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Original Article

The Relationship between Environmental Performance Index, Economic Growth and Public Health Expenditures: Panel Cointegration Approach

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Abstract

Introduction: Economic growth has a direct impact on public health expenditures; also, it indirectly affects public health expenditures through the environment's quality. Therefore, this study aimed to investigate the relationship between environmental performance index, economic growth, and public health expenditures in countries with high and very high human development index.

Methods: The present descriptive-analytical and applied study was performed on 16 countries with high and very high human development index. The time-series data required for the years 2006-2018 were extracted from the World Bank and United Nations database and environmental performance index extracted from the Yale University website. Im, Pesaran and Shin (IPS), Levin, Lin, and Chu (LLC), Augmented Dickey–Fuller (ADF)– Fisher, and Phillips-Perron (PP)–Fisher tests for stationary and Pedroni and Kao tests for cointegration were used. The study model was estimated by the DOLS cointegration method in Eviews 10 software.

Results: The mean environmental performance index for selected countries with very high and high human development index was 79.04 and 64.71, respectively; also, the elasticity of public health expenditures to gross national production, environmental performance index, physician supply, and urbanization ratio were 0.96, -2.41, 0.441 and 0.448, respectively.

Conclusion: Increasing economic growth, urbanization ratio, and physician supply had a positive effect, and improving environmental performance index had a negative effect on public health expenditures. Therefore, to reduce public health expenditures, policies are recommended to maintain environmental sustainability and reduce environmental pollutants, and to invest in advanced equipment to purify pollutant gases. Maintaining and increasing economic growth is also essential for adopting policies to increase physicians and invest in health infrastructure.

Keywords: Public Health Expenditure, Environmental Performance Index, Economic Growth.

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Introduction

Achieving higher economic growth and sustainable development is the ideal goal of all nations and is an important factor for the sustainability of the quality of the environment and public health system (1). High economic growth combined with industrialization, greenhouse gas emissions, mining, and extraction from natural resources leads to environmental degradation, and environmental degradation can undermine public health indicators (1-3); health care costs in countries have increased due to poor environmental performance in terms of higher carbon dioxide, greenhouse gas emissions, and industrialization (2). On the other hand, economic growth by increasing the ability to pay for health expenditures can lead to improved health indicators, so although economic growth directly leads to improved public health, it can indirectly and through the environment have a negative impact on public health. Therefore, in general, economic growth and environmental quality are two important factors on the health status of society so that the study of their effects on public health expenditures is important and necessary.

Along with economic growth and increasing environmental pollution, the households' demand for health care and services has increased, which has also led to increased health expenditures. In fact, in most countries, the growth of health expenditures has outpaced economic growth (4-6), and the rate of air pollution in developing countries is often several times higher than in developed countries (1). In general, environmental degradation leads to chronic lung diseases, decreased mental and work efficiency, nervous tension, and physical and mental fatigue, which affect the health and medical costs of the society. Environmental changes such as climate change also affect the performance of ecosystems as well as human health (7). On the other hand, improving the performance of the environment leads to improvement of the health status of people through clean air and reducing greenhouse gas emissions, as well as increasing productivity and efficiency of the workforce (2). Therefore, examining the relationship between health expenditures and the environment has become a necessity due to the prevalence of infectious diseases due to air pollution and high temperatures.

Recent studies by Narayan and Narayan (8) for OECD countries have stated that in short-term, income and carbon monoxide emissions have a positive effect on health expenditure. Zaidi and Saidi (7) for sub-Saharan Africa using the panel ARDL method showed that economic growth had a positive effect and the emission of carbon dioxide and nitrogen dioxide had a negative effect on health expenditures in the long-term. Hao et al. (1) stated that air pollution (sulfur dioxide) and Gross Domestic Product (GDP) led to an increase in health expenditure in China. Government expenditures, education, number of physicians, and hospital beds also affect health expenditures. Raeissi et al. (6) for Iran, Badulescu et al. (4) for European countries, Blazquez Fernandez et al. (9) for OECD countries, and Khoshnevis and Khanalizadeh (10) for MENA countries also stated that economic growth and air pollution had a positive effect on health expenditures in the long term. Nafngiyana et al. (11), using the dynamic simultaneous equations, and the GMM-System Estimator and GMM Arellano-Bond method for 10 ASEAN member countries, showed that there was a simultaneous relationship between CO2 emotions and health expenditures, and economic growth led to increased air pollution emissions as well as increased health costs.

