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Environmental Quality and its Human Health Effects: A Causal Analysis for the EU-25

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Abstract: Life expectancy at birth is one of the important key indicators of population health and economic development of a country. Life expectancy has increased rapidly due to onset of industrialization and modernization in the world. On the other hand, along with a high population growth in the world the fact that the deterioration of the environmental quality is related to serious human health issues is reason that the relationship between environmental quality and health is investigated both by many researchers and by policy makers. The main objective of this study was to determine whether there exists a causal relationship between environment and health for EU countries. The analysis shows that there exists causal relationships among health, education and environmental quality, is proxied by carbon dioxide emissions in terms of consumption coal, natural gas and petroleum. This also shows that environmental quality could be considered as a constraint for economic growth, is related to the causes of education and the quality of human life in EU-25 member countries.

Keywords: CO_2 emissions, health expenditure, education, life expectancy, panel data analysis, panel causality
JEL Classification: C33, I10, O52, Q5

1. Introduction

The increasing deterioration in environmental quality across the world is bringing out serious challenge to healthy living along with the increasing threat of global warming. Given the current debates on global warming, environmental problems, the relationship between the environment and health outcomes are getting more attention for economic policy makers. Environmental consequences of global warming and greenhouse gas emissions increase the concerns of the consumption of fossil fuels. Environmentalists as well as policy makers are concerned about the air pollution. Especially, air pollution from rapid industrialization and the use of energy has been recognized to be a cause of serious health problem. Particularly, sulphur dioxide and carbon dioxide emissions from burning of fossil fuels are contributing significantly to pollution. In fact carbon dioxide, a greenhouse gas is considered to be a major contributor to global climate change, which has been a topical issue among policy makers and focus of quite a number of researches across different fields of study (Odusanya et al. 2014).

The economic approach considers the CO_2 emission as the logical consequence of industrial activities which, although they are polluting, they are creating added values, and therefore they are a guarantee of strong economic growth. Hence, it has generally seemed that most studies have focused on the trade-off between economic growth and CO_2 emissions. However, the impacts of environment degradation on human health affect society both in terms of loss of quality of life and in terms of expenditure on health care. So, health care expenditures due to environmental degradation are substantial and the studies examining

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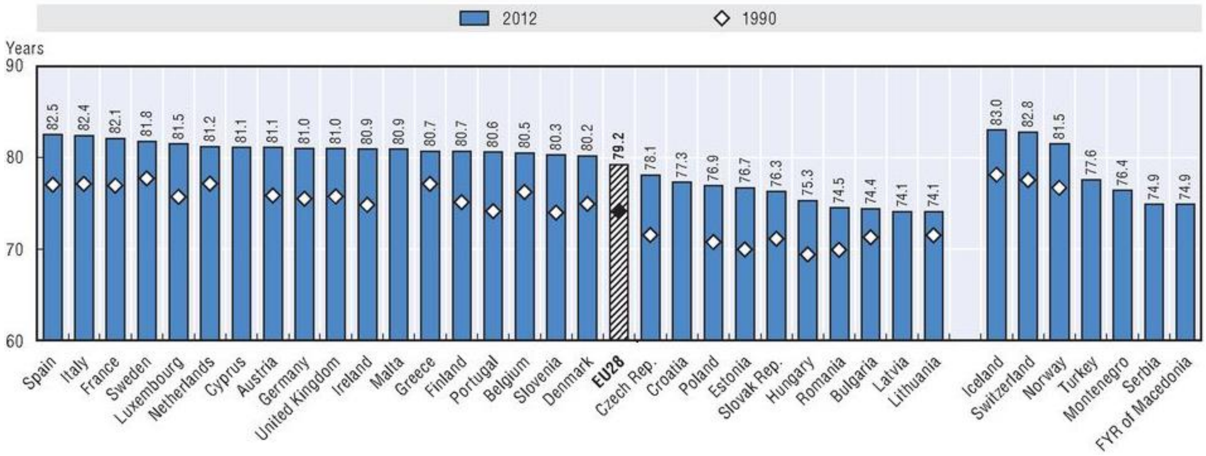
the impact of CO_2 emissions, health expenditure and education on life expectancy are relatively rare and recent.

In this article, it is taken the carbon dioxide emissions as a proxy variable for environmental quality, and it is analyzed the presence of the causality relationships among the carbon dioxide emissions in terms of the source of consumption, total health expenditures, educational attainment and total life expectancy at birth for the EU countries.

