more efficient than renewable portfolio standards (RPS) for photovoltaic (PV) development and wind energy development.

Other studies have examined the effectiveness of carbon taxation on environmental quality (e.g., Kim et al., 2011; Nordhaus, 2007; and Pearce, 1991). Lin and Li (2011), in a study for five northern European countries, stated that the carbon tax in Finland has a significant impact on CO_2 reduction. Meanwhile, the carbon tax effects in Denmark, Sweden, and the Netherlands are not substantial. Nevertheless, in Norway, the rapid growth of energy products has significantly increased CO_2 emissions in the oil drilling and natural gas sectors. Guo et al. (2014) in a study for China using the CGE model. The authors found that the average carbon tax significantly reduces carbon emissions and energy consumption of fossil fuels but slightly slows down economic growth. However, high carbon taxes have a significant negative impact on the economy and social welfare. In addition, they found that carbon taxes improved the use of clean energy.

Vera and Sauma (2015), in a study for the electricity sector of Chile during the period 2014-2024, stated that the carbon tax policy of 5 $ (per ton of carbon) reduces CO_2 emissions by (1%) per year. In a study for Greece during the period 1998-1998, Floros and Vlachou (2005) stated that 50$ (per ton of carbon) carbon tax leads to a significant reduction in direct and indirect CO_2 emissions, but at a high cost to the economy imposes, while Bruvoll and Larsen (2004) in their study for Norway using general equilibrium simulations during the period 1990-1999 stated that the carbon tax only helps to reduce greenhouse gas emissions by (2%). Results of carbon tax incentive policies to reduce carbon emissions in air transport by Qiu et al. (2020) in China showed that incentive policies could encourage airlines to improve fuel consumption and emissions performance under appropriate conditions.

In their study, Liu et al. (2014), in addition to a carbon tax as an economic instrument. The authors used command-and-control (CAC) to reduce air pollution in China's iron and steel sector. The simulation results show that the carbon tax can control CAC has excellent effects in controlling different pollutants separately. Many other studies examined the effectiveness of the fuel tax and subsidies. Zimmer and Koch (2017), in a study for Europe, found that reforming fuel taxes could prevent significant amounts of air pollutants, while Davis and Kilian (2009), in a study for the United States, states that a (10%) increase in gasoline taxes reduces the CO_2 emissions in the United States by (1.5%). Xie et al. (2021) used China's clean energy vehicle subsidy policy, finding that these policies generally significantly improve urban air quality and, in the long run, lead to effective technological advances. Wang (2020), in another study for China, stated that market-based policies and top-down policies reduce pollution.

Other studies used several economic instruments simultaneously to compare their effectiveness. Mao et al. (2012), using the CIMS model system, examined the effectiveness of economic instruments (carbon tax, energy tax, fuel tax, subsidised clean energy vehicles). They said energy and fuel tax policies had the most significant impact on reducing environmental pollution, while subsidies had a negligible impact. Jorgenson and Wilcoxen (1993) evaluated the effect of three types of taxes (e.g., fossil fuels, VAT, and carbon taxes) on reducing carbon dioxide emissions in the United States. They found that carbon taxes could significantly impact coal mining and achieve a certain reduction in CO_2 with minimal impact on the economy. The energy tax is almost the same as the carbon tax but has a slightly smaller impact on coal mining and a slightly higher overall cost.

In contrast, VAT has a much smaller effect on reducing coal mining but significantly impacts the economy. Cao et al. (2008), in a study for the Chinese electricity sector, simulated three environmental tax policies (production tax, fuel tax, and carbon tax) using a top-down recursive dynamic CGE model (computable general equilibrium). The results suggest that the preferred policy for China is fuel tax or carbon tax at the national level. Shmelev and Speck (2018) stated that the carbon tax does not significantly reduce CO_2 emissions in Sweden, while the energy tax for coal and liquefied petroleum gas has been statistically significant. Furthermore, renewable energy (excluding hydraulic) has not been statistically significant in reducing CO_2 emissions.

Indeed, several other studies have examined the role of financial instruments in the environment. Katircioglu and Katircioglu (2018), in a study to investigate the role of fiscal policies on environmental degradation in Turkey between 1960-2013, found that fiscal policies reduce carbon dioxide emissions. Kosonen and Nicodème (2009) stated that taxes and other types of financial instruments in EU countries could complement each other effectively to achieve an environmental goal. Postula and Radecka-Moroz (2020), in examining the effectiveness of EU member states tax policies, stated that in addition to the type of financial instruments, they must also consider the impact of the time dimension; otherwise, the effectiveness of these policies on the environment will be very limited. López and Palacios (2014), in their study of the role of fiscal policies and energy taxes on environmental quality in the 12 richest European countries during the period 1995-2008, concluded that fiscal policies significantly reduced the concentration of sulfur dioxide and ozone While the energy tax reduces the concentration of nitrogen dioxide but has no effect on ozone and sulfur dioxide. Ike et al. (2020) stated that a (1%) increase in fiscal policy caused a (6.5%) decrease in CO_2 emissions from natural gas, (0.2%) from oil derivatives, and a (0.2%) increase from solid fuels (coal). Droste et al. (2018) confirmed the impact of financial incentives on environmental protection in Europe.

In contrast, some studies have shown that fiscal policy instruments either have little impact on the environment or cause environmental degradation in the long run. Ring (2002), in a study for Germany, found that these incentives are only effective in the short term. The results of Halkos and Paizanos (2016) for the United States using the var model during the period 1973-2013 showed that the implementation of expansionary finance costs has a slight effect on the emission source. Cao et al. (2021) used a spatial panel model. The authors stated that although the implementation of ecological fiscal policies stimulates local governments' efforts to improve the quality of the environment, these policies do not improve the environment, while Yuelan et al. (2019) in a study for China during the period 1980 to 2016, they found that fiscal policy instruments significantly increase environmental degradation in the long run.

As seen in previous studies, different economic instruments have been used to evaluate their impact on the environment in different regions and countries. Nevertheless, no study has been done on the LAC region. Furthermore, this study considers a set of instruments (e.g., fiscal incentive policies, tariffs, taxes, loans, subsidies, feed-in tariffs, premiums, and grants) an indicator for economic instruments. Another distinguishing feature of this study is investigating the effects of economic instruments on air pollution death rates, which previous studies have not addressed. The following section will present the method and data used to realise this empirical investigation.

3. Method and data

This section will show the method approach and data/variables used in this empirical investigation.

3.1 Method

As mentioned before, this subsection will show the method approach that this empirical investigation will use and the preliminary and post-estimation tests.

3.1.1. Panel quantile model

The panel quantile model approach that developed by Machado and Silva (2019). Then, this method has several advantages that were highlighted by Koengkan et al. (2021a); for example, **(i)** allows for the estimation of conditional quantiles using panel data in the presence of individual effects; **(ii)** allows to provide information on how the regressor affects the entire conditional distribution; **(iii)** allows to estimate in the presence of cross-section dependence and with endogenous variables; and **(iv)** this method is based on the moment conditions that find the conditional means under exogeneity. Besides, it can find the same structural quantile function for these advantages that this empirical investigation opted to use this method.

Therefore, after a brief explanation of the main method approach that will use, it is necessary to show the equation of the panel quantile model, see **Equation** (**1**) below.

$$\lambda_{it} = \lambda_i + e'_{it}\beta + (\omega_i + Z'_{it}\gamma)\mu_{it}\,, \quad \textbf{(1)}$$

Where λ_{it}, e'_{it} from a panel of N individuals i = 1, …, N over T time-periods with $P\{\omega_i + Z'_{it}\gamma > 0\} = 1$.