Unlike previous studies, in this research, the environmental performance index was used to measure the quality of the environment. This index is a composite index published by Yale and Columbia University on environmental protection. According to the Yale University report in 2020 (12), it has two main criteria of Health and Ecosystem Vitality and 11 categories, which includes a total of 32 indicators and focuses on two main objectives of environmental protection, including reducing environmental pressures for human health and improving the condition of ecosystems and proper resource management. The range of this index is between zero and one hundred, with zero being the worst case and 100 being the best statues.

Identifying the factors affecting public health expenditures can be useful and effective in determining the best policies to control and manage health expenditures. Also, given that the process of economic growth and development trend has led to environmental degradation and increased health expenditures in the world, the main aim of this study was to investigate the relationship between economic growth, environmental performance index and public health expenditures in countries with high and very high human development index (HDI); we also sought to investigate the effect of economic growth and environmental performance index on public health expenditures and determine the elasticity of public health expenditure to economic growth and the environmental performance index.

Methods

The present descriptive-analytical and applied study was performed for countries with high and very high HDI. Among the countries with high and very high HDI, according to the United Nations classification in 2020, 16 countries (eight with high HDI and eight with very high HDI) with the highest HDI were selected. The data required for the study was an annual time series that was extracted from various databases for the year 2006-2018. Per capita public health expenditures, GDP per capita, number of physicians per 10,000 populations, urbanization ratio, and average years of schooling were extracted from World Bank databases (13), and the Environmental Performance Index were extracted from the Yale University website (12). The estimation of the models and tests was conducted in Eviews 10 software.

To estimate the impact of economic growth and environmental performance index on public health expenditures, first, based on theoretical foundations and previous studies, the factors affecting public health expenditures were selected and then the model coefficients were estimated by Dynamic Ordinary

Least Squares (DOLS). According to theoretical foundations and previous studies, economic growth and indicators of environmental degradation are among the most important factors affecting public health expenditures; in this study, based on other studies (1, 4, 6, 7, 10, 14), the per capita GDP and environmental performance index variables were used as a proxy of economic growth and environmental quality, respectively. The Environmental Performance Index is a composite index published by Yale and Columbia University on environmental protection. Since this index is reported biennially, the average of the years before and after it was used for the year when the index was not reported. Since some social variables such as urbanization ratio and education level may affect public health expenditures by affecting health conditions (1, 7, 15, 16), these variables were also included in the model. Health resources are another important factor in health status (1, 17, 18). In this study, the number of physicians and that of hospital beds were included in the model as health resources, but since the hospital bed variable was not statistically significant, it was excluded from the model; therefore, the model of the present study based on previous studies (1, 2, 7, 11, 14) was as follows:

$$\ln GHE = \alpha + \beta_1 \ln GDP + \beta_2 \ln EPI + \beta_3 \ln EPI^2$$
$$+ \beta_4 \ln PHY + \beta_5 \ln URBAN)$$

InGHE: Natural logarithm of per capita public health expenditure (PPP)
LnGDP: Natural logarithm of per capita GDP (PPP)
lnEPI: Natural logarithm of the environmental performance index
lnEPI2: The second power of the natural logarithm of the environmental performance index
InPHY: Number of physicians per 10,000 populations
InURBAN: Ratio of urbanization (% total population)

lnGHE is the dependent variable and the rest of the variables are the independent variables. Before estimating the above model, the test for cross-sectional dependence in panel-data, the stationary of the variables and the existence of a cointegration vector between the model variables must be determined. To test the cross-sectional dependence, the Pesaran CD test was used. In this test, null hypothesis was cross-section independence. The stationary tests of variables are necessary to ensure the absence of spurious regression coefficients; for this purpose, unit root tests of panel data such as Im, Pesaran and Shin (IPS), Levin, Lin and Chu (LLC), Augmented Dickey–Fuller (ADF)– Fisher, and Phillips-Perron (PP) – Fisher were used (19-22). In these tests, the null hypothesis indicates the unit root or non-stationary nature of the variables. Therefore, if the calculated value of the test is greater than its critical value, the null hypothesis based on the non-stationary nature of the variable at the desired significance level is rejected and the variable is stable.

