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AIR POLLUTION, HEALTH AND ECONOMIC GROWTH: A PANEL DATA ANALYSIS FOR COUNTRIES WITH THE HIGHEST CO_2 EMISSION

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Abstract

Raising disposable income per capita due to economic growth enables people to benefit more from education and health services. This situation improves the quality of human capital and ultimately affects economic growth positively. On the other hand, air pollution can adversely affect labor productivity, reducing industrial production and output level, thus economic growth. There are feedback loops among economic growth, air pollution and human health. In this study, the interactions between air pollution, which is determined as an indicator of environmental degradation, economic growth and infant mortality, which is the indicator of health, is modeled and analyzed. The long and the short-term relationships are tested by three different Panel ARDL Methods for 41 countries with the highest CO_2 emission. It is concluded that there is no relationship among air pollution-health and economic growth in the short-therm. However, in the long-term, a 1% raise in CO_2 emission increases infant mortality by 0.181%, and a 1% raise in GDP per capita decreases infant mortality by 0.179%. Even considering only the air pollution variable, the impact of economic growth on health cannot eliminate the benefits gained from growth.

Keywords: *Economic Growth, Air Pollution, Health*

HAVA KİRLİLİĞİ, SAĞLIK VE İKTİSADİ BÜYÜME ETKİLEŞİMİ: EN YÜKSEK CO_2 EMİSYONUNA SAHİP ÜLKELER İÇİN BİR PANEL VERİ ANALİZİ

Öz

İktisadi büyüme ile artan kişi başına harcanabilir gelir, insanların eğitim ve sağlık hizmetlerinden daha fazla yararlanmasına imkân vermektedir. Bu durum beşeri sermayenin kalitesini artırmakta ve sonuçta ekonomik büyümeyi olumlu etkilemektedir. Öte yandan, hava kirliliği işgücü verimliliğini olumsuz etkileyebilmekte, endüstriyel üretimi ve çıktı seviyesini ve dolayısıyla ekonomik büyümeyi azaltabilmektedir. Bu bağlamda iktisadi büyüme, hava kirliliği ve insan sağlığı arasında döngüsel bir ilişki olduğu söylenebilir. Bu çalışmada çevresel bozulmanın bir göstergesi olarak belirlenen hava kirliliği, ekonomik büyüme ve

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sağlığın göstergesi olan bebek ölümleri arasındaki etkileşimler modellenmiş ve analiz edilmiştir. Uzun ve kısa dönemli ilişkiler, en yüksek CO_2 salınımına sahip 41 ülke için üç farklı Panel ARDL yöntemi ile test edilmiştir. Kısa dönemde, hava kirliliği bebek ölümleri ve iktisadi büyüme arasında bir ilişki olmadığı sonucuna varılmıştır. Bununla birlikte, uzun dönemde CO_2 salınımına % 1'lik bir artış bebek ölümlerini % 0.181 artırırken, kişi başına GSYH'deki % 1'lik artış bebek ölümlerini % 0.179 azaltmaktadır. Çevresel bozulma göstergelerinden biri olan hava kirliliği değişkeni dikkate alındığında dahi ekonomik büyümenin sağlık üzerindeki etkisinin büyümeden elde edilen faydaları ortadan kaldırdığı görülmektedir.

Anahtar Kelimeler: *Ekonomik Büyüme, Hava Kirliliği, Sağlık*

Introduction

The effects of environmental degradation on living beings' lives and the interaction with economic activity level and human health are among the subjects of interest in last decades. Problems related to environmental degradation such as deterioration of air quality and water pollution come to the fore as important issues that jeopardize human health and life expectancy. Environmental degradation is one of the main causes of negative externalities that keep the economy out of equilibrium. With this regard, the increase in production level may have detrimental impacts on the quality of physical capital and human capital by negatively affecting the quality of environmental capital. Human health is an important factor that affects the efficiency of human capital. There are numerous researches that reveal the negative impacts of environmental degradation on human health (Graff-Zivin and Neidell, 2012). On the other hand, air pollution can adversely affect labor productivity, reducing industrial production and output level, thus economic growth (Yazdi and Khanalizadeh, 2017). Nevertheless, in the economic growth models, growth is regarded as a function of human capital and physical capital. For instance, the pioneer researchers such as Barro (1990), Lucas (1988) and Romer (1986) described their growth model including variables such as physical capital, human capital, technology, R&D and economic policy tools, but neglected to include environmental degradation variables, which have direct and indirect impact on economic growth.