3.1.2. Pooled ordinary least squares (OLS) model with fixed effects

The Pooled OLS model with fixed effects can estimate the slope and intercepts for a set of observations as mentioned by Fuinhas et al. (2021). Furthermore, according to the same author, this model can estimate the mean response for the fixed predictors (see **Equation 2**, below).

$$y_{it} = \beta_0 + \beta_1 x_{it} + \beta_2 a_{it} + \beta_3 e_{it\cdots} + \varepsilon_{it} \quad \textbf{(2)}$$

where β_0 is the intercept, and β is the value of fixed covariates being fitted to predict the dependent variable y_{it}, and ε_i is the error term, and each variable enters regression for country *i* at year *t*.

Indeed, before realising model estimations (e.g., Panel quantile model and Pooled OLS model with fixed effects), it is necessary to carry out the preliminary tests. Therefore, the following subsection will evidence the initial tests used in this empirical analysis.

3.1.3. Preliminary and post estimation tests

Indeed, before realising the panel quantile model regression and pooled OLS model with fixed effects, it is necessary to carry out the preliminary tests. The same occurs after the model regressions, where it is necessary to compute the post-estimation tests. **Table 1** below evidence the preliminary and post-estimation tests used in this empirical investigation.

Table 1. Preliminary and Post-estimation tests for the panel quantile model and pooled OLS model with fixed effects

Preliminary tests	
Tests	**Objective**
Bias-corrected LM-based test (Born and Breitung, 2015)	To find the presence of serial correlation in the fixed-effects panel model.
Variance inflation factor (VIF) (Belsley et al., 1980)	To find the presence of multicollinearity between the variables.
Cross-section dependence (CSD) (Pesaran, 2004)	To find the presence of cross-sectional dependence (CSD) in the panel data.

Correlation test	To find the correlation between the variables of the model.
Panel unit root test (CIPS) (Pesaran, 2007)	To find the presence of unit roots.
Hausman test	To find the presence of heterogeneity, i.e., whether the panel has random effects (RE) or fixed effects (FE).
Post-estimation tests	
Wald test (Agresti, 1990)	To find the global significance of the estimated models.

Notes: This table was created by the authors.

All model estimations and testing procedures will be accomplished using **Stata 17.0**, and all Stata' commands used in this empirical analysis will be provided in the notes of tables to allow their reapplication. Moreover, **Figure 1** below evidence the conceptual framework this empirical investigation will follow.

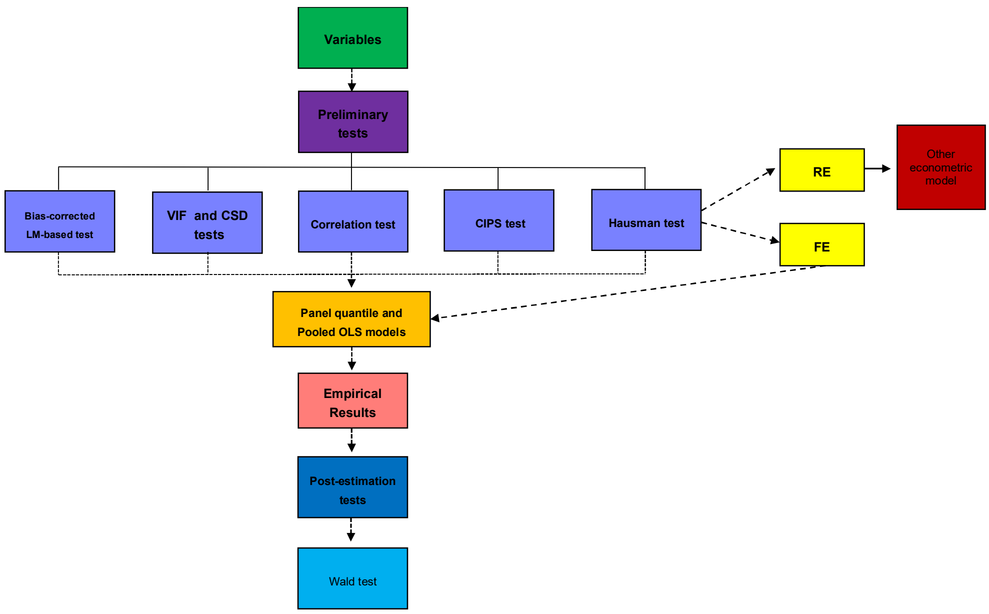


Figure 1. Conceptual framework. This figure was created by the authors. **Notes**: (RE) denotes the random-effects model, and (FE) denotes the fixed-effects model.

The Stata commands such as *sum*, *xtqptest*, *vif*, *xtcd*, *pwcorr*, *multipurt*, *hausman (with the options sigmamore)*, *xtqreg, xtreg,* and *testparm* were used in this empirical investigation. The following subsection will show the data/variables used in this investigation.

3.2 Data

This subsection will present the data/variables utilised in this study. In this context, fifteen countries from the LAC region were selected to realise this empirical analysis. For example, **Argentina**, **Bolivia**, **Brazil**, **Chile**, **Colombia**, **Costa Rica**, **Dominican Republic**, **Ecuador**, **Guatemala**, **Mexico**, **Panamá**, **Paraguay**, **Peru**,

Uruguay, and **Venezuela**. Furthermore, this study opted to use data from 1990 to 2017 due to data availability. Therefore, the variables used and their summary statistic are shown in **Table 2** below.

Table 2. Variables' description and summary statistics

Variables' description		
Variable	**Definition**	**Source**
DRAP	Death rates from air pollution measure the number of deaths per 100,000 population from outdoor and indoor air pollution.	Our World in Data (2021)
CO_2	Carbon dioxide emissions in kilotons (Kt) per capita from the burning of fossil fuels and cement manufacture. This variable also includes carbon dioxide produced during the consumption of solid, liquid and gas fuels and gas flaring.	World Bank Open Data (2021)
REC	Electricity consumption from new renewable energy sources (e.g., biomass, solar, photovoltaic, wind, wave, and waster) in (kWh) per capita.	World Bank Open Data (2021)
EIP	Economic instruments-fiscal/financial incentives policies for developing and using renewable energy sources. The economic instruments include feed-in tariffs/premiums, grants and subsidies, loans, tax relief, taxes, and user charges. This variable was built in accumulated form, where each policy that was created is represented by (1) accumulated over other policies throughout its useful life or end (e.g., 1, 1, 2, 2, 2, 3,3).	International Energy Agency (2021)
FOC	Electricity consumption from non-renewable energy sources (e.g., Oil, gas, and coal) in (kWh) per capita.	World Bank Open Data (2021)
GDP	Gross Domestic Production in constant local currency units (LCU) and expressed per capita.	World Bank Open Data (2021)
URB	Urban population rate refers to people living in urban areas as defined by national statistical offices, and this variable is a proxy of urbanisation.	World Bank Open Data (2021)
KOFSoGI	Social Globalisation index de facto measures interpersonal, information, and cultural globalisation.	KOF Globalisation Index (2021)
KOFEcGI	Economic Globalisation index in the de facto measures trade and financial globalisation. Trade globalisation is determined based on trade in goods and services, and financial globalisation includes foreign investment in various categories.	KOF Globalisation Index (2021)

Summary statistics					
Variables	**Obs.**	**Mean**	**Std. Dev**	**Min**	**Max**
DRAP	448	0.6264	0.6290	-0.7084	2.0414
CO_2	448	10.3819	0.7230	9.0951	12.0487
REC	448	0.8165	0.7767	0.0000	2.7080
EIP	448	11.2117	0.8426	8.6280	12.6843
FOC	448	11.2087	3.0597	7.2408	17.1658
GDP	448	4.2469	0.2019	3.7374	4.5642
URB	448	0.6264	0.6290	-0.7084	2.0414
KOFSoGI	448	3.9936	0.2259	3.3184	4.4012
KOFEcGI	448	3.8869	0.2378	3.2576	4.4117

Notes: The Stata command *sum* was used; All variables in this model were transformed in the natural logarithms; Obs. denotes the number of observations in the model; Std.-Dev. denotes the Standard Deviation; Min. and Max. denote Minimum and Maximum, respectively.