The graph (1) allows us to follow the evolution of total life expectancy at birth in the 28 EU member countries for the years 1990 and 2012. Life expectancy, which is an estimate of an individual's life span derived from averaging the age all individuals who die in a particular year, has increased rapidly and human aging seems to be postponed since the onset of industrialization and modernization in the world as seen by EU countries. Life expectancy at birth across the 28 EU member countries reached 79,2 years on average in 2012, an increase of 5,1 years since 1990 (Figure 1). A marked reduction in mortality from cardiovascular diseases, particularly among people aged 50 to 65 is the one of important reasons of these gains in longevity. Moreover, improved living conditions, better education and greater access to quality health services have been attributed to these gains in longevity (OECD 2014).

Figure 1. Life expectancy at birth, 1990 and 2012



Source: OECD, 2014.

The rest of this article is organized in five sections. Section 2 reviews the literature on the relationship between health and environment. Section 3 is devoted to the empirical design, presents the information about the data set and the empirical methodology. Section 4 presents the empirical results and Section 5 concludes the paper.

2. An Overview of the Literature

In this section, we reviewed the literature on the links among environment quality, education, the health input and the health output. The review of the literature can be divided into three research categories. The first one has tried to test the effect of the environment on the health. The second has tried to test the effect of the health on the environment. The third component has attempted to establish a dynamic relationship between health inputs and health outputs.

Regarding the first research component we can refer to the work of Chen and Ching (2000) who investigated the effects of some economic and social variables on life expectancy at birth in 146 countries. Their empirical findings exerted that life expectancy is positively correlated to GNP per capita, population growth, fertility, enrollment and access to safe water and negatively correlated to AIDS, tuberculosis, forest and woodland percentage and rate of deforestation.

Berger and Messer (2002) considered per capita health expenditures, per capita tobacco consumption, alcohol consumption per person aged 15 and over, education, female labor force participation rate, total health expenditures that are publicly financed in order to determine the factors affecting mortality rate per 1000 population for 20 OECD countries from 1960-92. Their estimation results showed that increases in female labor force participation rate, tobacco use per capita, alcohol consumption and health expenditures that are publicly financed are associated with higher mortality rates while higher education levels and increases in total health expenditures are associated with lower mortality rates.

Jerrett et al. (2003) examined the link between environmental quality and health care spending. Using cross-sectional data from 49 counties of Canada, the authors concluded that counties with higher pollution have higher the per capita health expenditures and counties with more environmental budget, significantly pay lower health expenditures.

Narayan and Narayan (2008) investigated the relationship between per capita health expenditures and carbon monoxide emissions, sulphur oxide emissions and nitrogen oxide emissions as proxy variables of environmental quality in eight OECD countries for the period 1980-99 in both short-run and long-run. Taking a panel cointegration approach, the authors found that all selected variables are cointegrated in long-run. In addition, they found that carbon monoxide emissions and sulphur oxide emissions have positive effect on health expenditure.

Similarly to Declerc et al. (2011), who showed that life expectancy would increase up to 22 months if the major European cities can reduce air pollutions, Chenaet et al. (2012) found that there is a negative correlation between longevity and the environmental degradation (Fakhri et al. 2015).

Assadzadeh et al. (2014) examined the role of environmental quality and life expectancy in determining per capita health expenditures in OPEC countries for the period 2000-2010. They found that an increase in carbon dioxide emissions increases health expenditures, while a rise in life expectancy at birth decreases health expenditures in short-run.

Taking into account ARDL approach, Yazdi et al. (2014) examined the role of environmental quality and income in determining health expenditures from 1967 to 2010 in Iran. They found that income, health expenditures and the pollutants such as sulphur oxide emissions and carbon monoxide emissions are cointegrated in long-run. Moreover, their empirical findings showed that income and the pollutants are correlated with health expenditures in both short-run and long-run.

Odusanya et al. (2014) examined the effect of per capita carbon dioxide emission on real per capita health expenditures in Nigeria from 1960 to 2011. They concluded that as carbon dioxide emission increases, health expenditures significantly increase both in long-run and short-run. Analyzing the causal relationship between environmental degradation and mortality rates for India during 1971-2010, Sinha (2014) found out that there exists bi-directional causal relationship between infant mortality rate and growth in carbon dioxide emission and between growth in gross capital formation and child mortality rate.