Nevertheless, raising disposable income per capita due to economic growth enables people to benefit more from education and health services. This situation improves the quality of human capital and ultimately affects growth positively. In addition, environmental regulations can have a positive impact on economic growth by increasing the quality of human capital over education and health as well. In other words, strict environmental regulations can positively affect economic growth through productivity growth and innovation (Dell, Jones and Olken, 2012).

On the other hand, since policies implemented to reduce environmental pollution mean additional costs, it is thought that there will be adverse effects on economic growth. However, in the absence of environmental pollution measures, it also reduces labor productivity due to its adverse impact on human health and therefore on economic growth.

In this context, it can be suggested that there are feedback loops among economic growth, environmental degradation and human health. Therefore, it is questioned if the gains arising from economic growth could eliminate the adverse effects of economic growth on environmental capital.

In this study, the interactions between air pollution, which is determined as an indicator of environmental degradation, economic growth and health will be modeled and analyzed. Afterwards, the long and the short-term relationships will be revealed by testing with the appropriate panel data analysis method for the 41 countries with the highest CO_2 emission.

1. THEORETICAL FRAME WORK AND LITERATURE REVIEW

In the economics literature, the relationship between CO_2 emission and economic growth is based on Simon Kuznets' pioneering research in 1955. The research of Simon Kuznets (1955) forms the basis of both empirical and theoretical literature. Kuznets (1955) demonstrated that there is an inversed -U-shaped relationship between per capita income and income inequality in the process of economic development over time. This inverted U-shaped relationship was adapted to investigate the relationship between per capita income and environmental quality (Grossman and Krueger, 1991; Seldon and Song, 1994) and was paved the way for the birth of the "Environmental Kuznets Curve Hypothesis EKC."

In this context, at the initial phase of economic development, economic growth causes an increase in pollutant emissions due to the increase in industrial production and energy consumption. This positive relationship between production and environmental pollution continues up to a threshold income level. From this point on, as the economy grows even more, environmental pollution gradually decreases due to the development of services and knowledge-based technology-intensive industries, social environmental awareness and legal regulations. Therefore, the interaction between economic growth and air pollution is depicted as inverted U-shaped curve and is called the "Environmental Kuznets Curve hypothesis (EKC)" referred to Simon Kuznets (1955).

In the literature, there are numerous studies focusing on the interaction between output level, and thus economic growth, and environmental pollution in the context of EKC. Those can be classified under six different types of relationships: a) Monotonic increasing curve, b) Monotonic decreasing curve: c) Inverted U-shaped curve, d) U-shaped curve, e) N-shaped curve, f) Inverted N-shaped curve, g) No relationships (Shahbaz and Sinha, 2018)

Although most of the studies supporting the existence of the relationship between carbon dioxide emission and economic growth, it is noteworthy that there is no clear consensus on the form of the relationships and the outcomes. At this point, it should be determined that, in studies conducted in the context of the EKC hypothesis, the relationships between economic growth and environmental degradation have been examined with different country groups and methods, but the interaction of both variables with health has been neglected. Therefore, in this study, the relationship between economic growth and air pollution will be analyzed by taking the health dimension into consideration.

Before the research of Barro et al. (1990) on the factors, which affects the long-term economic growth, including longevity, there are very few studies investigating the influence of health on economic growth. Theoretically, the healthy and longevity of the workforce enhance productivity (Romar, 1990) and contributes to economic output by deducting the number of days off owing to health problems. However, the relationship between health and economic growth is uncertain due to direction, channels and other factors, which have impact on both variables. For instance, inclusion of education, technological progress and quality improvements, which affect both health and labor productivity, (Becker, 2007) into the models make the analysis more complex (Deaton, 2013; Weil, 2015) and could produce different outcomes.

Moreover, there are studies investigating the causality from health to income, thus towards economic growth (Bloom and Fink, 2014) or from economic growth to health (Hall and Jones, 2007). Increasing disposable income per capita due to economic growth heighten demand for goods and services, which are required by higher quality of life standards. Increasing in demand encourages the production of higher quality goods and services, which is called “quality change effect”, while also allowing the development of medical technologies, which is called “medical technology effect”. This will lead to a rise in the consumption of higher quality goods and services like higher quality living spaces, medical care services and educational opportunities at individual level (Fayissa and Gutema 2005).

