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Study the Effective Economic Factors on Diffusion of Environmental Pollutions, Case Study: Carbon De-Oxide

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ABSTRACT

One of the environmental problems in the past two decades has been raising trend of global warming and climate change resulting in destruction and environmental damage. This damage caused by a combination of factors such as population growth, economic growth, international trade and production activities, because these activities increased energy consumption in various economics sectors. The main purpose of this study was to examine the dynamic causal relationship between carbon dioxide diffusion (pollution index), energy consumption, per capita income, foreign trade and GDP of agriculture sector in Iran in 1983-2007. By using a ARDL method and error correction model (ECM), the long run and short-run relationship between variables was evaluated. Results showed a relationship between CO2 diffusion with energy consumption, per capita income and foreign trade. Economic growth, energy consumption and trade have a positive effect on CO_2 diffusion. Also, finding suggest an inverse U shape relationship between income and pollution, that confirmed environmental Kuznets hypothesis in Iran

KEY WORDS: environmental, pollution, economic growth

1. INTRODUCTION

Carbon dioxide is one of the important gases in organisms' life cycle, playing a fundamental role in plants photosynthesis cycle. Carbon dioxide is generated through breathing of plants, animals, fungi and microorganisms and then is used directly or indirectly for food production in plants to form the carbon cycle. Carbon dioxide plays an important role in the body buffering system and preserves and regulates blood PH. Any increase or decrease in the level of PH can be dangerous for human beings. As a result, it can be said that regulating PH in the body, carbon dioxide plays a vital role in the body and is an essential substance for human survival.

Iran is one of the largest producers and consumers of energy resources in the world and therefore enjoys a high potential for the emanation of CO_2. The high rate of energy consumption in Iran caused CO_2 per capita emission to be increased form 607 Kg in 1967 to 5972.6 Kg in 2006. Meanwhile, per capita emission of other toxic gases such as CO has increased from 11.2 Kg to 11.9 Kg in the same period (Energy balance sheet, 2006).

Exploration and discovery of socioeconomic factors affecting the emission of these gases is of high significance in policymaking and finding strategies and ways to reduce the emission and pollution of these toxic gases. In many studies, the relationship between carbon dioxide emissions and economic growth has been estimated as an inverted U. this relationship has been introduced as Kuznets's environmental pollution hypothesis. Therefore, the present study aims to determine the economic factors affecting CO_2 and also to test Kuznets's environmental pollution hypothesis in Iran.

Dynda (2006) examined the effect of globalization on the pollution rate, intensity, and its relative change for developed countries in the membership of the Organization for Economic Cooperation and Development countries (OECD), Non-OECD developing countries, and the entire world using a panel data method. Chaby and Bujelbon (2008) studied the relationship between CO_2 emission, energy consumption, and economic growth in Tanzania. Their study aimed to determine short-and long-term relationships among these variables in the time period of 1971 – 2004. Jiango et al., (2008) investigated the existence of Kuznets's environmental curve and its relationship with economic growth and environmental stability in China. The results of the study showed that there is a reversed U shaped relationship per capita income and per capita CO_2 emission. Olosgan (2009) examined the relationship between gross domestic production (GDP) and environmental quality in Nigeria using data related to 1970 to 2005.

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2. RESEARCH METHODOLOGY

In order to examine the relationship between the CO_2 emission, energy consumption, economic growth, foreign trade, and the ratio of GDP in the industry compared to that of agriculture sector and to test the Kuznets's hypothesis (EKC), a second order logarithmic form was employed in the form of Equation (1):

$$LnCO_{2t} = a_0 + a_1 LnEU_t + a_2 LnY_t + a_3 (LnY_t)^2 + a_4 LnOPEN_t + a_5 LnINAGRI + \varepsilon_t \quad (1)$$

Where:
$LnCO_2$: the logarithm of per capita CO_2 emission (in tons)
LnEU: the logarithm of per capita energy consumption (Kgs crude oil)
LnY: the logarithm of national income per capita (Rial /Person)
$(LnY)^2$: logarithm square of the national income per capita (Rial /Person)
LnOPEN: the Logarithm of economic openness ratio used as an index for foreign trade and is equal to the logarithm for the ratio of total exports and imports to GDP
LnINAGRI: Logarithm of the industry GDP to GDP in agriculture sector
ε_t : The regression error
Ln: the natural logarithm for variables.
It is expected that in equation (1):
1. The sign of a_1 is positive as higher levels of energy consumption will result in greater economic activities and thus resulting in more CO_2 emission.
2. Based on EKC hypothesis, it is expected that the sign of a_2 to be positive and that of a_3 to be negative. If the sign of a_3 is not statistically significant it indicates a steady increase in the relationship between per capita CO_2 emission and per capita income and, as a result, EKC hypothesis is not confirmed.
3. The expected sign of a_4 is dependent on economic development stages in a country. In developed countries, the sign is expected to be negative because they stop the production of goods resulting in the pollution and begin to import the same goods from other countries that have less restrictive laws concerning environmental protection. In developing countries, the sign is expected to be positive because these countries tend to have high pollution industries (Grossman and Krueger, 1995).