All variables that were used align with the existing literature. It is worth remembering that the variables (e.g., **CO_2**, **REC**, **FOC**, **GDP**, **URB**, **KOFSoGI**, and **KOFEcGI**) are already used by the literature to explain the increase or decrease of air pollution death rate. Nevertheless, the literature explores only the variable **EIP**, making this study innovative compared to others approaching a similar topic. Moreover, the Economic instruments-fiscal/financial incentives policies for developing and using renewable energy sources are considered renewable energy policies as mentioned by International Energy Agency (2021) and Fuinhas et al. (2017). In **Table 2**, all variables are in natural logarithms, and in this analysis, we decided to use the variables in per capita values (e.g., **CO_2**, **REC**, **FOC**, and **GDP**). Indeed, the use of per capita values allows us to mitigate the disparities between the variables caused by population growth over time in the crosses, as cited by Koengkan et al. (2021a) and Kazemzadeh et al. (2021).

In this subsection, we approached the group of countries and the variables used in our study. In the next section, we demonstrate the empirical results and discussions.

4. Empirical results and discussions

This section will present the preliminary and post-estimation tests results, the primary model and the robustness check, and possible explanations for the impacts. In this context, the results from the preliminary tests indicate the presence of serial correlation up to the second-order, where the null hypothesis of Bias-corrected LM-based test can be rejected (see **Table 1A** in the **Appendix**); The presence of low-multicollinearity and cross-sectional dependence of variables of the model (see **Table 2A** in the **Appendix**), and most of the variables present the existence of low correlation under (60%), except for between the variables **FOC** to **CO_2, URB** to **CO_2**, **URB** to **FOC**, and **KOFSoGI** to **FOC** (see **Table 3A** in the **Appendix**). Moreover, the variables **CO_2**, **EIP**, and **FOC** are stationary, and **DRAP**, **GDP**, and **KOFEcGI** are non-stationary. In contrast, the variables **REC**, **URB**, and **KOFSoGI** are stationary when the variables are without trend and non-stationary with the trend. That is, these variables are on the borderline between the I (0) and I (1) orders of integration (see **Table 4A** in the **Appendix**). Additionally, the preliminary tests indicate the presence of fixed effects was found, where the null hypothesis of the Hausman test can be rejected (see **Table 5A** in the **Appendix**).

After realising preliminary tests, it is needed to carry out the panel quantile model regression, and OLS fixed effect. The **0.10**, **0.25**, **0.5**, **0.75**, and **0.90** quantiles were respectively calculated. These quantiles were used to simplify the exhibition of empirical results. **Table 3** below shows the panel quantile model regression results and Pooled OLS fixed effects.

Table 3. Panel quantile model and post-estimation test and Pooled OLS fixed effects

Variables	Dependent variable (DRAP) – Quantiles regression at					OLS
	0.10Q	**0.25Q**	**0.50Q**	**0.75Q**	**0.90Q**	**Fixed Effects**
CO_2	-0.1877 *	-0.1705 **	-0.1501 ***	-0.1289 **	-0.1150	-0.1497 ***
REC	-0.1038 *	-0.1231 ***	-0.1467 ***	-0.1703 ***	-0.1860 ***	-0.1468 ***
EIP	-0.0329	-0.0297 **	-0.0259 ***	-0.0220 **	-0.0194	-0.0259 **
FOC	0.4346 ***	0.3930 ***	0.3434 ***	0.2919 ***	0.2582 ***	0.3424 ***
GDP	-0.3730 ***	-0.3105 ***	-0.2358 ***	-0.1582 **	-0.1074	-0.2341 ***
URB	0.6314 **	0.6540 ***	0.6810 ***	0.7090 ***	0.7274 ***	0.6816 ***
KOFSoGI	-0.3109 **	-0.2847 ***	-0.2534 ***	-0.2208 ***	-0.1996 *	-0.2527 ***
KOFEcGI	0.1802 **	0.1456 ***	0.1043 ***	0.0615 *	0.0334	0.1035 ***
Obs	448	448	448	448	448	448
Post-estimation test for the panel quantile model						
F / Wald test	Chi2(8) = 104.29 ***		Chi2(8) = 174.64 ***		Chi2(8) = 105.50 ***	

Notes: ***,**,* denotes statistically significant at (1%), (5%), and (10%) levels; The Stata commands *xtqreg, xtreg,* and *testparm* were used.

The results from the panel quantile model regression show that in the **0.10**, **0.25**, **0.5**, **0.75**, and **0.90** quantiles, the variables Carbon dioxide emissions (**CO_2**), Electricity consumption from new renewable energy sources (**REC**), Economic instruments-fiscal/financial incentives policies to enable renewable energy deployment and use (**EIP**), Economic growth (**GDP**), and Social Globalisation (**KOFSoGI**) reduces the air pollution deaths (**DRAP**). In contrast, the variables Electricity consumption from non-renewable energy sources (**FOC**), Urbanisation (**URB**), and Economic Globalisation (**KOFEcGI)** encourages the increase of these deaths in the LAC region. To check the robustness of the model, the Pooled OLS fixed effects model has been used. The Pooled OLS fixed effects results show that **CO_2**, **REC**, **EIP**, **GDP**, and **KOFSoGI** causes a decrease in **DRAP**, while **FOC**, **URB**, and **KOFEcGI** has positive effects on an increase in **DRAP**. Comparing the Pooled OLS fixed effects results with Quantile 50th, it can be said that the model results are well confirmed. Moreover, the results from the post-estimation test for the panel quantile model indicates that the model estimator that this study choose is adequate to perform this analysis.

After realising the main model regression, the next step is verifying the robustness of the results. To this end, we added variables, dummies, in the panel quantile model regression (see **Table 4**, below).

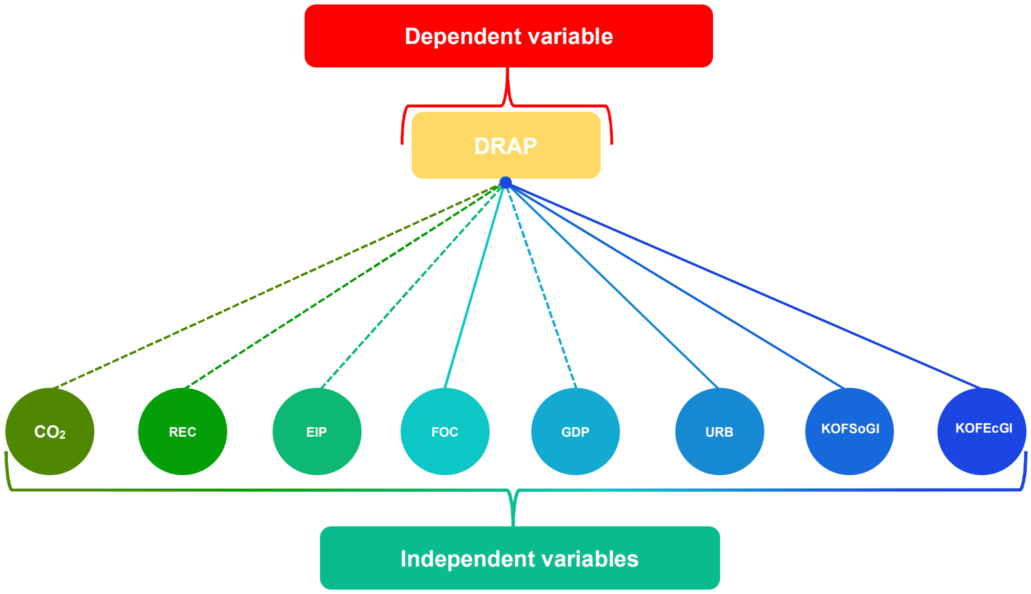
Table 4. Panel quantile model (with dummy variables) and post-estimation test and Pooled OLS fixed effects