On the other hand, economic growth positively affects health by allocating more resources to social programs such as sanitation, clean water, health awareness and health care opportunities that improve health at the national level (Biggs et al., 2010). Human health is also affected by environmental quality and lifestyle preferences, such as the quality of drinkable water, breathing air, and the quality of the living area. These impacts can occur through three channels: (a) scale effect, (b) composition effect, and (c) technique effect. Depending on economic growth, increases in production scales cause structural transformations, changes in agricultural structures and consumption preferences, increasing in urbanization and population, overutilization of natural resources and raises in air pollution, and thus environmental damage (Gangadharan and Valenzuela, 2001). Besides, changes in unhealthy lifestyle trends such as working in stressful professions, irregular eating habits, smoking, excessive alcohol and harmful food consumption, traffic and sedentary lifestyle negatively affect health. The conflicts between positive and negative factors affecting health cause questioning of the idea that rising disposable income per capita, which means economic growth, always affects health positively. Environmental damage caused by the increase in disposable income could prevent the achievement of the expected health level of economic growth. (Gangadharan and Valenzuela, 2001).

The increase in human capital that one of the production factors increases the economic growth (Mankiw, Romer, and Weil 1992). However, increasing economic growth also increases environmental pollution and negatively affects human capital. There are large number of researches revealing the negative impacts of environmental pollution on human health. Human health is a substantial element that affects the efficiency of human capital. In this context, taking measures to reduce environmental pollution is an investment in human capital and can therefore be seen as an instrument to enhance economic growth (Graff-Zivin and Neidell, 2012).

The relationship between environmental pollution and human capital have effects on the availability of employment and labor due to reasons such as absenteeism, health problems, and deaths. Health problems reduce the return on human capital. Human capital is an expression of skills acquired through education and experience. In this context, attendance in school life and business life are important at the point of effectiveness of human capital. The educational process is important in the development of human capital. Consequently, absenteeism interrupts the development of human capital (Graff Zivin and Neidell, 2013).

There are evidences showing that air pollution causes the diseases and therefore increase absenteeism in school life and business life. For example, Ransom and Pope III (1992) reveal a relationship between air pollution and absenteeism. Accordingly, a raise of 100 ug/m3 in PM10 in air pollution heighten absenteeism by 40%. Currie et al. (2009) revealed that the increase in carbon monoxide also negatively affects absenteeism. There are also researches revealing that air pollution increases absenteeism in business life. For instance, Holub et al. (2016) provide evidence that an increase in PM10 concentration of 10 μg/m3 bring about a 1.6 percent increase in absenteeism. Aragon et al., (2017) reveals that absenteeism in business life increases not only because of the employee's illness, but because of also when the employee needs to take care of a sick family member. Similarly, Hanna and Oliva (2015) shows that increasing pollution significantly reduces working hours.

It is proponed that children are more sensitive against the effects of environmental pollution and therefore more prone to health problems, which affect the cognitive abilities and physical functions of children, and therefore, their concentration and performance (Currie et al., 2009). For example, when PM2.5 is inhaled, particles can penetrate the lungs and impairs lung function. In addition, this pollutant can pass from the lungs to the bloodstream, thereby affecting the heart and brain functions (Du et al., 2016). As pollution have impact on both physical and cognitive function, it can reduce the output level by affecting employee productivity (Graff-Zivin and Neidell, 2012). In this respect, environmental pollution affects human capital development negatively through illnesses and low performance in education life and as well as business life, and consequently have a negative impact on economic growth.

Chakrabort et al, (2010) explained the relationship between economic growth and infectious diseases with the help of "overlapping generation growth model" based on the rates of morbidity and mortality. Accordingly, even if countries' growth rates converge in the long run, economies exposed to diseases take longer to reach steady growth rates. In this case, the increase in the death rates by infectious diseases causes a "development trap", while the increase in infectious diseases causes a "poverty trap".

The average life expectancy, which increases as a result of the developments in people's health conditions, prompts the economic units that want to benefit from the return on investments in the future to accumulate more human capital and physical capital, and thus accelerate economic growth (Cervelatti and Sunde, 2005). Zhang and Zhang (2005) revealed that increasing schooling and decreasing mortality rates affect life expectancy, which has a positive effect on economic growth and all effects are subject to the law of decreasing productivity. Lorentzen et al. (2008) found that the decline in adult mortality reduces fertility rate, increases investment in physical capital, and consequently increases economic growth.

Raffin and Seegmuller (2012) examined the relationship between life expectancy, environmental quality, and economic growth. Accordingly, if the incumbent party implements a fiscal policy in line with the environmental quality, the policy will be effective and the growth rate will be positively affected depending on the increase in life expectancy and the decrease in death rates. However, if the environmental taxes are excessively high, economic growth will be negatively affected and the fiscal policy will not produce effective results. Cervellati and Sunde (2015) argue that a rise in life expectancy can have a positive impact on the economic growth of countries only if the birth and death rates decrease.