Regarding the second category, a series of studies was interested by analyzing the effect of the health on environment. Although the studies that have examined the impact of the health on the environment are relatively rare, we can refer to the work of Fakhri et al. (2015) investigating the determinants of carbon dioxide emissions in ten MENA countries from 1990 to 2010. Using energy consumption, GDP per capita, life expectancy and the percentage of urban population relatively to the overall population as independent variables, the study showed that the carbon dioxide emission is positively related to energy consumption and negatively related to life expectancy.

Regarding the third category, we can refer to those of Nixon (2000), Kim and Lane (2013), Deshpande et al. (2014) and Jaba et al. (2014). Nixon (2000) aimed at responding to the question of whether a causal relationship between health input and health outcome exists in 16 European Union countries for the period 1960-95. The empirical findings of the study suggested that infant mortality reduces with increasing healthcare expenditure and life expectancy for females increases.

Kim and Lane (2013) considered infant mortality rate, life expectancy and government health expenditure in order to empirically analyze the relationship between public health expenditure and national health outcomes in 17 developed countries between 1973 and 2000. The results of the study showed a negative relationship between government health expenditure and infant mortality rate and a positive relationship between government health expenditure and life expectancy.

The study by Deshpande et al. (2014) examined whether or not there is a relationship between healthcare expenditure and national life expectancy in 181 developed and developing nations. Empirical results of the study showed that there is no significant correlation between healthcare expenditure and life expectancy in developing countries, but it does exist in developed countries. So, they interpreted this finding as confirmation that in developing countries, money is not allocated effectively towards health spending, but in developed countries, the spending may be more efficient and thus more effective than developing countries.

Similarly, Jaba et al. (2014) analyzed the relationship between the dynamics of the inputs and the outputs of healthcare systems. Applying panel data analysis for 175 countries from 1995 to 2010, the authors found that health expenditures as a input of the healthcare system have a significant positive impact on the health outcome, namely on life expectancy at birth.

Consequently, these mixed empirical evidences including the relationship between health input and health output suggest that health expenditure effects on life expectancy may differ between countries, due to differences in population and economic factors that modify the expenditure effects (Obrizan and Wehby 2012).

3. Methods

To test the presence of the causality relationships among of life expectancy at birth, carbon dioxide emissions in terms of the source of consumption, total health expenditures, education, it has been selected a sample of 25 EU member countries (Austria, Belgium, Bulgaria, Czech

Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Sweden and United Kingdom) covering the period 1995 to 2013.

Econometric specification and data

This research is based on the following equation, in which the explanatory variables were selected from a varied literature:

$$LEXP = f\,(CO_2\_coal,\ CO_2\_nat,\ CO_2\_pet,\ HEX,\ EDU)$$

The variables used in this study are:

LEXP: Life expectancy is representing of the quality of life in a country, since individuals can hope to live longer, fuller lives. It has chosen life expectancy as a general indicator of health for a country. It is an estimate of an individual's life span derived from averaging the age all individuals who die in a particular year (Chen and Ching 2000). The data were collected from World Bank’s Worldwide Governance Indicators database.

CO_2: Carbon dioxide emissions, measured on metric tons per capita, are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. In this study, we analyzed the effect of CO_2 emissions on life expectancy by dividing into the three consumption areas, which are CO_2 emissions from the consumption of coal (CO_2_coal), from the consumption of natural gas (CO_2_nat) and from the consumption of petroleum (CO_2_pet). Greater carbon dioxide emissions are associated with more air pollution, which leads to health issues involving the lungs, heart and cardiopulmonary system (Davidson 2003). Countries with higher levels of carbon dioxide emissions would also likely tolerate higher levels of other harmful chemicals and pollutants, further increasing the risk of health problems among its citizens. Thus, we would expect that as carbon dioxide emissions increases, life expectancy will decrease. The data were collected from U.S. Energy Information Administration.

HEX: Health is one of the most critical development issues facing the world today. HEX variable is represented by total health expenditure, which is the sum of public and private health expenditure. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation (World Bank 2015). We expect that if a state is spending money on a good or service, it is allocating itself a necessary resource. Because of this, we would assume that, logically, healthcare expenditure would result in some kind of health benefit (Desphande et al. 2014). Thus, we expect an increase in healthcare expenditure to indicate a higher quality of health, quantified in our model through the use of life expectancy. The data were collected from World Bank’s Worldwide Governance Indicators database.