Panel Data cointegration tests such as Pedroni and Kao were used to examine the cointegration between the variables (19-21). In these tests, the null hypothesis is that there is no cointegration, and the number of optimal intervals was determined based on Schwartz criteria. The most popular test in panel cointegrating test is the Pedroni test. Pedroni (1999) derives seven panel cointegration statistics. To test the null hypothesis of no cointegration, $p_i=1$, the following unit root test is conducted on the residuals as follows: $\varepsilon_{it} = \rho\varepsilon_{it-1} + u_{it}$. The first category of four statistics is defined as within-dimension-based statistics and includes a variance ratio statistic, a non-parametric Phillips and Perron type statistic, a non-parametric Phillips and Perron type *t*-statistic and a DF type *t*-statistic. The second category of three panel cointegration statistics is defined as between-dimension-based statistics and is based on a group mean approach (23). Kao (1999) also presented the generalized Dickey fuller cointegration test, assuming that the cointegration vectors were homogeneous at any point. Therefore, if the variables are cointegration, the error terms will integrate of zero order I(0), and if the variables are not cointegration, the error terms will integrate of one order I(1).

To estimate the mentioned model, considering that the time series data were less than the cross-sectional data (T<N) and also regarding the effect of the dependent variable from its previous values, we

Selected the panel cointegration method using the DOLS method. Another advantage of this method is that DOLS has the lowest square root mean square error among all cointegration vector regression estimators. Also, the residues obtained from this method are not correlated with any of the independent variables and are suitable for correcting the problem of endogenousness and autocorrelation (24).

Results

The results of descriptive statistics showed that the average LNEPI for selected countries with very high HDI was 4.37, which was equivalent to 79.04 for the EPI variable, and the average for selected countries with high HDI was 4.17, which was equivalent to 64.71 for the EPI variable. The mean of the model variables (no natural logarithm) for each of the countries studied during 2006-2018 were presented in Table 1.

Table 1: Mean of model variables for countries during 2006-2018

	GHE	GDP	EPI	EPI2	PHY	URBAN
Norway	4706.26	63665.43	80.91	6546.13	42.41	79.96
Switzerland	1971.89	56663.76	86.41	7467.15	40.26	73.65
Sweden	3676.56	44605.27	83.19	6920.39	41.91	85.75
Germany	3558.84	42227.65	78.18	6112.40	38.81	76.97
Ireland	3464.12	51510.16	75.07	5635.54	28.59	61.94
Australia	2675.97	42639.14	75.69	5729.00	32.34	85.38
Iceland	3092.52	43556.39	81.93	6712.17	36.97	93.57
Netherlands	3200.97	46865.52	74.58	5562.14	34.85	88.10
Denmark	3826.05	45578.75	77.62	6024.69	37.12	87.07
Trinidad and Tobago	811.25	30553.04	61.68	3804.46	19.57	53.80
Iran	489.25	17607.46	59.61	3553.68	10.02	71.65
Mauritius	339.41	17005.13	71.69	5139.33	15.64	41.35
Panama	797.74	17762.46	68.92	4750.42	14.79	65.77
Albania	390.99	10170.06	69.00	4761.33	12.11	54.08
Georgia	143.45	8209.35	61.32	3759.61	47.70	56.28
Sri Lanka	169.20	9428.20	63.04	3974.22	8.15	18.27
MEAN	2082.15	34252.99	73.05	5403.29	28.83	68.35

Source: Authors' calculations

According to Table 1, the means of GHE, GDP, EPI, EPI2, PHY and, URBAN variables for all study countries were 2082.15, 34252.99, 73.05, 5403.29, 28.83 and 68.35, respectively. Also, all variables' values were higher for countries with very high HDI than for those with high HDI. The first stage before doing any other tests in panel data econometrics is finding the cross-sectional dependency or independency. For this, Pesaran CD test was used, and the results showed that null hypothesis was not rejected; therefore, all the variables had cross-sectional independency. After checking the cross-sectional independency, it is necessary to check the variables' stationary and select the appropriate model based on it. The stationary of the variables was conducted by Levin, Lin Chu (LLC), Im, Pesaran and Shin (IPS), ADF Fisher Chi-square and PP Fisher Chi-square tests, as shownin Table 2.

According to Table 2, some of the model variables were stable at the level and others were stable at the first-order difference, so there is a possibility of cointegration between the model variables. Pedroni and Kao tests were used for cointegraiton investigation. Pedroni test results are presented in Table 3.