There are studies showing that longevity has positive effects on economic growth (Zhang and Zhang, 2005; Lorentzen et al. 2008). In the study of Bhargava et al. (2001), the initially positive relationship between longevity and economic growth turns negative afterwards. This means that in countries where high living standards, high quality services using high health technologies and access to these health services are accessible to large masses, further improvement of longevity can only be possible with high resource costs that will negatively affect the economic growth. In addition, it is stated that decreasing mortality and increasing retirees will increase the pressure on growth. However, Hansen (2014) concluded in his study for the

US states that longevity has no effect on economic growth. Conversely, Hansen and Lönstrup (2015) concluded in their study using data starting from the 1900s that longevity negatively affected economic growth at the beginning.

The relationship between environmental degradation and population have been investigated in many studies so far (Graff-Zivin and Neidell, 2013). In this context, today it is a well-known issue that the air pollution has unfavorable impact on human health. The impact of air pollution on human health can adversely affect economic growth by causing losses in human capital. Jerret et al (2005) revealed that there is a significant relationship between the deaths of individuals with chronic diseases and air pollution. According to the study conducted by the World Health Organization in 2012, it is estimated that the cause of 3.7 million deaths corresponding to 5.4% of deaths on a global basis is because of air pollution. Similarly, Cohen et al. (2017) revealed in their study that air pollution was responsible for 4.2 million demises worldwide in 2015, which is 7.6% of the total globally.

On the other hand, air pollution increases premature birth and infant mortality rates. For example, Chay and Greenstone (2003) found that a one-unit reduction in PEP reduced infant mortality rates by 0.35 unit. Accordingly, we can say that the decrease in airborne particles such as PM2.5 and TSP causes a decrease in infant mortality.

Air pollution especially increases respiratory and heart diseases and the mortality rates associated with these diseases (Pope et al., 2002). On the other hand, air pollution raises the rates of premature birth and infant mortality. For instance, on the other hand, air pollution increases premature birth and infant mortality rates. For example, Chay and Greenstone (2003) found that a one-unit reduction in PEP reduced infant mortality rates by 0.35 unit. Similarly, Currie and Neidell (2005) showed that the decrease in PM10 and CO_2 caused a decrease in infant mortality with their research. Accordingly, we can say that the decrease in airborne particles such as PM2.5 and TSP causes a decrease in infant mortality. Another interesting study related to the increase in disease rates, Chen et al. (2017) show that the increase in death rates from diseases and birth causes migration. Migration is a factor affecting economic growth.

Bhargava et al. (2001) noticed that there are significant differences in the effects of health interventions on the economy of developing and developed countries. Luca et al., (2018), for instance, brought light that even a low level of health intervention in underdeveloped countries would have powerful positive impacts, especially on the health of the working population. In contrast, according to Poterba and Summer (1987), whatever improvement in health, it mostly occurs in the less economically active population. Fuchs (2004) presented that even high-level interventions in developed countries can have little effect on the health status of the population.

Schlenker et al. (2016) shows that 6 million people living in the area surrounded by the twelve largest airports in California and exposed to carbon dioxide cause an extra 540K US$ expense in hospitalization related to respiratory and heart dieses. Deryugina et al. (2019), in his research on mortality, healthcare use and medical costs of the US elderly who were exposed to acute fine particulate matter; it has been concluded that among the elderly population exposed to air pollution, death effects are intensified in around 25% of the elderly population.

Erkişi and Çelik (2020) investigated the relationships between carbon dioxide emission, non-renewable energy consumption and economic growth. In the short-term they found one-way relationship from non-renewable energy consumption to CO_2 emission in the short-term. Based on variance decomposition results in the long-term, CO_2, 44% was due to non-renewable energy consumption and 12% to economic growth.

Considering the theoretical and empirical literature, environmental pollution significantly affects the level of economic activity through many channels including health-related variables. In this respect air pollution, as a prominent indicator of environmental degradation, could affect economic growth through the following channels a) mortality, b) morbidity, c) migrations, d) absenteeism and e) quality of environmental capital.

Given this conceptual framework, the interaction mechanism between air pollution, health, and economic growth can be shown as in Figure 1.