EDU: An average year of schooling of adults is defined as the average number of years a person in a given country aged 25 and over has spent in school. Data for this variable were obtained from a paper by Robert Barro and Jong-Wha Lee entitled “International Data on Educational Attainment: Updates and Implication.” It has been shown that individuals with more education earn higher real wages. Greater real wages mean average household income is higher, enabling people to increase the quality and quantity of the healthcare services they purchase. Moreover, people with more education can better comprehend information about proper nutrition, hygiene, and healthcare services, as well as common illness-preventative measures (Kossis 2010). Thus, we would expect that as average years of school increases, life expectancy will increase.

Table (1) will give us the overall descriptive statistics of all variables in the model for the 25 EU member countries.

Table 1 Global Descriptive Statistics

	LEXP	**HEX**	**CO_2_coal**	**CO_2_nat**	**CO_2_pet**	**EDU**
Mean	76.65133	8.038266	46.68339	37.54605	78.82696	10.04124
Median	77.59878	7.953187	18.56846	12.96172	32.19005	9.990000
Std. Dev.	3.457443	1.790092	73.51800	52.71168	97.47441	1.276764
Probability	0.000000	0.017339	0.000000	0.000000	0.000000	0.043434

Cross-sectional dependency test

The first stage of this study, before investigating the presence of the causality relationships among the health indicators and the environmental quality is finding the cross sectional dependency or independency across countries. This type of correlation may arise from common global shocks with different impacts across countries (Samadi and Rad 2013). Various tests, such as Breusch-Pagan test, and Pesaran (2004) CD tests, are used to test for cross sectional dependency.

In this study, Pesaran (2004)'s CD_{LM} test was applied to control cross-sectional dependence among the selected countries. The test statistics can be calculated through the below panel data model:

$$y_{it} = \alpha_i + \beta_i'.x_{it} + \mu_{it} \quad \text{for i=1,2,…,N;} \quad \text{t=1,2,…,T} \tag{1}$$

The test statistics, developed by Pesaran (2004) is as follows:

$$CD_{LM} = \sqrt{\frac{1}{N.(N-1)}}\left[\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T.\hat{\rho}_{ij}^2 - 1)\right] \sim N(0,1)$$

where $\hat{\rho}_{ij}$ shows the estimation of the correlation coefficient among the residuals obtained from individual OLS estimations of Equation (1). The null and the alternative hypotheses of this test are as follows:

$H_0 : Cov(\mu_{it,}\mu_{jt}) = 0$ for all t and $i \neq j$

$H_0 : Cov(\mu_{it,}\mu_{jt}) \neq 0$ for at least some $i \neq j$

Under the null hypothesis of no cross-sectional dependence CD_{LM} test is useful when N is large relative to T and it is asymptotically distributed as standard normal.

Panel stationarity test

Having analyzed cross-section dependency, it must be controlled whether there exists unit root in the series to obtain unbiased estimations. If the model has cross sectional dependency, using first generation panel data unit root testing methods, such as Hadri (2000), Levin Lin Chu (2002) and Im Pesaran Shin (2003), will increase the probability of the occurrence of spurious unit root (Samadi and Rad 2013). Therefore, for overcoming this problem, Hadri and Kurozumi (2012) proposed the Z_A^{SPC} test statistic. They consider the below equation:

$y_{it} = z'_t\delta_i + f_t.\gamma_i + \varepsilon_{it}$, $\varepsilon_{it} = \phi_{i1}.\varepsilon_{it-1} + ... + \phi_{ip}.\varepsilon_{it-p} + v_{it}$ for i=1,...,N, t=1,...,T

where z'_t is deterministic, $z'_t\delta_i$ is the individual effect while f_t is a one-dimensional unobserved common factor, γ_i is the loading factor, and ε_{it} is the individual-specific error, following an AR(p) process.

For the correction of cross-sectional dependence, for each i, Hadri and Kurozumi (2012) regress y_{it} on $w_t = \left[z'_t, \bar{y}_t, \bar{y}_{t-1}, ..., \bar{y}_{t-p}\right]$ and construct the following test statistic:

$Z_A = \dfrac{\sqrt{N}(\overline{ST} - \xi)}{\zeta}$ where $\overline{ST} = 1/N.\sum_{i=1}^{N} ST_i$ with $ST_i = \dfrac{1}{\hat{\sigma}_i^2.T^2}\sum_{t=1}^{T} S^w{}_{it}$, where $S_{it}{}^w = \sum_{s=1}^{t}\hat{\varepsilon}_{is}$,

$\hat{\sigma}_i^2$ is the estimator of the long-run variance.