Table 2: Panel unit root test results

Variables	Levin, Lin& Chu	Im, Pesaran and Shin	ADF - Fisher Chi-square	PP - Fisher Chi-square
lnGHE	-7.087***	-1.802**	51.091***	57.277***
lnGDP	-3.203	1.756	17.360	18.880
DlnGDP	-7.271***	-6.787***	101.368***	96.156***
lnEPI	-6.210***	-4.355***	73.921***	24.734
$LnEPI^2$	-6.250***	-4.382***	74.311***	24.728
lnPHY	-2.065***	1.152	22.418	20.324
DlnPHY	-9.110***	-7.388***	108.340***	103.195***
lnURBAN	-6.998***	-3.212***	61.965***	131.549***

The optimal lag length was selected automatically using the Schwarz information criteria. * Significance at 10%., ** Significance at 5%., *** Significance at 1%. D=1'st difference; Source: Authors' calculations

Table 3: Pedroni test results

Within dimension	Statistic	Between dimension	Statistic
Panel v-statistic	-1.80	Group p-statistic	4.91***
Panel p-statistic	3.28	Group PP-statistic	-9.03***
Panel PP-statistic	-3.26***	Group ADF statistic	-3.80***
Panel ADF-statistic	-2.85***		

***Significance at 1%. Source: Authors' calculations

Table 4: Results of model estimation by DOLS method

Variables	Coefficient	Std. Error	Prob.
LNGDP	0.9615	0.2780	0.0008
LNEPI	-2.4174	0.8884	0.0078
LNEPI2	-0.2518	0.1093	0.0234
LNPHY	0.4418	0.2209	0.0485
LNURBAN	0.4488	0.2579	0.0852
R-squared=0.99	Adjusted R-squared= 0.984223	Jarque-bera=20.82 Probability=0.00003	

Source: Authors' calculations

The results of Table 3 showed that the two statistics Panel PP-statistic and Panel ADF-statistic from the statistics of the within dimension and all three statistics of the between dimension rejected the null hypothesis, indicating that there is no cointegration. Therefore, according to the Pedroni test, there was a cointegration vector between the model variables. The Kao test results also showed that the value of t-statistic was equal to -3.67, which rejected the null hypothesis that there is no cointegration, with a probability of 0.0001. Therefore, based on both Pedroni and Kao tests, there was a cointegration vector between model variables. The DOLS method was used to estimate this vector, and the results are presented in Table 4. Stability and diagnostic tests were also performed after model estimation. R-squared was equal to 0.99 which is a sign of good fitting of the model. Jarque bera was equal to 20.82 which showed that the residuals were normal. The stationary test of residuals was also performed. The results of Levin, Lin, and Chu (LLC), Im, Pesaran and Shin (IPS) tests, ADF-Fisher Chi-square and PP-Fisher Chi-square test showed that the unit root assumption of residuals was rejected, so the residuals of the model were stable. Therefore, there were no spurious regression coefficients, and the estimated coefficients of the model were efficient.

Table 4 showed that all model variables were significant at the 0.05 level and the LNURBAN variable was significant at the 0.10 level. Since all variables in the model are logarithmic natural, the coefficients can be expressed as elasticity. The LNGDP coefficient was 0.9615, which indicates that the elasticity of public health expenditures to GDP is 0.9615. The LNEPI coefficient was -2.4174, which indicates a negative relationship between public health expenditure and environmental performance index. In other words, if the environmental performance index increases by one percent, public health expenditure decreases by 2.41 percent. Besides, LNEPI2 coefficient showed that the elasticity of public health expenditures to the second power of environmental performance index was 0.2518. The elasticity of public health expenditures compared to the number of physicians was equal to 0.44, namely with a one percent increase in the number of physicians, public health expenditures increased by 0.44 percent. Also, the elasticity of public health expenditures to the ratio of urbanization was equal to 0.44. Therefore, if the proportion of the urban population to total population increases by one percent, public health expenditures will increase by 0.44 percent.

Discussion

The results showed that there was a negative relationship between public health expenditures and environmental performance index among countries with high and very high HDI. This result was expected as one of the criteria of environmental performance index was the effect of air pollution on human health; the higher this impact, the lower the environmental performance index will be, and finally these conditions are expected to increase health expenditure. Khan et al. (2) and Shahraki and Ghaderi (14) stated that increasing the environmental performance index had a negative impact on public health expenditures, and environmental sustainability improved the health and increased the economic growth. Also, improving the environmental performance of countries reduced the health expenditures and strengthened the economic activities. In addition, it attracted foreign investment and improved the country's situation in the international arena. Charfeddine (25) stated that poor environmental performance was directly related to rising health costs and that human life was at risk due to air and water pollution. Many studies have also shown the positive effect of air pollution emissions on health and public health expenditures (1, 4, 6, 10), which is consistent with the results of this study in terms of decreasing environmental performance index due to increasing pollution. However, higher public health expenditures and poor environmental performance are detrimental to economic activity in terms of inefficiency and low labor productivity (2).