Figure 1: **Interactions between Pollution Health and Economic Growth**

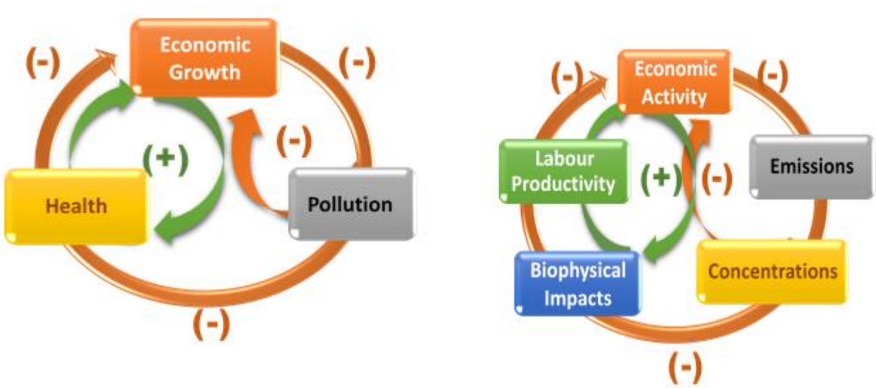

Figure 1 depicts that economic growth increases CO_2 emission. Increasing CO_2 emission has direct negative impact on economic growth and indirect negative affects through labor productivity due to the reasons such as mortality, mobility, and absenteeism. However, environmental measures taken in parallel with economic growth and the people's benefiting from higher health and education services have positive effects on labor productivity and therefore economic growth. In this context, cost-benefit analysis can be made by analyzing the magnitude of these positive and negative effects.

2. ECONOMETRIC ANALYSIS

2.1. Data Set, Variables, Methodology

The data set comprises 2009 observation for each of series consist of "number of infant deaths, GDP per capita and National Fossil-Fuel CO_2 Emissions" of 41 Countries[1] generating the most CO_2 emissions between 1970 and 2018. The data set was compiled from the "World Bank-Development Indicators Statistics".

Initially, the functional and the statistical form of the model were described under the following title. Before carrying on investigation of the long and the short-term relationships, the pre-tests such as "cross-section dependence", "stationary of the series", and "homogeneity of the parameters" tested in order to choose the appropriate error correction model (ECM).

Cross-section dependence was examined by the "Pesaran (2015) CD Test" in order to select the proper unit root test method. By considering the outcomes of the Pesaran CD Test, to figure out the stationary of the series, Pesaran CADF, IPS, and LLC, which are the unit-root test methods, were exploited. Swamy S Test Method, which is used to examining of homogeneity of the parameters that is another critical point in choosing the proper ECM model, was employed. Westerlund ECM Panel Cointegration Test, which considers the heterogeneity of the parameters, was preferred to reveal whether a long-term relationship existed. As a result of all these tests, it was decided to employ three ECM models consist of "Pooled Mean Group (PMG)", "Mean Group (MG)", and "Dynamic Fixed Effects (DFE)". Finally, the "Hausman Test" was used to decide which of the three ECM models explained the model best and the results were interpreted accordingly.

2.2. Model

In Eq (1), the model is defined as functional. Accordingly, "number of infant deaths (IR)" is the dependent variable, as an indicator of health, GDP is the per capita income in US$ represents the economic growth, as independent variable. "National fossil-fuel CO_2 emissions", which is

[1] Algeria, Argentina, Australia, Austria, Bangladesh, Belgium, Brazil, Canada, Chile, China, Colombia, Egypt, France, Germany, Greece, India, Indonesia, Iran, Iraq, Italy, Japan, Korea, Kuwait, Malaysia, Mexico, Morocco, Netherlands, Nigeria, Oman, Pakistan, Philippines, Qatar, Saudi Arabia, Spain, Thailand, Turkey, Ukraine, United Arab Emirates, United Kingdom, United States, Venezuela

symbolized with CO is the other independent variable, which indicate the air pollution.

$$\boldsymbol{IR} = \boldsymbol{f}\,(\boldsymbol{GDP}, \boldsymbol{CO}) \tag{1}$$

IR	: Number of infant deaths
GDP	: GDP per capita (US$)
CO	: National Fossil-Fuel CO_2 Emissions

Eq (1) is needed to be transformed in to the mathematical form in to proceed the analysis further. In this context, the mathematical form of the model is expressed as in Eq. (2).

$$\boldsymbol{IR_{it}} = \boldsymbol{a} + \boldsymbol{\beta_1 GDP_{it}} + \boldsymbol{\beta_2 CO_{it}} + \boldsymbol{u_{it}} \tag{2}$$

In Eq. (2), a represents intersect parameter, as ($\beta_1 \ldots \beta_4$) are the slope parameters, i denotes the countries ($i = 1, \ldots, 41$), ; t shows the time period ($t = 1970, \ldots, 2018$), and u_{it} refers to the error term.