and $\begin{cases} \xi = \xi_m = 1/6 \quad \zeta^2 = \zeta_m{}^2 = 1/45 \quad when \quad z_t = z^m{}_t = 1 \\ \xi = \xi_\tau = 1/15 \quad \zeta^2 = \zeta_\tau{}^2 = 11/6300 \quad when \quad z_t = z^\tau{}_t = [1, t]' \end{cases}$

Hadri and Kurozumi (2012) called Z_A statistic as the panel-augmented KPSS test statistic, due to the fact that ST is the average of the Kwiatkowski et al. (1992) test statistic across i. They construct S_{it}^w using these regression residuals. So, it can be seen that numerators of each ST_i weakly converges to

$\dfrac{1}{T^2}\sum_{t=1}^{T}(S_{it}{}^w)^2 \overset{T}{\Rightarrow} \sigma_i^2 \int_0^1 \left[V_i^\varepsilon(r) + \tilde{\gamma}_i R_N\right]^2$, where $\tilde{\gamma}_i = \gamma_i / \bar{\gamma}$, R_N is $O_p(1/\sqrt{N})$ over $0 \le r \le 1$

$\sigma_i^2 = \sigma_{vi}^2 / (1 - \varphi_{i1} - ... - \varphi_{ip})^2$

Hadri and Kurozumi (2012) divide the numerator of each ST_i by a consistent estimator of the long-run variance σ_i^2 to correct for serial correlation and estimate the AR(p) model augmented by the lags of $\bar{y}_t$ for each i by the least-squares method,

$y_{it} = z'_t\hat{\delta}_i + \hat{\varphi}_{i1}.y_{it-1} + ... + \hat{\varphi}_{ip}.y_{it-p} + \hat{\Psi}_{i0}\bar{y}_t + ... + \hat{\Psi}_{ip}\bar{y}_{t-p} + \hat{v}_{it}$.

Hadri and Kurozumi (2012) obtain the estimator of the long-run variance by

$\hat{\sigma}_{iSPC}^2 = \dfrac{\hat{\sigma}_{vi}^2}{(1 - \hat{\varphi}_i)^2}$ where $\hat{\sigma}_{vi}^2 = 1/T.\sum_{t=1}^{T}\hat{v}_{it}^2$ and $\hat{\varphi}_i = \min\left\{1 - \dfrac{1}{\sqrt{T}}, \sum_{j=1}^{p}\hat{\varphi}_{ij}\right\}$.

So, Hadri and Kurozumi (2012) create the test statistic of Z_A^{SPC} as below:

$$Z_A^{SPC} = \frac{1}{\hat{\sigma}_{iSPC}^2.T^2}\sum_{t=1}^{T}(S_{it}{}^w)^2$$

Under a null hypothesis, the test states that series do not contain unit root, while an alternative hypothesis states that series contain unit root. Moreover, the null distribution of statistic Z_A^{SPC} is asymptotically standard normal, while it diverges to infinity under the alternative hypothesis. In addition, the test allowing serial correlation and cross-sectional dependence can be used in which both T<N and T>N.

Panel non-causality test

In this study, bilateral causality relationships are investigated among the carbon dioxide emissions, total health expenditures, educational attainment and total life expectancy at birth for the EU countries via the Dumitrescu and Hurlin (2012)'s non-causality test. The test is a simple version of the Granger (1969) non-causality test for heterogeneous panel data models with fixed coefficients and considers the below model:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} x_{i,t-k} + \varepsilon_{i,t} \qquad \text{i=1,...,N, t=1,...,T}$$

where $x_i = (x_{i1,...,}x_{iT})'$ and $y_i = (y_{i1,...,}y_{iT})'$ are stationary variables in T periods. $\beta_i = (\beta^{(1)}{}_i, ..., \beta^{(k)}{}_i)'$.It is assumed that lag orders K are identical for all cross-section units of the panel and the panel is balanced. Besides, it is allowed that autoregressive parameters $\gamma_i^{(k)}$ and the regression coefficients slopes $\beta_i^{(k)}$ are constant in time, but vary across groups. The hypotheses of the test are formulated as follows:

$$H_0 : \beta_i = 0 \quad \forall_i = 1, ..., N$$
$$H_1 : \beta_i = 0 \quad \forall_i = 1, ..., N_1$$
$$\beta_i \neq 0 \quad \forall_i = N_1 + 1, ..., N$$

Under the null hypothesis, it is assumed that there is no individual causality relationship from x to y exists. This hypothesis is denoted the Homogeneous Non Causality (HNC) hypothesis. Thus under the null hypothesis of HNC, there is no causal relationship for any of the cross-section units of the panel. The alternative hypothesis is denoted the Heterogeneous Non Causality (HENC) hypothesis. Under the alternative hypothesis, it is assumed that there is a causal relationship from x to y for a subgroup of individuals and β_i may differ across groups. Dumitrescu and Hurlin (2012) propose the average statistic $W_{N,T}^{HnC}$ associated with the null HNC hypothesis, as follows:

$W_{N,T}^{HnC} = 1/N.\sum_{i=1}^{N} W_{i,T}$, here $W_{i,T}$ denotes the individual Wald statistics.