The results also showed that economic growth had a positive effect on public health expenditures and the elasticity of public health expenditures to GDP was estimated at 0.96. Increasing production and income will not only lead to investing in more production in the future, but will also lead to an increase in household spending with the purchasing power they create for individuals, which will be part of this increase in health expenditures. Therefore, it is expected that as production and national income increase, people who care about their health will increase their health expenditures and increase public health expenditures by creating demand for health care. Experimental studies also confirmed this positive association. Badulescu et al. in 2019 (4) estimated this elasticity at 1.145 and stated that GDP growth had the greatest impact on increasing long-term health expenditure in EU countries and that per capita GDP growth was necessary to support the rising health expenditure. If this increase is unstable, it will not be able to deal with the negative effects of environmental pollution on human health. Raeicie et al. in 2018 (6) stated that in Iran, the elasticity of public and private health expenditures to GDP was 0.51 and 0.43, respectively. Khoshnavis and Khanalizadeh in 2017 (10) estimated this elasticity for the MENA member countries as 0.66. Hao et al. (1) obtained different coefficients for this elasticity for China with different air pollution scenarios, but in all of these scenarios this elasticity was more than one. Zaidi and Saidi (7) for sub-Saharan Africa confirmed this positive relationship in the long term.

The negative relationship between the economic growth and public health expenditures is also perceived in such a way that increasing economic growth leads to a decrease in public health expenditures (1). However, this relationship is achieved in very high stages of economic growth and for developed countries. One of the reasons for this relationship can be considered in the more attention of people in these countries to their health status and society; to achieve this change, changes in lifestyle, increased exercise and healthy eating can reduce the risk of acute and chronic diseases and finally public health expenditures.

The results also showed that the number of physicians per ten thousand population had a positive effect on public health expenditures; it is arguable given that physicians' training is usually funded by the public sector. Increasing health resources, especially training new physicians and hospitals, is costly and are usually done and legislated by governments, thus leading to increased public health expenditures (26, 27). Also, increasing the number of physicians and hospital beds, which will facilitate access to medical care and potentially reduce the cost of family health care, can reduce private health spending. Hao et al. (1) stated that the increase in the number of doctors and hospital beds had reduced the health expenditures. Despite the positive effect of physician supply on public health expenditures, the increase in the number of physicians has led to improved health status in various countries. Hosseini et al. (17) and Or et al. (28) for OECD countries showed that the number of physicians had a direct impact on life expectancy. Liebert and Mader (29) showed that increasing one physician per thousand populations could reduce the children mortality rate by 23% and the infant mortality rate by 16%. It should be noted that although increasing the supply of physicians has led to improved health in the world, there is a risk of induced demand (increased healthcare costs) by increasing the supply of physicians and exposing the patients to unnecessary health services.

This study also had some limitations. Because the environmental performance index data has been calculated and published for countries since 2006, this study was limited to the period of 2006 to 2018. Also, the variables of the number of hospital beds and mean years of schooling were not statistically significant and were not included in the model. Moreover, the model is not complete and there are many other variables that affect health expenditures that were not examined for various reasons such as lack of data access or missing data. Finally, this is an ecological study (at the macro level), so care should be taken in interpreting and using the results.

Conclusion

This study aimed to investigate the relationship between economic growth and environmental performance index with public health expenditures. The results showed that there was a negative relationship between general health expenditures and environmental performance index among countries with high and very high HDI. Also, GDP, urbanization ratio and number of physicians had a positive effect on public health expenditures, of which GDP had the greatest impact on public health expenditures. Given that the increase in environmental performance index led to a decrease in public health expenditures, measures should be taken to increase and sustain the environmental performance index and reduce environmental pollutants. In this regard, legislation to limit the activities of industries that have excessive pollution, increase in taxes and pollution tariffs for these industries to reduce the negative consequences of their products, and investing in advanced equipment to purify pollutant gases will be beneficial. Besides, investing in information technology infrastructure is also necessary to reduce environmental degradation and public health costs. In addition, considering the positive impact of economic growth and the supply of physicians on public health expenditures, it is recommended to maintain and increase the economic growth so that governments can adopt policies to increase the number of physicians and invest in health infrastructure.

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