The mathematical model seen in Eq. (2) should be redefined according to the Panel ARDL Model. Accordingly, general equation form of Panel ARDL can be express as in Eq. (3);

$$\Delta \boldsymbol{y_{it}} = \boldsymbol{\theta_i} \left[\boldsymbol{y_{i,t-1}} - \boldsymbol{\lambda'_i X_{i,t}} \right] + \sum_{j=1}^{m-1} \boldsymbol{\xi_{ij}} \Delta\, \boldsymbol{y_{i,t-j}} + \sum_{j=0}^{n-1} \boldsymbol{\beta'_{ij}} \Delta \boldsymbol{X_{i,t-j}} + \boldsymbol{\varphi_i} + \boldsymbol{e_{it}} \tag{3}$$

In Eq.(3), λ' is the parameter represents the long-term relationships. The phrase of $\left[y_{i,t-1} - \lambda'_i X_{i,t} \right]$ is the error correction term. ξ_{ij} and β' are the short-term dynamic coefficients. The model can be specified as in Eq. (4)

$$\Delta \boldsymbol{IR_{it}} = \boldsymbol{\theta_i} \left[\boldsymbol{IR_{i,t-1}} - \boldsymbol{\lambda'_i X_{i,t}} \right] + \sum_{j=1}^{m-1} \boldsymbol{\xi_{ij}} \Delta\, \boldsymbol{IR_{i,t-j}} + \sum_{j=0}^{n-1} \boldsymbol{\beta'_{ij}} \Delta \boldsymbol{X_{i,t-j}} + \boldsymbol{\varphi_i} + \boldsymbol{e_{it}} \tag{4}$$

θ_i is the adjustment coefficient. “m-1” is the number of lags of dependent variable and n-1 is the lags for the repressors.

2.3. Descriptive Statistics

Table 1 shows the traits of each of series in the model. The standard deviation is considerable sufficient to discover the variation in the data.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min.	Max.
CO	2,009	462.6711	1114.132	.2345	10064.69
IR	2,009	34.02882	35.1113	1.8	169
GDPPC	2,009	11776.28	14613.49	79.17819	85076.15

2.4. Cross Section Dependence Test

Before investigating the stationary of the series, it is needed to be examined whether cross-section dependence in order to choose the convenient unit root test method, which reveals the integration level of the variables and also figure out the proper panel ECM. The outcomes of the cross section dependence test show existence of correlations between the unites.

In the case of existence of cross section dependence, it is needed to be employed the second-generation panel unit root test, and the proper ECM Test methods that consider correlation. To this end, "H_0: cross-section independence" the null hypothesis is tested by implementing "Pesaran (2015) CD Test Method" and the results are presented in Table (2)

Table 2. Pesaran (2015) CD Test

Variable	CD-test	p-value	average joint T	mean ρ	mean abs(ρ)
CO	98.176	0.000	49.00	+ 0.49	0.79
IR	194.086	0.000	49.00	+ 0.97	0.97
GDPPC	173.089	0.000	49.00	+ 0.86	0.86

Table 2 covers the CD-test statistics, p-values, mean ρ values, and the absolute value of mean ρ of the series. H_0: cross-section independence, CD ~ N (0,1) was tested. Because the probability values of the CD test statistics belong to the series are below than 5%, the H_0 hypothesis is not confirmed but H_A hypothesis, which admit the existence of cross-section dependence, was approved.

2.5. Stationary Test

As the conclusion of the CD-Test confirmed the existence of cross-section dependence, the stationary of the series will be tested below via Pesaran (2007) CADF, IPS, and LCC unit root tests. "H_0: all panels contain unit roots" is tested against "alternative hypothesis of some panels are stationary" and the results are displayed in Table 3.

Table 3. Outcomes of the Unit Root Tests

Method	Variables	I(0) Stat.	I(0) P-value	I(1) Stat.	I(1) P-value
Pesaran CADF Unit-Root Test	CO	-1.810	0.392	-4.287*	0.000
	IR	-3.298*	0.000	-	-
	GDP	-1.736	0.590	-4.018*	0.000
Im-Pesaran-	CO	3.7743	0.9999*	-28.3596	0.0000
	IR	-14.6147*	0.0000	-	-

Shin Unit-Root Test	GDP	-2.0270	0.0213*	-27.9887	0.0000
Levin-Lin-Chu Unit-Root Test	CO	4.2122	1.0000	-31.7551*	0.0000
	IR	-18.8053*	0.0000		
	GDP	-4.3643	0.3239	-36.6654*	0.0000

Note: %10, %5, %1: -2.050 -2.110 -2.230

According to the unit root test results reported in Table 3, it is seen that the IR series is stationary at the level, and the GDP and CO series become stationary when the first order differences are taken. In other words, integration level of IR is I (0), while integration levels of CO and GDP are I (1). Therefore, it is decided to be employed Panel ARDL method for estimation of the coefficients of the short run and the long run.