Let denote Z_i the (T, 2K+1) matrix Z_i = [e: Y_i: X_i] where e denotes a (T, 1) unit vector and by $\theta_i = (\alpha_i \gamma'_i\ \beta'_i)'$ the vector of parameters of the model. Let the test for the HNC hypothesis be $R.\theta_i = 0$ where R is a (K, 2K+1) matrix with $R = \left[O : I_k \right]$. For each i=1,...,N, the Wald statistic $W_{i,T}$ corresponding to the individual test $H_0 : \beta_i = 0$ is defined as $W_{i,T} = \hat{\theta}'_i .R'.\left[\hat{\sigma}_i^2.R(Z_i'.Z_i)^{-1}.R' \right].R.\hat{\theta}_i$

where $\hat{\theta}'_i$, is the estimate of parameter θ_i obtained under the alternative hypothesis, and $\hat{\sigma}_i^2$ is the estimate of the variance of the residuals. Under the null hypothesis of non-causality, each individual Wald statistic converges to a Chi-squared distribution with K degrees of freedom:

$W_{i,T} \to \chi^2(K)$, $\forall_i = 1, ..., N$

The standardized average statistic $\tilde{Z}_N^{HnC}$ for a fixed T dimension with $T \succ 5 + 2K$ is as follows:

$$\tilde{Z}_N^{HnC} = \sqrt{\frac{N}{2K}}.\sqrt{\frac{T-2K-5}{T-K-3}}.\left[\left(\frac{T-2K-3}{T-2K-1} \right).W_{N,T}^{HnC} - K \right] \to N(0,1)$$

4. Results

Table 2 shows the results of Pesaran (2004)'s CD_{LM} test. The null hypothesis of this test is that no cross sectional dependency exists among the variables. As the table 2 depicts, all the variables had cross sectional dependency.

Table 2 Results for cross-sectional dependence test

Variable	CD_{LM} test statistic	prob. value
LEXP	8,896***	0,00
HEX	5,921***	0,00
CO_2_coal	4,312***	0,00
CO_2_pet	4,494***	0,00
CO_2_nat	4,827***	0,00
EDU	76,080***	0,00

*** indicates rejection of the null hypothesis at the 1% level of significance. Source: Author's estimations.

Table 3 reports the results of the Hadri-Kurozumi (2012) test. According to this test with the null hypothesis is that all the panels are stationary, the null hypothesis cannot be rejected. So, it can be said that all the variables are stationary at the significance level of 1%.

Table 3 Results for the Hadri-Kurozumi (2012) stationary test

Constant			Constant		
Variable	**Statistic**	**p-value**	**Variable**	**Statistic**	**p-value**
LEXP Z_A^{SPC}	-2,370	0,99	**CO_2_coal** Z_A^{SPC}	-0,276	0,60
HEX Z_A^{SPC}	-3,000	0,99	**CO_2_pet** Z_A^{SPC}	-4,212	1,00
EDU Z_A^{SPC}	-4,058	1,00	**CO_2_nat** Z_A^{SPC}	-3,480	0,99

***, **,* indicate rejection of the null hypothesis at the 1%, 5% and 10% levels of significance respectively. Source: Author's estimations.

In the framework of the findings from the cross-sectional dependency tests and the second generation panel unit root test, the Dumitrescu and Hurlin (2012) test seems to be an appropriate method as a panel causality approach. The Dumitrescu and Hurlin (2012) panel non-causality test results are given in Table 4.

According to the results in Table 4, there exists a bidirectional causal relationship between life expectancy and all the other explanatory variables, except for carbon dioxide emissions consumption from coal.

Similarly, there is a bidirectional causal relationship between health expenditures and other variables, except for carbon dioxide emissions from consumption of coal. Moreover, it is observed for education-environmental quality, is proxied by carbon dioxide emissions that there is a causal relationship from education to the environmental quality.