Variables	Dependent variable (DRAP) – Quantiles regression at 0.10Q	0.25Q	0.50Q	0.75Q	0.90Q	Pooled OLS Fixed Effects
IDPARAGUAY_2010	0.2530 ***	0.2105 ***	0.1578 ***	0.1047 ***	0.0684	0.1575 *
IDPARAGUAY_2011	0.2092 ***	0.1688 ***	0.1187 ***	0.0681 ***	0.0336 **	0.1184 **
CO_2	-0.1802 *	-0.1655 **	-0.1474 ***	-0.1290 **	-0.1165	-0.1473 ***
REC	-0.1074 **	-0.1255 ***	-0.1480 ***	-0.1708 ***	-0.1863 ***	-0.1482 ***
EIP	-0.0333 *	-0.0301 **	-0.0261 ***	-0.0222 *	-0.0195	-0.0262 **
FOC	0.430 ***	0.3899 ***	03403 ***	0.2902 ***	0.2561 ***	0.3400 ***
GDP	-0.3611 ***	-0.3022 ***	-0.2292 ***	-0.1555 **	-0.1052	-0.2288 ***
URB	0.6218 **	0.6468 ***	0.6779 ***	0.7093 ***	0.7308 ***	0.6782 ***
KOFSoGI	-0.3192 **	-0.2922 ***	-0.2587 ***	-0.2249 ***	-0.2019 *	-0.2585 ***
KOFEcGI	0.1829 **	0.1493 ***	0.1077 ***	0.0658	0.0371	0.1075 ***
Obs	448	448	448	448	448	448
Post-estimation test for the panel quantile model						
F / Wald test	Chi2(8) = 107.90 ***		Chi2(8) = 178.56 ***		Chi2(8) = 107.30 ***	

Notes: ***, **, * denotes statistically significant at (1%), (5%), and (10%) levels; The Stata commands *xtqreg, xtreg* and *testparm* were used.

To verify the robustness of the panel quantile model regression that was carried out before, this investigation opted to add in the model regression dummy variables. These dummies variables represent possible shocks (e.g., economic, pollical, and social) that some LAC countries passed. However, if not considered it, could have produced inaccurate results, which could lead to misinterpretations. Therefore, dummy variables added to the model regression are **IDPARAGUAY_2010** (Paraguay, the year 2010) and **IDPARAGUAY_2011** (Paraguay, the year 2011). These two dummies represent a peak in Paraguay's GDP, wherein in 2010, the country registered a growth of (13%), while in 2011, it was registered an increase of (4.3%) (World Bank Open Data, 2021). Indeed, this rapid growth in economic activity in Paraguay affected consumer behaviour, industrial production, the consumption of energy, and consequently the air pollution.

Therefore, the results from the panel quantile model with dummy variables indicate that in the **0.10**, **0.25**, **0.5**, **0.75**, and **0.90** quantiles, the variables Carbon dioxide emissions (**CO_2**), Electricity consumption from new renewable energy sources (**REC**), Economic instruments-fiscal/financial incentives policies to enable renewable energy deployment and use (**EIP**), Economic growth (**GDP**), and Social Globalisation (**KOFSoGI**) reduces the air pollution deaths (**DRAP**). In contrast, the variables Electricity consumption from non-renewable energy sources (**FOC**) and urbanisation (**URB**) encourage an increase in these deaths in the LAC region. Moreover, the Economic globalisation (**KOFEcGI)** in **0.10**, **0.25**, and **0.5** quantiles, also increase this problem. The Pooled OLS fixed effects results show that **CO_2**, **REC**, **EIP**, **GDP**, and **KOFSoGI** causes a decrease in **DRAP**, while the variables **FOC**, **URB**, and **KOFEcGI** have positive effects on an increase in **DRAP**. These results also confirm the results of the 50th quantile. The dummy variables are statistically significant at (1%) levels, indicating that the approach used, such as adding dummy variables in the model regression, is correct. The results from the post-estimation test for the panel quantile model indicates that the model estimator that this study choose is adequate to perform this analysis. Finally, the results obtained from the model regression confirm that this investigation's results are robust and reliable even in the presence of chocks. Indeed, to summarise the effect of independent variables on dependent ones, ones created in **Figure 2**, below. This figure was based on the results of the panel quantile model.



Negative impact **Positive impact**

Figure 2. Summary of the variable's effect. The authors created this figure.

After to found that the Carbon dioxide emissions (**CO_2**), Electricity consumption from new renewable energy sources (**REC**), Economic instruments-fiscal/financial incentives policies to enable renewable energy deployment and use (**EIP**), Economic growth (**GDP**), and Social Globalisation (**KOFSoGI**) reduces the air pollution deaths (**DRAP**). At the same time, the variables Electricity consumption from non-renewable energy sources (**FOC**), Urbanisation (**URB**), and Economic Globalisation (**KOFEcGI)** encourages the increase of these deaths caused by air pollution in the LAC region, and we raise the following question. **What are the explanations for these effects?**

As shown in **Figure 2**, the effect of carbon dioxide emissions on air pollution deaths rates in the countries under study is negative. The negative signal of CO_2 emissions could seem atypical but reflect the substitution of more dangerous gases by less aggressive ones for human beings in several activities. However, they are CO_2 emitters (e.g., Koengkan et al., 2021a). The period under review was a period of solid technological innovation that reduced the level of pollution associated with the combustion of fossil fuels. It was also a period in which energy use was deepening. This result means that an important part of the pollution, such as fine particle emissions, decreased more intensely than the CO_2 emission. Fuinhas et al. (2017) that studied the effect of renewable energy policies on CO_2 emissions in the LAC region, identify that the renewable energy policies in the region encourage the process of the energy transition by consumption of renewable energy, reducing the consumption of fossil fuels, and consequently reduces the emissions of CO_2. This reduction in CO_2 emissions is reflected in reducing air pollution deaths. Moreover, evidence that the energy transition reduces the consumption of non-renewable energy in the LAC region was found by Koengkan et al. (2021b). According to the author, renewable energy consumption that is a proxy of the energy transition reduces the consumption of fossil fuels. The same authors also add that reducing non-renewable energy sources by consuming renewable energy sources is possible due to the presence of effective renewable energy policies that encourage the development, investment, and consumption of green energy in the region.

This explanation was confirmed using the Pooled OLS fixed effects model regression. **Table 5** below shows the capacity of economic instruments-fiscal/financial incentives policies to encourage the development and consumption of renewable energy sources. Moreover, the results also indicate that the consumption of renewable energy and economic instruments-fiscal/financial incentives policies decrease the consumption of fossil fuels and CO_2 emissions in the LAC region.

Table 5. Pooled OLS fixed effects model regression and post-estimation test

Independent variables	Dependent variable (REC)
EIP	0.0958**
GDP	0.0898***
URB	1.1756***
Constant	4.3257***
Obs	448
Post-estimation test for the Pooled OLS fixed effects model	
F / Wald test	$F_{(3,444)}$ = 60.97***
Independent variables	**Dependent variable (FOC)**
REC	-0.0677***
EIP	-0.2695***
GDP	-0.0622***
URB	2.5894***
KOFSoGI	-2.1868***
KOFEcGI	0.2759***
Constant	-7.1211***
Trend	-0.0075***
Obs	448
Post-estimation test for the Pooled OLS fixed effects model	
F / Wald test	$F_{(6,440)}$ = 405.86***
Independent variables	**Dependent variable (CO_2)**
REC	-0.2733***
EIP	-0.0735***
GDP	-0.0113***
URB	0.1753*
FOC	0.7019***
Constant	-4.9631***
Obs	448
Post-estimation test for the Pooled OLS fixed effects model	
F / Wald test	$F_{(5,442)}$ = 647.92***

Notes: ***, **, * denotes statistically significant at (1%), (5%), and (10%) levels; The Stata commands xt*reg* and *testparm* were used.

