

Investigation on the Factors Affecting Air Pollution Emissions in Caspian Sea Countries: Panel Spatial Durbin Model

Kiumars Shahbazi¹, Davoud Hamidi Razi^{2*}, Majid Feshari³

1. Associate Professor, Faculty of Economics and Management, University of Urmia, Iran
(k.shahbazi@urmia.ac.ir)
2. M.A. in Economics, University of Urmia, Iran
3. Assistant Professor, Faculty of Economic, University of Economic Sciences, Iran
(m.feshari@ues.ac.ir)

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Extended Abstract

Introduction

Under the principles of international law, no state has the right to use or permit the use of its territory in such a manner as to cause damage to the environment of other states. Spatial econometrics provides a powerful instrument to assess the influence of the pollution of neighboring countries on a country's pollution level. Spatial spillover effects play a significant role in assessing the impact of economic growth on environmental quality, because some environmental phenomena have inherently spatial characteristic. These are flowing of polluted water, atmospheric pollution and the spread of epidemic phenomena causing spatial autocorrelation in analysis of spatial econometrics. Moreover, countries can interact strongly with each other through channels such as trade, technological diffusion, capital inflows, and common political, economic and environmental policies. The Environmental Kuznets Curve (EKC) hypothesis assumes that there is an inverted-U-shaped relationship between emissions and per capita income; In other words, emissions increases up to a certain level as income goes up; after turning point, it decreases. Some studies have suggested that the shape of the EKC is a consequence of high-income countries in effect exporting their pollution to lower-income countries through international trade. In such cases, externalities can spillover the limits among countries, contributing in the explanation of environmental effects of economic growth. According to the empirical studies ignoring spatial autocorrelation and spatial heterogeneity in econometrics analysis will lead to false statistical inference. In new conception of common environment, planet earth composed inseparable environment which all the elements are correlated together and, therefore, damage to the environment and state responsibility in this regard should not be strictly limited to national borders and territories under them. After the collapse of the USSR and the emergence of new states in the Caspian coastal area, this unique sea is affected by various pollutants. Sensitive and fragile environment of the Caspian Sea due to its situation as a closed sea and accumulation of pollutants have confronted this sea by ecological crisis.

With regard to the outline mentioned above, the main objective of this paper is to investigate the factors influencing CO₂ emissions among 11 Caspian Sea countries based on the spatial form in "STIRPAT" model. STIRPAT is summarized form of "Stochastic Impacts by Regression on Population, Affluence and Technology". To examine the hypothesis of Environmental Kuznets Curve, square of per capita income is also considered in the model. The results show a significant impact of energy intensity and urbanization on the level of per capita carbon dioxide emissions in the presence of positive spatial spillover effects of pollution and energy intensity (proxy of technology). The contributions of this study are: (a) method of estimation; (b) stipulated model; and (c) considering contiguity and inverse-distance spatial matrices to estimate the spillover effects.

Materials and Method

General specification for the spatial panel data models is:

$$y_{it} = \tau y_{it-1} + \rho W y_{it} + X_{it} \beta + \theta D X_{it} + a_i + \gamma_t + v_{it} \quad (1)$$

$$v_{it} = \lambda E v_{it} + u_{it}$$

where u_{it} is a normally distributed error term, W is the spatial matrix for the autoregressive component, D the spatial matrix for the spatially lagged independent variables, E the spatial matrix for the idiosyncratic

* Corresponding Author:

E-mail: davod.hamidi@yahoo.com

error component. a_i is the individual fixed or random effect and γ_t is the time effect. Depending on conditions, the following nested models are:

- i) The Spatial Autoregressive Model (SAR) with lagged dependent variable ($\theta=\lambda=0$)
- ii) The Spatial Durbin Model (SDM) with lagged dependent variable ($\lambda=0$)
- iii) The Spatial Autocorrelation (SAC) Model ($\theta=\tau=0$)
- iv) The Spatial Error Model (SEM) ($\rho=\theta=\tau=0$)
- v) The Generalized Spatial Panel Random Effects (GSPRE) Model ($\rho=\theta=\tau=0$).