4. The sign of a_5 is positive because an increase in proportion of GDP in the industry sector over the agriculture sector will result in an increase in the pollution level.

In the present study, factors under consideration include per capita energy consumption, national income per capita (as an indicator of economic growth), foreign trade, and the GDP proportion in industrial sector to the agriculture sector. Thus the present study aims to examine dynamic causal relationships between carbon dioxide emissions, energy consumption, per capita income, foreign trade, and the GDP proportion in industrial sector to the agriculture sector in Iran in the time period of 1981 to 2007 in the form of an econometric model using collective ARDL method and also to test Kuznets's environmental pollution curve hypothesis.

3. RESULTS AND DISCUSSION

Given that the data used in the study were time series, first the process of moving data (immobility) was analyzed through Dickey and Fuller Test and Generalized Dickey and Fuller Test. Te results of immobility test of variables used in the model have been summarized in Table 2. As the table indicates, all variables except for CO_2 emission and the GDP proportion in industrial sector to the agriculture sector are static. In other words, all variables except for the two mentioned static variables are of zero degree. In order to determine the degree of immobility of CO_2 emission and the GDP proportion in industrial sector to the agriculture sector, the first order subtraction of the above variables was used. The results of Generalized Dickey and Fuller Test showed that the first order differentiation of the variables under study is static. As a result, it is concluded that CO_2 emission and the GDP proportion in industrial sector to the agriculture sector are static and first order. The results of Generalized Dickey and Fuller Test showed that all variables are static and of one and zero degrees. Thus, the prerequisites for using the collective ARDL method in order to estimate the parameters in Model (1) are satisfied.

Table 2: Immobility test of variables

	Variable name	Intercept	Process	Optimal number of interruptions	ADF Statistics	Mackinnon's Critical value	Level of significance	Results
Level	$LnCO_2$	*	*	0	-3.37	-3.60	%5	Non-static
	$LnEU$	*	*	0	-4.93	-3.60	%5	static
	LnY	*	*	2	-4.76	-3.61	%5	static
	$(LnY_t)^2$	*	*	2	-4.41	-3.61	%5	static
	$LnOPEN$	*	*	1	-4.15	-3.60	%5	static
	$LnINAGRI$	*	*	0	-0.93	-3.60	%5	Non-static
First order difference	$DLnCO_2$	*	*	0	-7.11	-2.98	%5	static
	$DLnINAGRI$	*	*	0	-5.46	-3.60	%5	static

Source: Research Findings D: represents the first order difference of variables

Results of the estimation of dynamic ARDL model have been presented in Table (3). In order to determine the optimal number of interruptions of variables, the Schwarz-Bayesian equation (SBC) was used because this equation reduces the number of interrupts. The maximum number of optimal interruptions has been determined 1 with regard to the sample size and the number of variables.

According to the estimation done via the dynamic ARDL model and the Schwarz-Bayesian equation, an optimal interruption has been determined for the dependent variable i.e. CO_2 emission and independent variables including per capita energy consumption and the square of national income per capita and a zero interruption for national income per capita, economic openness index, the GDP proportion in industrial sector to the agriculture sector.

As it is shown in the table, the determination coefficient is very high (R^2= 0.98), suggesting the explanatory power and the high fitness of the model. In addition, according to the diagnostic tests, the assumption of the nonexistence of self-correlation, non-integer incidental form, abnormality, and variance of dissonance in this model was confirmed.

Table 3: Estimation of dynamic ARDL model

Variable name	Coefficients	Standard deviation	*t* statistics
$LnCO_2(-1)$	-0.38	0.17	*-2.21*
$LnEU$	0.76	0.21	*3.60*
$LnEU(-1)$	0.55	0.23	*2.39*
LnY	0.69	0.31	*2.23*
$(LnY_t)^2$	-0.032	0.013	*-2.47*
$(LnY_t)^2(-1)$	0.007	0.004	*-1.76*
$LnOPEN$	0.13	0.03	*3.87*
$LnINAGRI$	0.23	0.34	*0.69*
C	-12.14	3.89	*-3.12*
	DW= 1.89		$R^2 = 0.98$

After the estimation of dynamic ARDL models, the presence of a long-term relationship between variables was tested. According to the table (3), if the sum of variable coefficients along with the interruption related to the dependent variable is smaller than one then the dynamic model will be oriented towards long-term equilibrium. As it is indicated by Equation (5), the desired test statistic is calculated as follows:

$$\frac{\sum_{i=1}^{P}\hat{\alpha}_i - 1}{\sum_{i=1}^{P} S\hat{\alpha}_i} = \frac{-0.38-1}{0.17} = -8.11$$

Since the critical value provided by Benreji, Dulow, and Master at 95% confidence level is equal to – 3.82 and the t-statistics is – 8.11, the null hypothesis (H_0) is rejected. Therefore, there is a long-term equilibrium relationship between variables used in the model. The results of long-term equilibrium relationship between variables are shown in Table (4).