According to **Table 3**, electricity consumption from new renewable energy sources on DRAP in all quantiles is negative and significant. In other words, with a (1%) increase in REC, the air pollution deaths decrease by (0.12%) at 0.25th quantile, and higher quantiles, the negative effect of REC on air pollution deaths increases. It can be said that the use of renewable energy sources to generate electricity reduces the emission of carbon dioxide and other pollutants, which can ultimately reduce air pollution deaths.

This finding is consistent with Kharecha and Hansen (2013), Hanif (2018), Taghizadeh-Hesary and Taghizadeh-Hesary (2020), and Koengkan et al. (2021a).

The economic instruments-fiscal/financial incentives policies to enable renewable energy deployment and use have a negative and significant effect on air pollution deaths rate in the LAC region except for the 90th quantile. As shown in **Table 3**, with increasing quantile, the impact of this factor on air pollution deaths is decreased. In other words, the impact of EIP in countries that account for (25%) high of air pollution deaths is lower than those at the lowest levels. In other words, the government's financial incentives policies to enable renewable energy deployment and use cause industries and companies in the countries under study to use clean and environmentally friendly technologies, thus reducing pollutants and, consequently, a decrease in air pollution deaths.

The impact of non-renewable energy sources on air pollution deaths is positive and significant. Electricity consumption from non-renewable energy sources such as oil and gas emits pollutants such as CO_2, SO_2, and NO_x into the air and increases air pollution deaths. This finding is consistent with Mukhopadhyay and Forssell (2005), Machol and Rizk (2013), Lelieveld et al. (2019), Marais et al. (2019), and Rasoulinezhad et al. (2020).

According to the results, the impact of GDP on air pollution deaths is negative and significant except the 90th quantile. It can be argued that increasing GDP and economic growth may be an essential tool for improving countries' infrastructure that reduces mortality. Zhang et al. (2001), Janssen et al. (2006), and Hanif (2018) confirm a negative relationship between GDP and deaths. On the other hand, other studies such as Chaabouni et al. (2016) and Rasoulinezhad et al. (2020) have shown that the impact of GDP on mortality is positive. In fact, in these studies, economic growth may lead to pollutants due to the need to use fossil fuels, endangering human health. Indeed, evidence that the Latin American and Caribbean countries are decarbonisation is found in **Table 5**, where it was found that economic growth reduces emissions. This result is related to the capacity of economic growth to increase the consumption of renewable energy sources.

According to **Table 3**, urbanisation has a positive and significant effect on air pollution deaths in all quantiles. Accordingly, a (1%) increase in urbanisation led to a (0.65%) increase in air pollution deaths in the 25th quantile. An increase in urbanisation means an increase in population, leading to carbon dioxide emissions (e.g., Mansoor and Sultana, 2018; and Dogan and Inglesi-Lotz, 2020). Therefore, CO_2 emissions increase air pollution deaths. This finding confirms that found by Rumana et al. (2014), Liu et al. (2017a), Chen et al. (2017), and Liu et al. (2017b). This explanation is confirmed with results pointed in **Table 5** above, where the urbanisation process increases the consumption of fossil fuels and CO_2 emissions.

According to **Figure 2**, there is an inverse relationship between the Social Globalisation index and the air pollution deaths, so that with the increase of KOFSoGI, the air pollution deaths in the studied countries decreases. In other words, through information and cultural links, social globalisation connects the people of the LAC region countries. Social globalisation enables countries to access new information. New knowledge help reduce energy consumption in production processes, improve environmental quality, and reduce air pollution deaths (e.g., Shahbaz et al., 2018). Indeed, this explanation is confirmed with results pointed in **Table 5** above, where social globalisation reduces the consumption of fossil fuels.

Finally, according to the research findings, the Economic Globalisation index increases air pollution deaths in the countries under study. As economic globalisation connects the economy through trade in goods and services, foreign investment, and financial activities, the expansion of the global economy leads to more energy consumption, resulting in more carbon dioxide emissions, and endangers people's health (e.g., Shahbaz et al. 2015 and Shahbaz et al., 2018). This outcome is linin e with studies in the literature such as Kan (2014). This explanation is confirmed with results pointed in **Table 5** above, where economic globalisation increases the consumption of fossil fuels.

As mentioned before, this section showed the results and their possible explanations for the results found in our empirical investigation. The following section will present the conclusions and possible policy implications.

5. Conclusions and policy implications

A panel quantile model was used to analyse the impact of renewable energy policies (e.g., economic instruments-fiscal/financial incentives policies to enable renewable energy deployment and use) on the death rate provoked by outdoor and indoor air pollution in fifteen countries from the LAC region from 1990 to 2017. Given the complexity of the link between renewables and air pollution, the relationship requires a broad model that must include quite a few control variables. Those variables were identified based on the literature and the phenomenon's economic and social nature under analysis. Thus, to explain the deaths from air pollution were used: (i) carbon dioxide emissions; (ii) electricity consumption from new renewable energy sources; (iii) economic instruments-fiscal/financial incentives policies to enable renewable energy deployment and use; (iv) electricity consumption from non-renewable energy sources; (v) Gross Domestic Production; (vi) urban population rate; (vii) social globalisation index (de facto); and (viii) economic globalisation index (de facto).

The results confirm the nonlinear relationship between the explanatory variables and the explained variable. Provided that deaths rates from air pollution in the LAC region are mainly associated with massive urban centres, much of the analysis applies to that reality. Indeed, the quantiles evolve in a way compatible with the perceived status quo of big cities of The LAC region.

The variables that reduce deaths from air pollution are carbon dioxide emissions, electricity consumption from new renewable energy sources, economic instruments-fiscal/financial incentives policies to enable renewable energy deployment and use, Gross Domestic Production, and the social globalisation index (de facto). Except for electricity consumption from new renewable energy sources, these variables decrease their effect on deaths rates from air pollution as the quantiles increase.

The variables that aggravate the deaths rates from air pollution are electricity consumption from non-renewable energy sources, urban population rate, and economic globalisation index (de facto). Except for the urban population rate, these variables decrease their effect on deaths rates from air pollution as the quantiles increase.

The specific contribution of this research for literature end policy-making and makes it innovative is an analysis of the variable economic instruments-fiscal/financial incentives policies to enable renewable energy deployment and use that is few studied by the literature. As expectable economic instruments-fiscal/financial incentives policies (feed-in tariffs/premiums, grants and subsidies, loans, tax relief, taxes, and user charges) to enable renewable energy deployment and use contributes to decreasing deaths rates from air pollution. Their effect is more intense for lower quantiles supporting that intervention is more effective when health problems are not as severe.

A more subtle effect detected in this research is the negative signal of CO_2 emission on the deaths rates from air pollution. The explanation for this result that could seem atypical indeed is the reflex of two leading causes. First, it reflects the substitution of more dangerous gases to activities less aggressive for humans, but there are CO_2 emitters (Koengkan et al., 2021a). Second, it is also consistent with the switch of massive pollution activities from big cities to other locations less demanding health standards, political pressure that has contributed to the tertiarisation of economic activities in big cities.

Another impressive result is the effect of globalisation on the deaths rates from air pollution. Here was found an opposite influence depending on whether globalisation is social or economic. In both cases, the effect is more pronounced in lower quantiles. The stimulation of interpersonal, informational, and cultural globalisation reduces the deaths rates from air pollution. In contrast, the trade in goods and services and financial and foreign investment globalisation go in a way that aggravates deaths rates from air pollution.

