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CO2 Emissions, Health Expenditures and Economic Growth in Iran: Application of Dynamic Simultaneous Equation Models

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ABSTRACT

Introduction: Studies on the causal dynamics between the environment, health expenditures, and economic growth have recently started in the economics literature for both developing and developed countries.

Methods: This study examines the causal relationship between CO_2 emissions, health expenditures, and economic growth, using dynamic simultaneous equation models for Iran over the period 1972–2012.

Results: Our empirical results show that there is a bidirectional relationship of causality between CO_2 emissions and economic growth. There is also a unidirectional relationship of causality from health expenditures to economic growth. The positive bidirectional causality relationship between CO_2 emissions and economic growth will be very important for environmental quality over the next few years in Iran.

Conclusion: It is clear that the government would like to increase economic growth over the period of the next Five-Year Development Plan. It seems that policymakers must examine the requirements for investment to promote environmental protection and increase technological transfers to reduce environmental damage.

Keywords: CO_2 emissions, Health expenditures, Economic growth, Dynamic simultaneous equation models, GMM.

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Introduction

The nexus between the environment, health expenditures, and economic growth has recently been the subject of considerable academic research. This causal relationship—between the environment, health expenditures, and economic growth—can be categorized into three testable hypotheses: the unidirectional hypothesis, the feedback hypothesis, and the neutrality hypothesis. The first strand relates to the unidirectional hypothesis. First, numerous studies confirm the feedback hypothesis for the nexus between CO_2 emissions and GDP.[1–3] Some studies have supported a unidirectional causal relationship from GDP to CO_2 emissions.[4] Second, some researchers confirm the feedback hypothesis for the nexus between health expenditures and GDP.[5, 6] On the other hand, some studies have confirmed the unidirectional causal relationship from health expenditures and GDP.[7, 8] Third, several studies have presented mixed results about the causal relationship between CO_2 emissions and economic growth.[9–11]

A survey of empirical studies in developed and developing countries shows that many economists have studied the relationship between health and economic growth. The effect of health on economic growth was first identified by a series of works by Fogel, who argued that around one- third of the economic growth in England over the last 200 years was the result of improvements in nutrition and health.[12] Mayer studied the long-run impact of health on economic growth in 18 Latin American countries.[13] Growth regressions, adapted as Granger-type causality tests, give strong evidence of a 30-year causality from health to income in these countries. In addition, Culyer studied individual OECD countries, using pooled data, and found a significantly positive correlation between healthcare expenditure and GDP.[14]

Murthy and Ukpolo probed the factors affecting average individual healthcare expenditure in the United States using a cointegration test, and the results of the regression analysis indicated that the income elasticity of healthcare expenditure is significantly different from the analytical results obtained from cross-sectional data.[15] Bloom et al. estimate a production function model of aggregate economic growth, including two variables of work experience and health, for a panel of 104 countries.[16] The results show that good health has a positive, sizable, and statistically significant effect on aggregate output. Li and Huang examine the augmented Mankiw, Romer and Weil’s model, which considers both health and education in human capital in the framework of the Chinese economy.[17] The empirical evidence shows that both health and education have positive significant effects on economic growth. Narayan et al. investigate the relationship between health and economic growth for five Asian countries using a panel long-run estimator for the period 1974–2007.[10] They find that health contributes positively to economic growth in the long run.

According to the Environmental Kuznets Curve (EKC) hypothesis, as output increases, carbon dioxide emissions increase as well till some threshold level of output is reached, after which these emissions begin to decline.[18] The main reason for studying carbon emissions is that they play a focal role in the current debate on environmental protection and sustainable development. Economic growth is also closely linked to energy consumption since higher levels of energy consumption lead to higher economic growth. However, it is also likely that more efficient use of energy resources requires a higher level of economic growth.

Numerous scholars have examined the “inverted-U-shaped” link (popularly called the Environmental Kuznets Curve or EKC) between economic growth and environmental degradation. Grossman and Krueger showed economic growth Granger causes environmental degradation in the early phase of development and, after a threshold level of development, economic activity triggers improvement of the environs, probably as a result of environmental awareness.[19] The studies that have also tested the existence of EKC are (among others): [20–24]. However, there is no consensus in these studies in terms of sign, magnitude and significance of the coefficients.

Generally, much less attention from academic researchers has been paid to the relationship between health expenditures and CO_2 emissions compared to the relationship between health expenditures and economic growth, as also economic growth and CO_2 emissions. Chaabouni and Zghidi have recently studied the causal relationship between CO2 emissions, health expenditures, and economic growth using dynamic simultaneous equation models for a global panel of 51 countries over the period 1995–2013.[1] The study also implements these empirical models for three groups: low income group, lower middle income group, and upper middle income group countries. Empirical results show that there is bidirectional causality between CO2 emissions and economic growth, between health expenditures and economic growth for the global panel, and unidirectional causality from CO2 emissions to health expenditures, except low income group countries. Most of the earlier studies focused on the cause effect from CO_2 emissions to health expenditures.[15, 25–33] However, they have focused on the two-way causation between health expenditures and CO_2 emissions.