2.6. Homogeneity Test

Swamy S Test method will be employed to examine homogeneity of the parameters, which is another considerable method in deciding the appropriate ECM Method. The results of Swamy S Test reported in Table 4.

Table 4. Homogeneity Test

	χ2 (160)	**Prob > χ2**
$IR_{it} = a + \beta_1 IR_{it-1} + \beta_2 GDP_{it-1} + \beta_3 CO_{it-1}$	12299.13	0.0000

In Table 4, it is seen the regression equation, which was tested and the value of χ2 (160) and Prob. of χ2. "H_0: the parameters are homogenous" is tested against "H_A: the parameters are heterogeneous". Since the Prob-value of χ2 is less than 0.05, it is decided that the parameters are heterogeneous. Therefore, the ECM Method, which will be used should consider heterogeneity.

2.7. Appropriate Lag-length Selection

It is necessary to determine the appropriate lag-length values in order to produce consistent results in the long and the short run analyzes. Analysis results may have deviating results if appropriate lag length values are not considered. Hence, Hansen J Test was utilized and the results are reported in Table5.

Table 5. Lag-length Selection

lag	**CD**	**J**	**J pvalue**	**MBIC**	**MAIC**	**MQIC**
1	.6927827	58.09999	.0112509	**-206.5417**	-13.90001	**-85.5298**
2	.0291303	40.84345	.0426347	-157.6378	-13.15655	-66.8789

3	-.3851395	12.17546	.8380475	-120.1454	**-23.82454**	-59.6394
4	-2.711324	2.092444	.9899199	-64.06798	-15.90756	-33.815

In Table 5, it is seen that the lengths of lags that assures the values of MBIC and MQIC information criteria minimum is 1. Similarly, the lag-length, which makes the value of MAIC information criteria value minimum is 3. Since both MBIC and MQIC indicated that the appropriate delay length is 1, it is decided the appropriate delay length is 1.

2.8. Confirmation of the Long-term Relationship

Before estimation of the coefficients by MG, PMG and DFE Estimators, which are appropriate Panel ARDL Methods decided based on the tests done so far, “Westerlund ECM Panel Co-Integration Test”, which considers the heterogeneity, will be employed in order to verify whether a long-term relationship exists between the variables.

Table 6. Westerlund Co-Integration Outcomes

Statistic	Value	z-value	P-value	Robust P-value
Gt	-4.856*	-21.227	0.000	0.000
Ga	-9.282*	-4.049	0.000	0.000
Pt	-132.429*	-95.146	0.000	0.000
Pa	-8.406*	-7.717	0.000	0.000

Note: * indicate co-integration 1% significance level.

Table 6 displays the values of test statistics, z-values, p-values, and the robust p-values of Gt, Ga, Pt and Pa. “H_0: no co-integration hypothesis” was tested. The outcomes of the Robust P-Value column are considered for the evaluation of heterogeneous panel. Since, the values of Gt, Ga, Pa in the last column are 0.000 and smaller than 5% the significance level, “H_0: no co-integration” is rejected”. It is concluded that a long-term relationship existed and therefore suitable ECM can be implemented to estimation of the parameters.

2.9. Estimation of the Long-Term and the Short-term Relationships

Since the results of Co-Integration Test in Table 6 indicated a long-term relationship, “Mean Group Estimator (MG)”, “Pooled Main Group Estimator (PMG)” and “Dynamic Fix Effect Estimator (DFE)” are implemented and the outcomes are reported in Table 7.

Table 7. Outcomes of PMG, MG and DFE Estimators

	PMG		MG		DFE	
D.LnIR	Coef.	Std. Err. (p-value)	Coef.	Std. Err. (p-value)	Coef.	Std. Err. (p-value)
Long run						
LnCO	.181210	.0612937 (0.003)	-2.378734	1.182735 (0.044)	-.1684492	.0516189 (0.001)
LnGDP	-.179475	.0341964 (0.000)	.2732755	.6866907 (0.691)	-.3830343	.0351936 (0.000)
ECT	-.0117989	.00309 (0.000)	-.0275949	.00588 (0.000)	-.0227632	.0016344 (0.000)
Short run						
LnCO D1.	.0047489	.0091393 (0.603)	.0023993	.0082996 (0.773)	-.0025861	.0044677 (0.563)
LnGDP D1.	.0010179	.004008 (0.800)	.0069951	.0041707 (0.094)	.0010256	.0027225 (0.706)
_cons	-.0051457	.0109076 (0.637)	.1762401	.0551745 (0.001)	.1225543	.0149075 (0.000)