Table 4 Results for the Dumitrescu-Hurlin panel non-causality test

Hypothesis	$\tilde{Z}_N^{HnC}$	**Hypothesis**	$\tilde{Z}_N^{HnC}$	**Hypothesis**	$\tilde{Z}_N^{HnC}$
LEXP ≠> HEX	3,99*** (0,00)	**LEXP ≠> EDU**	11,79*** (0,00)	**HEX ≠> EDU**	46,56*** (0,00)
HEX ≠> LEXP	15,31*** (0,00)	**EDU ≠> LEXP**	3,92*** (0,00)	**EDU ≠> HEX**	2,75*** (0,00)
LEXP ≠> CO2_coal	6,15*** (0,00)	**HEX ≠> CO2_coal**	4,76*** (0,00)	**CO2_nat ≠> EDU**	1,97* (0,05)
CO2_coal ≠> LEXP	1,23 (0,18)	**CO2_coal ≠> HEX**	1,59 (0,11)	**EDU ≠> CO2_nat**	2,84*** (0,00)
LEXP ≠> CO2_pet	14,06*** (0,00)	**HEX ≠> CO2_pet**	15,28*** (0,00)	**CO2_pet ≠> EDU**	2,47** (0,01)
CO_2_pet ≠> LEXP	2,43** (0,02)	**CO_2_pet ≠> HEX**	3,94*** (0,00)	**EDU ≠> CO_2_pet**	7,02*** (0,00)
LEXP ≠> CO_2_nat	3,30*** (0,00)	**HEX ≠> CO_2_nat**	11,43*** (0,00)	**CO_2_coal ≠> EDU**	-0,39 (0,36)
CO_2_nat ≠> LEXP	5,00*** (0,00)	**CO_2_nat ≠> HEX**	1,89* (0,06)	**EDU ≠> CO_2_coal**	4,76*** (0,00)

***, **,* indicate rejection of the null hypothesis at the 1%, 5% and 10% levels of significance respectively. The values in parentheses show probability values of the variables. Source: Author's estimations.

We also estimated the relationship among the health indicators and the environmental quality using panel least squares estimator in terms of individual and aggregate effects of carbon dioxide emissions. The results of panel estimation are summarized in Table 5 and Table 6. According to Table 5, education and health expenditures have statistically significant and positive effects on life expectancy as expected from the literature review. In addition, it is seen that the effect of education is larger than that of health expenditure. When analyzed individually effects of carbon dioxide emissions on life expectancy, it is seen that only carbon dioxide emissions from natural gas has statistically significant and negative effect on life expectancy.

Table 5 Results for Panel Least Squares Method

Dependent Variable: LEXP				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	3.730403***	0.026298	141.8538	0.0000
EDU	0.201892***	0.012235	16.50066	0.0000
HEX	0.075781***	0.005595	13.54387	0.0000
CO2_coal	-0.000105	6.61E-05	-1.582808	0.1142
CO2_nat	-0.000305***	8.18E-05	-3.721707	0.0002
CO2_pet	5.32E-05	4.97E-05	1.071218	0.2847

*** indicates rejection of the null hypothesis at the 1% level of significance. Source: Author's estimations.

The aggregate effects of carbon dioxide emissions on life expectancy are illustrated in Table 6. According to Table 6, education and health expenditures have statistically significant and positive effect on life expectancy, while carbon dioxide emissions in aggregate have statistically significant and negative effect as expected.

Table 6 Results for Panel Least Squares Method

Dependent Variable: LEXP				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	3.850719***	0.002467	1561.077	0.0000
HEX	0.074568***	0.000313	238.5961	0.0000
EDU	0.172382***	0.000855	201.5993	0.0000
CO2_nat+CO2_coal+CO2_pet	-0.014404***	0.000290	-49.69483	0.0000

*** indicates rejection of the null hypothesis at the 1% level of significance.

Source: Author's estimations.

5. Conclusions

Health is one of the most important factors that determine the quality of human capital, which also is a necessary factor for economic growth. The environmental pollution is detrimental to human health is well recognized. The impacts of environment degradation on human health affect society not only in terms of loss of quality of life, but also in terms of expenditure on health care. If environmental quality declines, it negatively impacts peoples' health. A deterioration in health demands more expenditures on health.

