A Decomposition Analysis of CO2 Emissions Related to Energy Consumption in Iran

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Received: April, 2011 Accepted: Oct., 2011

Introduction

Carbon Dioxide emissions related to energy consumption is an important challenge for the world economy. According to reports, 84% of the total CO_2 emissions in the world are related to energy consumption. Also, 64% of green house gases emissions in the world are CO2 emissions. On the basis of the IEA scenarios (2009), the growth of CO_2 emissions related to energy consumption will continue as a result of growing demand for fossil fuels by 2030.

The CO_2 emissions related to energy consumption increased from 20.9 G.T, in 1990 to 28.8 G.T, in 2007. The forecasts of IEA in 2009 show that the CO_2 emissions related to energy consumption will increase to 34.5 G.T, and 40.2 G.T, by 2020 and 2030, respectively. Its implications are that CO_2 emissions related to energy consumption will increase on average by 1.5% in the period of 2000-2030, while the other green house gases will increase on average by 0.3%.

The Iranian resource-based structure of the economy and the energy-based production system has caused the consumption of fossil fuels and non-fossil fuels to increase. Although the interrelation between energy consumption and green house gases, especially CO_2, shows the green house gas emissions will be high in the future. The statistics show that CO_2 emissions per capita in Iran have increased from 3.6 T in 1990 to 6.9 T in 2008, while the CO_2 emissions per capita decreased in the United States and Europe.

Predictions show that the CO_2 related to energy consumption will be an important challenge for the economic future in many countries including Iran. Considering the importance of this challenge, several countries have considered decreasing the CO_2 emissions by the definition of policy tools. To achieve this goal, knowing the structure of CO_2 emissions related to energy consumption is required. In the present research, the structure of CO_2 emissions related to energy consumption at the macroeconomic and sectoral levels is considered.

Materials and Methods

The theoretical evidence shows that there is a relationship between energy consumption, CO_2 emissions and economic growth. The structure of these relations depends on the economic structure and economic development stages of the countries in question. The empirical evidence has not been considered as demonstrating the structure of the relationship between energy consumption, CO_2 emissions and economic growth.

Review of the economic literature verifies the relationship between energy consumption, CO_2 emissions and economic growth. However, this relationship has been affected by other factors such as population, composition of fuels consumed, and the carbon contents of the fuels being consumed. It is noteworthy that most studies have not paid attention to these factors. Considering the importance of this subject for gaining knowledge about the CO_2 emissions structure and the importance of using policy tools, in this paper CO_2 emissions structure using the Index Decomposition approach was studied.

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In recent years, decomposition analysis has been used as an efficient tool for the study of CO_2 emissions changes related to energy consumption. Generally, there are two approaches for decomposition analysis: Index Decomposition Analysis (DIA), an approach in which aggregated data at the macroeconomic and sectoral levels are used; and Structural Decomposition Analysis (SDA), which uses Input-Output tables. There are different techniques such as the Logarithmic Mean Divisia Index (LIMDI), Arithmetic Mean Divisia Index (AMDI), and Laspear's Index (LI) for index decomposition analysis. Among these methods, the Logarithmic Mean Divisia Index has important characteristics such as time independence, computation flexibilities, consistency in aggregation, and possibility of negative and zero computation.

In this paper, the CO_2 emissions related to energy consumption in five factors are decomposed, using the Kaya (1990) approach as follows:

$$E_t = C_t \times S_t \times I_t \times G_t \times P_t$$

Where,

E: CO_2 emission related to energy consumption,

C: carbon intensity in fossil fuels,

S: share of fossil fuels in energy consumption,

I: energy intensiveness of the economy,

G: GDP per capita,

P: total population.

Using LMDI, changes in CO_2 emissions (ΔE) for the period of t-1 and t, will be as follows:

$$\Delta E(t, t-1) = C_{eff} + S_{eff} + I_{eff} + G_{eff} + P_{eff}$$

Where:

C_{eff}: changes in C (coefficient effect),

S_{eff} : changes in S (substitution effect),

I_{eff}: changes in I (intensity effect),

G_{eff}: changes in GDP per capita, and

P_{eff}: changes in population.

These effects have been computed by LMDI as follows:

$$C_{eff} = L[E(t),E(t\text{-}1)] \times ln[c(t)/c(t\text{-}1)]$$

$$S_{eff} = L[E(t),E(t\text{-}1)] \times ln[s(t)/(s(t\text{-}1)]$$

$$I_{eff} = L[E(t),E(t\text{-}1)] \times ln[I(t)/I(t\text{-}1)]$$

$$G_{eff} = L[E(t),E(t\text{-}1)] \times ln[G(t)/G(t\text{-}1)]$$

$$P_{eff} = L[E(t),E(t\text{-}1)] \times ln[(P(t)/P(t\text{-}1)]$$

In the above equations, $L(x,y) = (x\text{-}y)/ln(x/y)$ was used for computing (estimating) L[E(t),E(t-1)].

The CO_2 emissions related to energy consumption at the macroeconomic and sectoral levels -including industry, agriculture and services- for the period of 1346-1387 was analyzed. The data were extracted from the International Institute for Energy Studies (IIES) and the Power and Energy Planning Department of the Ministry of Energy. In addition, the GDP and population data were derived from the Central Bank of Iran.

Results and Discussion

The results of decomposition analysis show that the CO_2 emissions related to energy consumption at the macroeconomic and sectoral levels increased in the period of 1967-2008 (1346-1387). Changes in GDP per capita have had a determinant effect on CO_2 emissions related to energy consumption. As a result, the achievement of economic growth goals will be accompanied by increasing CO2 emissions related to energy consumption.

The changes in population have had a positive effect and have led to an increase in CO_2 emissions for all the periods under study. As a result, the changes in CO_2 emissions are in line with the population changes. Therefore, policies for controlling population will have a positive effect on decreasing in CO_2 emissions related to energy consumption.

The share of fossil fuels in energy consumption has increased over the period 1967-1986. These changes have led to an increase in CO_2 emissions related to energy consumption. The share of fossil fuels had a negative effect on CO_2 emissions for 1987-2001 but, at the beginning of the 2000s, this share has increased and has caused an increase in CO_2 emissions. These results show that, unlike world experiences and the global shift to the use of non-fossil fuels, the share of fossil fuels in Iranian energy consumption has increased. Therefore, paying attention to alternative energy sources is necessary, to decrease CO_2 emissions in Iran.

The energy intensity of the Iranian economy has increased over a long period and this has resulted in an increase in CO_2 emissions related to energy consumption. This result shows that unlike world experiences, the energy consumption in the Iranian economy is very high. Therefore, economic policies for reducing energy consumption are necessary in order to achieve the goal of lowering CO_2 emissions.

The contribution of agricultural sector to GDP has played a decreasing role in generating CO_2 emissions. This result is in conflict with the experience of industry and services experiences. The carbon contents of the fossil fuels used in the agricultural sector has increased, unlike that of fuels used in the industry sector. These results show that on one hand agricultural growth has changed in line with CO_2 emissions, while on the other hand carbon contents of fossil fuels used in the agricultural sector caused an increase in CO_2 emissions. Hence, attention must be paid to the composition of fossil fuels and the share of fossil fuels in energy consumption in order to lower CO_2 emissions.

Key words

CO2 emissions, Energy consumption, Fossil fuels, Index Decomposition Analysis