As the standard SAR and SDM models are obtained by setting $\tau=0$ (or when panel is static). The spatial panel Durbin model occupies an interesting position in Spatial panel Econometrics. Spatial Durbin model allows simultaneously spatial interactions for dependent variable and explanatory variables. In other words, the main feature of SDM relative to other spatial models (such as; SAR and SEM) is simultaneous input of spatial lag of dependent variable and spatial lags of explanatory variables as new explanatory variables in the model. In this paper, we stipulated spatial Durbin form of "STIRPAT" model as follows:

$$I=F(A, T, U, WI, DT) \quad (2)$$

where I is Influence (per capita CO₂ emissions), A is Affluence (per capita income), T is Technology (energy intensity as proxy), U is Urbanization Degree (% of urban population in total population), WI is spatial weighted of emissions and DT is spatial weighted of technology. W and D are row standardized contiguity and inverse-distance spatial matrices, respectively. In contiguity matrix, Element ij of W is 1 if points i and j are neighbors and is 0 otherwise. But in inverse-distance matrix, element ij of D contains the inverse of the distance between points i and j calculated from the coordinate variables (longitude and latitude). Dimensions of matrices W and D are 11×11 . Since all the variables are expressed in natural logarithm, the coefficients will be representing the elasticity. Furthermore, to examine Environmental Kuznets Curve hypothesis we stipulated the following model:

$$I=F(A, A^2, T, U, WI, DT) \quad (3)$$

where A^2 is square of Affluence (per capita income). If the estimated values of coefficients of A and A^2 were positive and negative, respectively, and also statistically significant, EKC hypothesis will be accepted for the countries of Caspian Sea region. The data of this paper are obtained from World Development Indicators CD-ROM of World Bank and online database of U.S. Energy Information Administration (EIA). The 11 countries under review are: Iran, Turkey, and Russia, Central Asian countries (Tajikistan, Turkmenistan, Uzbekistan, Kyrgyzstan and Kazakhstan) and Caucasus countries (Azerbaijan, Armenia and Georgia). Empirical model has been estimated by using *Stata / SE 12.0* and *Eviews 7.0* Softwares. Also, In order to determine the latitude and longitude coordinates for inverse-distance spatial weighted matrix and contiguity matrix, Geographic Information System (GIS) has been used.

Results and Discussions

Like most of the empirical researches in economics, we start with unit root tests. The LLC and IPS panel unit root tests were run for each series. These tests were run with a constant, and constant and trend term and an automatic lags election process using the AIC with a maximum of five lags. According to LLC, all variables are stationary in level with constant value and trend. In order to investigate panel unit root test in the presence of spatial dependence, panel unit root test with cross-sectional dependence was run. In the latter panel unit root test null hypothesis is homogeneous non-stationary and alternative is heterogeneous stationary. According to both panel unit root tests all variables are stationary in level and regression will not be spurious. Then, Panel-level heteroskedasticity and autocorrelation test were run. According to Hausman test result, spatial fixed effects are more efficient than random effect. According to Equation (2) with maximum likelihood method and the fixed effect, elasticity of emissions with respect to per capita income, energy intensity and urbanization were estimated to be 0.77, 0.46 and 1.97, respectively. Spatial autoregressive elasticity and spatial elasticity of emissions with respect to energy intensity were estimated to be 0.22 and 0.31, respectively. According to Equation (3), spatial environmental Kuznets curve phenomenon has been confirmed in these countries. Thus, increase in per capita income will initially increase per capita CO₂ emission, but after a certain threshold of per capita income, per capita CO₂ emissions will continue to decrease, given that we control effects of explanatory variables.

Positive spatial spillover of pollution is confirming this issue that it is required to take steps to decrease regional pollution, because a part of this pollution is influenced by contaminations in neighboring countries. This action is only solved by collaboration and obligation of regional countries for cutting down the emissions of pollutions. The magnitude of elasticity of per capita CO₂ emissions with respect to degree of urbanization in both models (1.97, 2.19) can also show a important point that most of the emissions air pollution are explained by urbanization movements. Therefore, urban policy makers should consider this vital issue. According to the Wald test and Likelihood Ratio (LR) test, the spatial coefficients are significant at 1% level and Spatial Durbin Model has correctly stipulated.

Conclusion

In this study, by the use of spatial panel Durbin model, the impact of per capita income, energy intensity and urbanization on per capita CO₂ emissions are assessed in the presence of spatial spillovers of pollution and technology among 11 countries around Caspian Sea during 1992-2010. The results of this study are consistent with those of similar studies that per capita CO₂ has spatial dependence and follow an inverted U pattern known as EKC (Environmental Kuznets Curve).

The Caspian Sea region has dimensions of geopolitics, geostrategic and geo-economics. These factors augmented the importance of regionalism and integration in order to achieve sustainable development in this area. There are the most important political advices for regional countries, such as the environmental common concept in the form of Caspian treaty convention (Tehran) and environmental treaties in the form of ECO (Economic Cooperation Organization). In addition to increase in per capita income, it is important that regional countries provide the substantial basis for decreasing the per capita CO₂ emissions through the rising of energy efficiency (reducing energy intensity) and improvements of urban infrastructures. Technical collaboration, especially in energy sector can be culminated in Synergy in sustainable economical development and decrease in emissions of pollutants in regional countries.

Keywords: Caspian Sea, EKC Hypothesis, JEL Classification: C23, Q53, Q14, R11, Q43, spatial Durbin model, spatial spillovers.

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