Table 7 presents the outcomes the coefficients, standard errors, and probability values of three estimators of the model in the long and the short-term. The first part of the table displays the estimations in the long-term, while the bottom part reveals the short-term outcomes. ECT, which is located in the middle of the table, symbolizes the "error correction term", which shows the joint effects of the variables and also whether a long-term relationship existed.

Hausman Test, the outputs of which are shown in Table 8, will be conducted to determine the best fit estimator, which will produce the most accurate result compatible with the model.

Table 8. Hausman Test Outcomes

Test Stats.		$\chi2$ (2)	Prob> $\chi2$	Decision
(1)	PMG or MG	4.11	0.1283	PMG
(2)	PMG or DFE	0.01	0.9932	PMG

Note: (1) H_0: PMG is efficient estimator than MG
(2) H_0: PMG is efficient estimator than DFE

Table 8 reveals the outcomes of the Hausman Tests, which consists of the value and the probability of $\chi2$. The null hypothesis of the PMG Estimator is more efficient than other estimators, tested by the Hausman Test. As it is seen the figures in the first raw, the null hypothesis confirmed, since the probability of $\chi2$ is 0.1283 > 5% the significance level. It is concluded that the model supports PMG rather than MG. Similarly, as it is seen in the second line, because of the probability of $\chi2$ is 0.9932, that is greater than 5% the significance level, the null hypothesis is approved and concluded that the model supports PMG rather than DEF. Therefore, it is decided to use outcomes of the PMG Estimator to interpret the relationships among the variables.

When the results of PMG Estimator are examined in Table 7, the value of ECT coefficient is negative and significant because of the probability value is less than 0.05. This result confirms the long-term relationships. The long-term outcomes indicated that CO has negative and GDP has positive impact on IR because of p-values are 0.003 and 0.000 respectively and less than 5% significance level. We can conclude that;

(a) One unit rise in CO_2 emission heighten the infant mortality by 0.18 unit.
(b) One unit rise in GDP per capita cause to fall infant mortality by 0.179%

In the short run, neither CO_2 emission nor GDP per capita have an impact on infant mortality, since p-values are insignificant.

Conclusion

Considering the theoretical and empirical literature, environmental pollution significantly affects the level of economic activity through many channels including health-related variables. In this respect air pollution, as a prominent indicator of environmental degradation, could affect economic growth, since it is one of the causes of negative externalities that keep the economy out of equilibrium. Air pollution can adversely affect labor productivity, reducing industrial production and output level, thus economic growth. Nevertheless, it is seen that, in the economic growth models, growth is regarded as a function of human capital, physical capital, technology, R&D and economic policy tools, but neglected environmental degradation variables, which have direct and indirect impact on economic growth.

On the other hand, as a result of the increase in the quality and quantity of health services due to economic growth, it has a positive effect on the human capital, and it may also have negative consequences on itself due to the increasing carbon dioxide emissions in parallel with the growth.

In this study, the relationships between air pollution, health and economic growth are theoretically examined and in the economic part of the study, the effects of economic growth and carbon dioxide emissions on health are examined.

While the dependent variable of the model is health, independent variables are air pollution and economic growth. Infant mortality is the indicator of health, which is the dependent variable; real income per capita in USD and carbon dioxide emissions are the indicators of economic growth and air pollution respectively. PMG, MG and DFE estimators, which are panel ARDL methods, were used in the estimation of the model.

PMG model estimates have been found to be more appropriate than the other two estimation methods. According to the PMG Estimator results, it is concluded that there is no relationship between the series in the short run. However, according to the long-term results, while there is an inverse relationship between air pollution and health, it has been observed that there is a positive relationship between economic growth and health. These results support the results of Bloom and Fink (2014) and Hall and Jones (2007), Fayissa and Gutema (2005) and Biggs et al. (2010).

On the other hand, it can be questioned, as Gangadharan and Valenzuela (2001), that whether the environmental damage caused by the increase in disposable income prevent the achievement of the expected health level of economic growth? Based on the empirical results of this research, although the positive effect of economic growth on health is enough to eliminate the negative effect of carbon dioxide emissions, we cannot say that the conclusions can support this argument, since the environmental damage caused by growth is far beyond air pollution.

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