Human activities intensify the blanketing effect through the release of greenhouse gases. For instance, the amount of carbon dioxide in the atmosphere has increased by about 35% in the industrial era, and this increase is known to be due to human activities, primarily the combustion of fossil fuels and removal of forests. Thus, humankind has dramatically altered the chemical composition of the global atmosphere with substantial implications for climate (IPCC 2007).

Specially, pollutants such as sulphur, carbon monoxide and nitrogen dioxide have been found to be related to health events. It follows that sulphur oxide emissions and carbon monoxide emissions all deteriorate the quality of the environment through polluting the air, thus negatively impacting human health.

In this study, carbon dioxide emission was used as a proxy variable of environmental quality because of the fact that carbon dioxide, a greenhouse gas is considered to be a major contributor to global climate change, which has been a topical issue among policy makers and focus of quite a number of researches across different fields of study. This study aimed to investigate whether there exists a causal relationship among carbon dioxide emissions in terms of the source of consumption, total health expenditures, educational attainment and total life expectancy at birth for the EU member countries.

The empirical results showed that bidirectional causal relationship between life expectancy and all the other explanatory variables, except for carbon dioxide emissions from coal. The finding that there is no significant causality relationship from carbon dioxide emissions from consumption coal to life expectancy may have stemmed from large decreases in consumption of hard coal in the EU-28 from the beginning of 1990s. Indeed, gross inland consumption of hard coal in the EU-28 decreased steadily in the 1990s. Further these large decreases were observed in 2008 and 2009. In 2014, gross inland consumption of hard coal in the EU-28 reached its lowest level at 285 Mt, 44% less than in 1990. Thus, specially, there is a shift from fossil fuels to renewable energy sources, such as hydropower, solar energy, wind power and biofuels (Eurostat 2015).

In addition, the results exerted that there is a bidirectional causal relationship between health expenditures and other variables, except for carbon dioxide emissions from consumption of coal as in the case of life expectancy.

Furthermore, the empirical results showed that there is a causal relationship from education to the environmental quality. Thus, education playing an effective role in mitigating carbon emissions may make important contributions to sustainable development.

In summary, the results exerted that reducing carbon emission that is primary source of greenhouse gas emissions must be priority in providing higher quality of health and life for people. For this purpose, carbon emissions that are primary source of greenhouse gas emissions can be reduced through reduction in the rate of land conversion and deforestation, better control of wildfires, adoption of alternatives to the burning of crop residues after harvest, reduction of emissions from commercial fishing operations, and more efficient energy use by forest dwellers, commercial agriculture and agro-industries (FAO 2008).

In addition, under a set of well specified conditions, a properly designed carbon tax can induce the level of carbon emission reductions. A tax on carbon leads to higher priced consumer goods, lower consumption and hence lower emissions. In addition, taxes allow for entry and exit of carbon emitters without resort to petition for emission right. If emissions are expanded, the tax bill rises. If emissions fall, the bill goes down (Zatzman 2012). Thus, the emission tax on carbon is considered as the one of the most important environmental policy tools.

The other environmental policy tool to control carbon emission is “no regrets” strategy. A “no regrets” strategy can be defined as the actions to achieve economic returns can be greater than input costs to achieve a certain degree of carbon emission reductions. Thus, if the total benefits are greater than the input costs by fostering innovation and economic efficiency, the reduction is “No-regrets” (Gang et al. 2008). A "no regrets" strategy, which means taking climate-related decisions that make economic good sense can be listed with the following 11 "no regrets" actions (Schnare 2008):

- Modify residential and commercial electronics energy use
- Replace incandescent residential and commercial lighting
- Use fuel economy packages on light trucks and cars
- Apply shell improvements on new residential and commercial buildings
- Apply combined heat and power options in commercial buildings
- Install efficiency improvements on older power plants
- Use conservation silage and non-tillage in agricultural settings
- Install various industrial process improvements that reduce energy needs
- Replace old with new residential water heaters
- Apply modern coal-mining methane management
- Install commercial building energy control systems

A true "no regrets" strategy will yield both economic and environmental gains. The economic gains will come from greater productivity and efficiency, while the environmental gains will come from increased production per unit of energy expended or emissions released (Adler 2000).

The EU has committed to a "no regrets" long term policy framework to 2030 that would see an increased share of renewables in the energy mix. Indeed, "no regrets" environmental policy tool may be the important policy implication to produce both favorable economic and environmental outcomes for EU member countries in the next decade. So, it has been expected that the European renewable energy market will become increasingly competitive through smart and flexible infrastructure and increased energy efficiency in the next decade (Renewable Energy Focus 2012).

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