Table 4: Results of estimates of long-term coefficients of variables used in the model

Variable name	Coefficients	Standard deviation	*t* statistics
$LnEU$	0.95	0.24	*3.93*
LnY	0.50	0.23	*2.2*
$(LnY_t)^2$	-0.018	0.009	*-2.06*
$LnOPEN$	0.093	0.024	*3.88*
$LnINAGRI$	0.17	0.25	*0.67*
C	-8.79	2.75	*-3.19*

The results of the estimation of long-term relationship between variables used in ARDL model suggest that all variables other than the GDP proportion in industrial sector to the agriculture sector are significant. As it is shown in Table 4, sensitivity or long-run tension of per capita CO_2 emissions relative to per capita energy consumption is more than that of any other variables in the model. The tension value is 0.95, indicating that a 1% increase in per capita energy consumption will lead to 0.95% increase in per capita CO_2 emissions. Besides, the positive sign of logarithm coefficient of per capita national income underlines the fact that an increase in national income per capita results in an increase in per capita CO_2 emissions or pollution levels. In other words, economic growth in Iran (a rise in per capita income) has been associated with generating and exacerbating pollution.

The significance of squared coefficient of the logarithm for per capita income in fact rejects the existence of a componential relationship between income and the release of pollution. In addition, since the sign of variable coefficient for per capita CO_2 emissions relative to the square of national income per capita is negative, it can be concluded that the relationship between income and pollution is a reversed U in the case of Iran. In other words, the Kuznets's environmental hypothesis is confirmed. It means that the level of environmental pollution at first increases with increasing income level until it reaches a return point, and then it decreases.

Long-run tension of per capita CO_2 emissions relative to the economy openness index is 0.093 which suggests a one percent increase in the economy openness index will lead to a 0.093 increase in per capita CO_2 emissions. Long-run tension of per capita CO_2 emissions relative to the GDP proportion in industrial sector to the agriculture sector is 0.17 and although it is directly associated with CO_2 emissions, this relationship is not statistically significant.

The results obtained from error correction model are summarized in Table (5). Based on error correction model estimation results it is clear that all variables except for the GDP proportion in industrial sector to the agriculture sector are significant. The signs of variable are just the same as their signs in the long term model. The error correction coefficient, ecm(-1) is significant with a negative sign. This coefficient shows the speed to reach the long-run equilibrium. The value of this coefficient is high and equal to -0.86% of the deviation (disequilibrium) of per capita CO_2 emissions out of its long-run equilibrium values after the pass of an equilibrium period.

Table 6: Results of error correction estimation

Variable name	Coefficients	Standard deviation	*t* statistics
$dLnEU$	0.77	0.21	3.61
$dLnY$	0.69	0.31	3.23
$d(LnY_t)^2$	-0.032	0.013	-2.47
$dLnOPEN$	0.13	0.033	3.87
$dLnINAGRI$	0.23	0.34	0.68
dC	-12.14	3.89	-3.12
$ecm(-1)$	-0.86	0.107	-8.003
		DW= 1.89	$R^2 =$ 0.83

Suggestions

Given the results of the model estimation, some suggestions will be provided as follows:

1. Energy as the driving force of most manufacturing and service activities has a unique position in economic development. Results of estimation of the model used in this study suggest there is a positive relationship between these two variables. Therefore, energy consumption is one of the variables affecting carbon dioxide emissions in Iran's. Iran as a developing country endowed with rich and extensive resources of energy and the existence of large oil reserves, vast underground mines and potential energies is considered as one of the examples of the development model exerting pressure on natural resources. Consequently, planning for energy production and consumption is of great importance and it should be done very carefully. The determination of the qualitative and quantitative relationship between energy consumption and carbon dioxide emissions can play an important role in compiling Iran's energy sector policies.
2. Given the positive effect of economic growth in Iran on CO_2 emissions it is recommended that policies related to economic growth in Iran are directed towards policies resulting in the efficiency of energy consumption in the economic sector. In addition, policymakers should also incorporate environmental concerns and issues more intensively in macro-economic policies to reduce pollution levels and thus will lead to sustainable economic growth.
3. Identification of pollutant industries and sectors can also help policymakers in country's economic planning which requires more extensive studies. Studying the issues related to CO_2 emissions in the form of other models such as computable general equilibrium models as comprehensive economic models can be helpful in better identification of factors and the pollutant sectors.

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