From a policy-making perspective, the combat to mitigate deaths rates from air pollution should intensify the transition from fossil fuels energy to renewable sources that can be magnified by recurring to economic instruments-fiscal/financial incentives policies to enable renewable energy deployment and use. The policymakers should promote the transfer of huge polluters' economic activities to places less populated, and it can take advantage of increasing industrial efficiency that demands more minor and less employment. Policymakers should actively take advantage of social globalisation benefits and limit the hampers made by economic globalisation. Finally, policymakers should stimulate economic growth because this allows access to health services and helps finance the transition to a more unpolluted environment.

References

Agresti, A. (1990). Categorical Data Analysis. John Wiley and Sons, New York. ISBN 0-471-36093-7.

Alatorre, C., Alves, L., Vergara, W. (2013). Rethinking Our Energy Future. A White Paper on Renewable Energy for the 3GFLAC Regional, p. 1-34. URL: https://publications.iadb.org/en/publication/16656/rethinking-our-energy-future-white-paper-renewable-energy-3gflac-regional-forum (Accessed on 26 December 2021).

Belsley, D.A., Kuh, E., Welsch, R.E. (1980). Regression Diagnostics: Identifying Influential Data and Sources of Collinearity. Wiley Series in Probability and Statistics, New York, p.1-26. https://doi.org/10.1002/0471725153.

Blackman, A., Harrington, W. (2000). The use of economic incentives in developing countries: Lessons from international experience with industrial air pollution. The Journal of Environment and Development, 9(1):5-44. https://doi.org/10.1177/107049650000900102.

Born, B., Breitung, J. (2015). Testing for Serial Correlation in Fixed-Effects Panel Data Models. Econometric Reviews, 35(7):1290-1316. https://doi.org/10.1080/07474938.2014.976524.

Breusch, T.S, Pagan, A.R. (1980). The Lagrange multiplier test and its applications to model specification in econometrics. The Review of Economic Studies, 47(1):239-253. URL: https://www.jstor.org/stable/pdf/2297111.pdf (Accessed on 26 December 2021).

Bruvoll, A., Larsen, B. M. (2004). Greenhouse gas emissions in Norway: do carbon taxes work?. Energy Policy, 32(4):493-505. https://doi.org/10.1016/S0301-4215(03)00151-4.

Cao, H-X., Qi, Y., Chen, J., Shao, S., Lin, S. (2021). Incentive and coordination: Ecological fiscal transfers' effects on eco-environmental quality. Environmental impact assessment review, 87:106518. https://doi.org/106510.101016/j.eiar.102020.106518.

Cao, J., Ho, M., Jorgenson, D. (2008). "Co-benefits" of greenhouse gas mitigation policies in china: an integrated top-down and bottom-up modelling analysis. Retrieved from URL: http://www.rff.org/RFF/documents/EfD-DP-08-10.pdf (Accessed on 26 December 2021).

Chaabouni, S., Zghidi, N., Mbarek, M.B. (2016). On the causal dynamics between CO2 emissions, health expenditures and economic growth. Sustainable Cities and Society, 22:184-191. https://doi.org/10.1016/j.scs.2016.02.001.

Chen, W., Zheng, R., Zhang, S., Zeng, H., Zuo, T., Xia, C., He, J. (2017). Cancer incidence and mortality in China in 2013: an analysis based on urbanisation level. Chinese Journal of Cancer Research, 29(1):1-10. https://doi.org/10.21147/j.issn.1000-9604.2017.01.01.

Dapper, S.N., Spohr, C., Zanini, R.R. (2016). Poluição do ar como fator de risco para a saúde: uma revisão sistemática no estado de São Paulo. Estudos Avançados, 86:83-97. http://dx.doi.org/10.1590/S0103-40142016.00100006.

Davis, L.W., Kilian, L. (2009). Estimating the effect of a gasoline tax on carbon emissions. National Bureau of Economic Research, p.1-14.URL: https://www.nber.org/papers/w14685 (Accessed on 26 December 2021).

Dogan, E., Inglesi-Lotz, R. (2020). The impact of economic structure to the environmental Kuznets curve (EKC) hypothesis: evidence from European countries. Environmental Science and Pollution Research, 27:12717–12724.doi:https://doi.org/10.1007/s11356-020-07878-2.

Droste, N., Ring, I., Santos, R., Kettunen, M. (2018). Ecological fiscal transfers in Europe–Evidence-based design options for a transnational scheme. Ecological Economics, 147:373-382. https://doi.org/310.1016/j.ecolecon.2018.1001.1031.

Floros, N., Vlachou, A. (2005). Energy demand and energy-related CO2 emissions in Greek manufacturing: Assessing the impact of a carbon tax. Energy Economics, 27(3):387-413. https://doi.org/310.1016/j.eneco.2004.1012.1006.

Fuinhas, J.A. Marques, A.C., Koengkan, M. (2017). Are renewable energy policies upsetting carbon dioxide emissions? The case of Latin America countries. Environmental Science and Pollution Research, 24(17):15044–15054. https://doi.org/10.1007/s11356-017-9109-z.

Fuinhas, J.A., Koengkan, M., Leitão, N.C., Nwani, C., Uzuner, G., Dehdar, F., Relva, S., Peyerl, D. (2021). Effect of Battery Electric Vehicles on Greenhouse Gas Emissions in 29 European Union Countries. Sustainability, 13:13611. https://doi.org/10.3390/su132413611.

Granger, C.W.J. (1981). Some Properties of Time Series Data and Their Use in Econometric Model Specification. Journal of Econometrics, 28:121-130. https://doi.org/10.1016/0304-4076(81)90079-8.

Greene, W. (2002). Econometric Analysis. Saddle River, New Jersey: Prentice-Hall, p.1-828. URL: https://spu.fem.uniag.sk/cvicenia/ksov/obtulovic/Mana%C5%BE.%20%C5%A1tati stika%20a%20ekonometria/EconometricsGREENE.pdf (Accessed on 26 December 2021).

Guo, Z., Zhang, X., Zheng, Y., Rao, R. (2014). Exploring the impacts of a carbon tax on the Chinese economy using a CGE model with a detailed disaggregation of energy sectors. Energy Economics, 45:455-462. https://doi.org/410.1016/j.eneco.2014.1008.1016.

Halkos, G. E., Paizanos, E. A. (2016). The effects of fiscal policy on CO2 emissions: evidence from the USA. Energy Policy, 88:317-328. https://doi.org/310.1016/j.enpol.2015.1010.1035.

Hanif, I. (2018). Energy consumption habits and human health nexus in Sub-Saharan Africa. Environmental Science and Pollution Research, 25(22):21701-21712. https://doi.org/10.1007/s11356-018-2336-0.

Harring, N. (2014). Corruption, inequalities and the perceived effectiveness of economic pro-environmental policy instruments: A European cross-national study. Environmental Science and Policy, 39:119-128. https://doi.org/110.1016/j.envsci.2013.1008.1011.

Ike, G.N., Usman, O., Sarkodie, S.A. (2020). Fiscal policy and CO2 emissions from heterogeneous fuel sources in Thailand: evidence from multiple structural breaks cointegration test. Science of the Total Environment, 702:134711. https://doi.org/134710.131016/j.scitotenv.132019.134711.

International Energy Agency (IEA) (2021). Database.URL: https://www.iea.org/energyaccess/database/(Accessed on 26 December 2021).

Janssen, F., Kunst, A. E., Mackenbach, J. P. (2006). Association between gross domestic product throughout the life course and old-age mortality across birth cohorts: parallel analyses of seven European countries, 1950–1999. Social Science and Medicine, 63(1):239-254. https://doi.org/10.1016/j.socscimed.2005.11.040.

Johansen, J., Juselius, K. (1990). Maximum Likelihood Estimation and Inference on Cointegration-with Applications to the Demand for Money. Oxford Bulletin of Economics and Statistics, 52(2):169-210. https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x.