The purpose of this paper is to shed light on the causal relationship between CO_2 emissions, health expenditures, and economic growth in Iran. It is clear that much less attention from academic researchers has been paid to the nexus between the environment, health expenditures, and economic growth compared to health expenditures and economic growth. From the survey of these literatures in Iran, it can be concluded that many academic researchers have focused their analysis on the relationship between health expenditures and economic growth while using the single-equation method.[34–36] This study contributes to this literature by examining the causal relationship between CO_2 emissions, health expenditures, and economic growth in Iran. We, for the first time (compared to previous literature in Iran), use simultaneous equation models estimated by the Generalized Method of Moments (GMM).

Methods

Following Chaabouni and Zghidi, the relationship between CO_2 emissions, health expenditures and economic growth is modeled using the production function.[1] Output (Y) can be written as a function of CO_2 emissions (CO_2), health expenditures (H), capital (K), and labor (L):

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} H_t^{\gamma} CO2_t^{\delta} e^{\varepsilon t} \quad (1)$$

In Equation (1), we divide both sides by population to obtain all series in per capita terms. It can be rewritten as:

$$Y_t / L_t = A_t (K_t / L_t)^{\alpha} (H_t / L_t)^{\gamma} (CO2_t / L_t)^{\delta} e^{\varepsilon t} \quad (2)$$

The natural logarithm of Eq. (2) gives the following equation:

$$Log (Y_t / L_t) = Log (A_t) + \alpha Log (K_t / L_t) + \gamma Log (H_t / L_t) + \delta Log (CO2_t / L_t) + \varepsilon_t \quad (3)$$

The production function in Eq. (3) is modeled by keeping the technology constant [i.e. Log (At) = a]. We have:

$$Log (Y_t / L_t) = a + \alpha Log (K_t / L_t) + \gamma Log (H_t / L_t) + \delta Log (CO2_t / L_t) + \varepsilon_t \quad (4)$$

Y stands for gross domestic product (GDP); A is the level of technology; K is the flow of services provided by the existing capital stock rather than the capital stock itself; H indicates health expenditures; CO_2 the environmental quality, ε is the error term; and α, γ and δ measure the elasticity of output with respect to physical capital, health and CO_2 emissions respectively.

The production function in Eq. (4) is then used to obtain the appropriate specifications to simultaneously examine the nexus between per capita GDP, per capita CO_2 emissions, and per capita health expenditures. These empirical models are also constructed on the basis of the theoretical and empirical insights from the previous studies. The estimation of the three-way linkages between CO_2 emissions–health expenditures–growth, stock capital (K), population ageing (POP), urbanization (U) and trade openness (TO) is considered, with these as instrumental variables.

For a better understanding of the dynamic relationship between CO_2 emissions, health expenditures and economic growth, the following corresponding simultaneous Equations (5) to (7) need be considered:

$$\text{Log}(GDP_t / L_t) = \alpha_0 + \alpha_1 \text{Log}(GDP / L)_{t-1} + \alpha_2 \text{Log}(K_t / L_t) + \alpha_3 \text{Log}(H_t / L_t) + \alpha_4 \text{Log}(CO_{2t} / L_t) + \varepsilon_t \quad (5)$$

$$\text{Log}(H_t / L_t) = \beta_0 + \beta_1 \text{Log}(H / L)_{t-1} + \beta_2 \text{Log}(GDP_t / L_t) + \beta_3 \text{Log}(CO_{2t} / L_t) + \beta_4 \text{Log}(POP_t) + \varepsilon_t \quad (6)$$

$$\text{Log}(CO_{2t} / L_t) = \gamma_0 + \gamma_1 \text{Log}(CO_2 / L)_{t-1} + \gamma_2 \text{Log}(GDP_t / L_t) + \gamma_3 \text{Log}(H_t / L_t) + \gamma_4 \text{Log}(U_t) + \gamma_5 \text{Log}(TO_t) + \varepsilon t \quad (7)$$

First, a number of alternative tests is available to test whether a series is stationary. Usually, the augmented Dickey Fuller (ADF) and Phillips and Perron tests have been used by researchers.[37, 38] This study used the ADF test to find the unit roots in time series. An indication of whether the researcher should supplement ADF tests by also using the adjustments proposed by Phillips and Perron can be gained by an inspection of the diagnostic statistics from the ADF regression.[38, 39]

The estimation procedure of our dynamic models in Eqs. (5)–(7) is an application of the specifications of the dynamic model. The one-period lagged levels of the endogenous variables, such as CO_2 emissions, health expenditures, and economic growth, can influence their current levels. According to Arellano and Bond, this estimation procedure is equivalent to the Generalized Method of Moments (GMM) estimator, which is both a single-equation and system estimator.[40]

The system GMM itself is an augmented version that was first outlined in Arellano and Bover and fully developed in Blundell and Bond.[40] The GMM estimator is a robust estimator, since it does not require information about the accurate distribution of error terms. It also helps correct endogeneity bias (time-varying component) via instrumenting the explanatory variables. This study, therefore, adopts the system GMM regression approach to implement the empirical estimations.