Jorgenson, D. W., Wilcoxen, P. J. (1993). Reducing US carbon dioxide emissions: an assessment of different instruments. Journal of Policy Modeling, 15(5-6):491-520. https://doi.org/410.1016/0161-8938(1093)90003-90009.

Kan, H. (2014). Globalisation and environmental health in China. The Lancet, 384(9945):721-723. https://doi.org/10.1016/S0140-6736(14)60957-0.

Katircioglu, S., Katircioglu, S. (2018). Testing the role of fiscal policy in the environmental degradation: the case of Turkey. Environmental Science and Pollution Research, 25(6):5616-5630. https://doi.org/5610.1007/s11356-11017-10906-11351.

Kazemzadeh, E., Fuinhas, J.A., Koengkan, M. (2021). The impact of income inequality and economic complexity on ecological footprint: an analysis covering a long-time span. Journal of Environmental Economics and Policy, p.1-22.doi: https://doi.org/10.1080/21606544.2021.1930188.

Kharecha, P.A., Hansen, J.E. (2013). Prevented mortality and greenhouse gas emissions from historical and projected nuclear power. Environmental Science and Technology, 47(9):4889-4895. https://doi.org/10.1021/es3051197.

Kim, Y.-D., Han, H.-O., Moon, Y.-S. (2011). The empirical effects of a gasoline tax on CO2 emissions reductions from transportation sector in Korea. Energy Policy, 39(2):981-989. https://doi.org/910.1016/j.enpol.2010.1011.1026.

Koengkan, M., Fuinhas, J.A., Silva, N. (2021a). Exploring the capacity of renewable energy consumption to reduce outdoor air pollution death rate in Latin America and the Caribbean region. Environmental Science and Pollution Research, p.1-19. https://doi.org/10.1007/s11356-020-10503-x.

Koengkan, M., Fuinhas, J.A.,Vieira, I. (2021b). The Reaction of the Consumption of Fossil Fuels to Trade Openness in Latin America and the Caribbean Countries. Revista de Estudos Sociais, 22(45):1-23. https://doi.org/10.19093/res10861.

KOF Globalization index (2021). KOF Globalization index. URL: https://www.kof.ethz.ch/en/forecastsand-indicators/indicators/kof-globalisation-index.html (Accessed on 26 December 2021).

Kosonen, K., Nicodème, G. (2009). The role of fiscal instruments in environmental policy. CESifo Working Paper Series No. 2719. URL: https://ssrn.com/abstract=1437501 (Accessed on 26 December 2021).

Lelieveld, J., Klingmüller, K., Pozzer, A., Burnett, R. T., Haines, A., Ramanathan, V. (2019). Effects of fossil fuel and total anthropogenic emission removal on public health and climate. Proceedings of the National Academy of Sciences, 116(15):7192-7197. https://doi.org/10.1073/pnas.1819989116.

Li, S.-J., Chang, T.-H., Chang, S.-L. (2017). The policy effectiveness of economic instruments for the photovoltaic and wind power development in the European Union. Renewable Energy, 101:660-666. https://doi.org/610.1016/j.renene.2016.1009.1005.

Lin, B., Li, X. (2011). The effect of carbon tax on per capita CO2 emissions. Energy Policy, 39(9):5137-5146. https://doi.org/5110.1016/j.enpol.2011.5105.5050.

Liu, M., Huang, Y., Jin, Z., Ma, Z., Liu, X., Zhang, B., Kinney, P. L. (2017a). The nexus between urbanisation and PM2. 5 related mortality in China. Environmental Pollution, 227:15-23. https://doi.org/10.1016/j.envpol.2017.04.049.

Liu, M., Huang, Y., Ma, Z., Jin, Z., Liu, X., Wang, H., Kinney, P. L. (2017b). Spatial and temporal trends in the mortality burden of air pollution in China: 2004–2012. Environment International, 98:75-81. https://doi.org/10.1016/j.envint.2016.10.003.

Liu, Z., Mao, X., Tu, J., Jaccard, M. (2014). A comparative assessment of economic-incentive and command-and-control instruments for air pollution and CO2 control in China's iron and steel sector. Journal of Environmental Management, 144:135-142. https://doi.org/110.1016/j.jenvman.2014.1005.1031.

López, R., Palacios, A. (2014). Why has Europe become environmentally cleaner? Decomposing the roles of fiscal, trade and environmental policies. Environmental and Resource Economics, 58(1):91-108. https://doi.org/110.1007/s10640-10013-19692-10645.

Machado, J.A.F., Silva, J.M.C.S. (2019). Quantiles via Moments. Journal of Econometrics. Journal of Econometrics, 213(1):145-173. https://doi.org/10.1016/j.jeconom.2019.04.009Get.

Machol, B., Rizk, S. (2013). Economic value of US fossil fuel electricity health impacts. Environment International, 52:75-80. https://doi.org/10.1016/j.envint.2012.03.003.

Mansoor, A., Sultana, B. (2018). Impact of Population, GDP and Energy Consumption on Carbon Emissions: Evidence from Pakistan Using an Analytic Tool IPAT. Asian Journal of Economics and Empirical Research, 5(2):183-190. https://doi.org/10.20448/journal.501.2018.52.183.190.

Mao, X., Yang, S., Liu, Q., Tu, J., Jaccard, M. (2012). Achieving CO2 emission reduction and the co-benefits of local air pollution abatement in the transportation sector of China. Environmental Science and Policy, 21:1-13. https://doi.org/10.1016/j.envsci.2012.03.010., 1-13.

Marais, E. A., Silvern, R. F., Vodonos, A., Dupin, E., Bockarie, A. S., Mickley, L. J., Schwartz, J. (2019). Air quality and health impact of future fossil fuel use for electricity generation and transport in Africa. Environmental Acience and Technology, 53(22):13524-13534. https://doi.org/10.1021/acs.est.9b04958.

Mukhopadhyay, K., Forssell, O. (2005). An empirical investigation of air pollution from fossil fuel combustion and its impact on health in India during 1973–1974 to 1996–1997. Ecological Economics, 55(2):235-250. https://doi.org/10.1016/j.ecolecon.2004.09.022.

Nathaniel, S. P., Nwulu, N., Bekun, F. (2021). Natural resource, globalization, urbanization, human capital, and environmental degradation in Latin American and Caribbean countries. Environmental Science and Pollution Research, 28(5):6207-6221. https://doi.org/10.1007/s11356-020-10850-9.

Nordhaus, W. D. (2007). To tax or not to tax: Alternative approaches to slowing global warming. Review of Environmental Economics and Policy, 1(1):26-44. https://doi.org/10.1093/reep/rem1008.

Our World in Data (2021). Air pollution. URL: https://ourworldindata.org/air-pollution (Accessed on 26 December 2021).

Pearce, D. (1991). The role of carbon taxes in adjusting to global warming. The Economic Journal, 101(407):938-948. https://doi.org/910.2307/2233865.

Pesaran, M.H. (2004). General diagnostic tests for cross-section dependence in panels. The University of Cambridge, Faculty of Economics. Cambridge Working Papers in Economics, n. 0435. https://doi.org/10.17863/CAM.5113.

Pesaran, M.H. (2007). A simple panel unit root test in the presence of cross-section dependence. Journal of Applied Econometrics, 22(2):256–312. https://doi.org/ 10.1002/jae.951.

Postula, M., Radecka-Moroz, K. (2020). Fiscal policy instruments in environmental protection. Environmental Impact Assessment Review, 84:106435. https://doi.org/106410.101016/j.eiar.102020.106435.

Qiu, R., Xu, J., Xie, H., Zeng, Z., Lv, C. (2020). Carbon tax incentive policy towards air passenger transport carbon emissions reduction. Transportation Research Part D: Transport and Environment, 85:102441. https://doi.org/102410.101016/j.trd.102020.102441.

Rasoulinezhad, E., Taghizadeh-Hesary, F., Taghizadeh-Hesary, F. (2020). How is mortality affected by fossil fuel consumption, CO2 emissions and economic factors in the CIS region?. Energies, 13(9):2255. https://doi.org/10.3390/en13092255.

Ring, I. (2002). Ecological public functions and fiscal equalisation at the local level in Germany. Ecological Economics, 42(3):415-427. https://doi.org/410.1016/S0921-8009(1002)00124-00126.

Rocher, C.L. (2017). Linear and nonlinear relationships between interest rate changes and stock return: International evidence. Universidad de Valencia, Working Paper, 17(16):119: URL:https://www.uv.es/bfc/TFM2017/16%20Carlos%20Lopez%20Rocher.pdf. (Accessed on 26 December 2021).

Rumana, H. S., Sharma, R. C., Beniwal, V., Sharma, A. K. (2014). A retrospective approach to assess human health risks associated with growing air pollution in urbanised area of Thar Desert, western Rajasthan, India. Journal of Environmental Health Science and Engineering, 12(1):1-9. https://doi.org/10.1186/2052-336X-12-23.

Salehnia, N., Alavijeh, N. K., Salehnia, N. (2020). Testing Porter and pollution haven hypothesis via economic variables and CO2 emissions: a cross-country review with panel quantile regression method. Environmental Science and Pollution Research, 27(25):31527-31542. https://doi.org/10.1007/s11356-020-09302-1.

Shahbaz, M., Bhattacharya, M., Ahmed, K. (2015). Growth-globalization-emissions nexus: the role of population in Australia. Department of Economics Discussion Paper Series (discussion paper 23–15). Monash University Clayton, Australia.URL: http://www.buseco.monash.edu.au/eco/research/paper ... shahbazmitaahmed.pdf (Accessed on 26 December 2021).

Shahbaz, M., Shahzad, S. J. H., Mahalik, M. K., Hammoudeh, S. (2018). Does globalisation worsen environmental quality in developed economies?. Environmental Modeling and Assessment, 23(2):141-156. https://doi.org/10.1007/s10666-017-9574-2.

Shmelev, S.E., Speck, S.U. (2018). Green fiscal reform in Sweden: econometric assessment of the carbon and energy taxation scheme. Renewable and Sustainable Energy Reviews, 90:969-981. https://doi.org/910.1016/j.rser.2018.1003.1032.

Stelling, P. (2014). Policy instruments for reducing CO2-emissions from the Swedish freight transport sector. Research in Transportation Business and Management, 12:47-54. https://doi.org/10.1016/j.rtbm.2014.1008.1004.

Taghizadeh-Hesary, F., Taghizadeh-Hesary, F. (2020). The impacts of air pollution on health and economy in Southeast Asia. Energies, 13(7):1812. https://doi.org/10.3390/en13071812.

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/410.1016/j.energy.2015.1005.1067.

Wang, P. (2020). China's air pollution policies: progress and challenges. Current Opinion in Environmental Science and Health, 100227. https://doi.org/100210.101016/j.coesh.102020.100227.

Wooldridge, J.M. (2002). Econometric analysis of cross-section and panel data. The MIT Press Cambridge, Massachusetts London, England, p.1-1096. ISBN: 9780262232586.

World Bank Open Data. (2021). Database. URL: http://www.worldbank.org/.(Accessed on 26 December 2021).

Xie, Y., Wu, D., Zhu, S. (2021). Can new energy vehicles subsidy curb the urban air pollution? Empirical evidence from pilot cities in China. Science of the Total Environment, 754:142232. https://doi.org/142210.141016/j.scitotenv.142020.142232.

Yuelan, P., Akbar, M. W., Hafeez, M., Ahmad, M., Zia, Z., Ullah, S. (2019). The nexus of fiscal policy instruments and environmental degradation in China. Environmental Science and Pollution Research, 26(28):28919-28932. https://doi.org/28910.21007/s11356-28019-06071-28914.

Zhang, J., Zhang, J., Lee, R. (2001). Mortality decline and long-run economic growth. Journal of Public Economics, 80(3):485-507. https://doi.org/10.1016/S0047-2727(00)00122-5.

Zimmer, A.,Koch, N. (2017). Fuel consumption dynamics in Europe: Tax reform implications for air pollution and carbon emissions. Transportation Research Part A: Policy and Practice, 106: 22-50. https://doi.org/10.1016/j.tra.2017.1008.1006.

Appendix

Table 1A. Bias-corrected LM-based test

Variables	LM (k)-stat
DRAP	3.01 ***
CO_2	6.40 ***
REC	4.73 ***
EIP	4.38 ***
FOC	6.02 ***
GDP	5.14 ***
URB	2.88 ***
KOFSoGI	7.79 ***
KOFEcGI	7.34 ***

Notes: *** denotes statistical significance at (1%) level; Under H0, LM(k) ~ N(0,1); The Stata command *xtqptest* was used.

Table 2A. VIF-and Pesaran CD-tests

Variables	VIF	1/VIF	Mean VIF	CD-test	p-value
DRAP	N.A			10.99	***
CO_2	8.45	0.1183		32.37	***
REC	2.31	0.4324		24.16	***
EIP	1.89	0.5285		42.49	***
FOC	15.68	0.0637	**5.06**	50.39	***
GDP	1.65	0.6070		50.89	***
URB	4.43	0.2258		45.94	***
KOFSoGI	4.40	0.2271		56.71	***
KOFEcGI	1.67	0.5991		26.10	***

Notes: *** denotes statistical significance at (1%) level; N.A denotes not available; The Stata commands *vif* and *xtcd* of Stata were used.

Table 3A. Pairwise correlation test

	DRAP	CO_2	REC	EIP	FOC	GDP	URB	KOFSoGI	KOFEcGI
DRAP	1.0000								
CO_2	0.5591	1.0000							
REC	-0.3214	-0.0015	1.0000						
EIP	-0.0172	-0.0737	0.0698	1.0000					
FOC	0.3256	0.8769	0.3406	0.0300	1.0000				
GDP	-0.4207	-0.1583	0.4184	-0.0970	0.0122	1.0000			
URB	0.3686	0.7036	0.3884	0.0973	0.8358	0.1391	1.0000		
KOFSoGI	-0.0530	0.4384	0.3261	0.4457	0.6271	0.2123	0.4576	1.0000	
KOFEcGI	-0.2670	0.0058	0.2467	0.2467	0.1444	0.1749	0.0231	0.5487	1.0000

Notes: The Stata command *pwcorr* was used.

Table 4A. Panel Unit Root test (CIPS-test)

Variables	Panel Unit Root test (CIPS) (Zt-bar)				
	Without trend			With trend	
	Lags	Zt-bar		Zt-bar	
DRAP	1	2.107		-0.767	
CO_2	1	-4.009	***	-2.076	**
REC	1	-2.051	**	0.136	
EIP	1	-2.636	***	-3.072	***
FOC	1	-3.530	***	-2.182	***
GDP	1	1.653		1.777	
URB	1	-2.341	***	0.456	
KOFSoGI	1	-3.182	***	-1.274	
KOFEcGI	1	-1.199		-0.743	

Notes: ***, ** denotes statistically significant at (1%) and (5%) level; The Stata command *multipurt* was used; The null for CIPS test is: series have unit root; the lag length (1) and trend were used in this test.

Table 5A. Hausman test

chi2(8) = 31.51 ***

Notes: *** denotes statistically significant at the (1%) level; Hausman results for H_0: difference in coefficients not systematic; The Stata command *hausman* (with the options *sigmamore*) was used.

Highlights

- Effect of renewable energy policies on deaths from air pollution on LAC countries.
- Renewable energy policies reduce deaths from air pollution.
- The CO_2 emissions and new renewable energy sources reduce the deaths.
- Fossil fuels consumption, urbanisation, and economic globalisation increase deaths.