Results

As the first step, we first conduct the augmented Dickey Fuller (ADF) test to establish the order of integration for the per capita GDP, CO_2 emissions, health expenditures, stock capital, population aging, urbanization, and trade openness series. The results of the unit root tests are presented in Table 1. The results show that only the “health expenditures” and “population aging” variables are stationary at level, but other variables are stationary at first difference. These results do not enable us to test the cointegration among variables.

Table 1. Results of unit root test

Series	Order	ADF[1]
GDP	Level	-1.3816
	1st difference	-4.3810
CO_2 emissions	Level	-2.5297
	1st difference	-5.5843
Health expenditures	Level	-6.8543
	1st difference	--
Stock capital	Level	-1.7529
	1st difference	-5.0280
Population ageing	Level	-2.9573
	1st difference	--
Urbanization	Level	-1.4852
	1st difference	-3.8387
Trade openness	Level	-2.8542
	1st difference	-7.3223

1 Augmented Dickey-Fuller unit root test, denotes significance at 5

According to the results of the unit root tests, we employ the Arellano and Bond GMM approach to estimate Eqs. (5)–(7).[40] Table 2 presents the results estimated for the system. The findings show that there is evidence of one relationship of bidirectional causality between CO2 emissions and economic growth. This finding supports previous studies.[1, 11] This result shows that CO_2 emissions and economic growth are highly interrelated with each other in Iran. In addition, there is evidence of a unidirectional causal relationship from health expenditures to economic growth without feedback. However, there is no significant causality between CO_2 emissions and health expenditures.

Table 2. Empirical results for simultaneous equations model

	Model 1 GDP	Model 2 Health expenditures	Model 3 CO_2 emissions
GDP	-	-0.109	0.273***
GDP(-1)	0.532***	-	-
CO_2 emissions	0.450***	0.574	-
CO_2 emissions (-1)	-	-	0.382***
Health expenditures	-0.052***	-	0.021
Health expenditures (-1)	-	0.868***	-
Capital stock	0.173***	-	-
Urbanisation	-	-	-0.346
Population ageing	-	0.520***	-
Trade openness	-	-	0.072***
Constant	2.902***	-7.807*	-0.305
Adjusted R-squared			

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Discussion

In Model 1, we found that economic growth is positively and significantly influenced by CO2 emissions at the 1% level. A 1% increase in CO2 emissions increases economic growth by around 0.45%. Our empirical evidence is in line with previous studies.[1, 10] Economic growth is also negatively and significantly affected by health expenditures (at 1%). Thus, the health expenditures cannot lead to social security, efficient resource allocation, and better economies of scale, which can stimulate economic growth in Iran. According to the theory, the capital stock also has positive and significant impacts on economic growth.

In Model 2, we found that only the effect of population aging on health expenditures is statistically significant, and the effects of economic growth and CO2 emissions on health expenditures are not statistically significant. A 1% increase in population aging raises the health expenditures by 0.520% in Iran.

Finally, in Model 3, economic growth has a positive and statistically significant impact on CO2 emissions. A 1% increase in the economic growth increases CO2 emissions by 0.273%. Our empirical evidence supports previous studies.[1, 22] CO2 emissions are also affected positively and significantly by trade openness, since a 1% increase in trade openness increases the CO2 emissions by around 0.07%.

Conclusion

The literature that examines the relationship between health expenditures and economic growth, and economic growth and CO_2 emissions, is growing. However, much less attention from academic researchers has been paid to the relationship between health expenditures and CO_2 emissions. In addition, most authors have studied the cause and effect from CO_2 emissions to health expenditures and little is known about the causal dynamics between the environment, health expenditures, and economic growth in Iran till now. Our aim was to contribute to this literature from this perspective. Therefore, the paper examined the relationship between CO_2 emissions, health expenditures, and economic growth for Iran over the period 1972–2012. We have investigated the simultaneous causal relationships between CO_2 emissions, health expenditures, and economic growth by using simultaneous equation models.

Our empirical results showed that there is a bidirectional causality relationship between CO_2 emissions and economic growth. This result supports previous studies.[1, 2] There is also a unidirectional causality relationship from health expenditures to economic growth. This evidence is in line with previous studies.[8] The positive bidirectional causality relationship between CO_2 emissions and economic growth will be very important for environmental quality in the next few years in Iran. It is clear that government would like to increase economic growth over the period of the next Five-Year Development Plan. On the other hand, the control of environmental damage is currently one of the very important problems in Iran. It seems that policymakers must examine the requirements for investment to promote environmental protection and increase technological transfer to reduce environmental damage. The results of this research can certainly be used as usefully effective policies to improve economic growth and development while considering both the environment and health in Iran.

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Conflict of Interest

No conflict of interest was reported by the authors.

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