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[Research]

The effect of higher fuel price on pollutants emission in Iran

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ABSTRACT

A key aspect of sustainable development in a country is how energy, environment and economic sectors interact. Greenhouse gas emissions and their impacts are among important environmental issues that have been in focus. The increase in the concentration of these gases in atmosphere to levels above the natural level results in global warming, depletion of the Earth's protective layer against harmful solar radiation, and threatening whole natural life. The present study aimed at examining the factors affecting CO_2 emission in Iran in 1981-2015. The studied variables included per capita CO_2 emission, fuel price, per capita production, and per capita energy consumption. The relationship was examined by auto-regressive distributed lag (ARDL) model. It was found that CO_2 emission is related to actual price of fuel indirectly and to per capita production and per capita energy consumption directly. According to the findings, 1% higher price of fuel would decrease CO_2 emission by 0.14%, while 1% higher per capita production would increase it by 0.59%. Given the effectiveness of subsidy reform policy and the increased price of fuel on the alleviation of greenhouse gas emissions by road transport sector, it is advisable to gradually increase fuel price until it reaches FOB price in the Persian Gulf.

Key words: CO_2 Emission, Environment, Fuel, Kuznets Curve, ARDL.

INTRODUCTION

When the activities of one consumer or enterprise are directly influenced by the environment of another consumer or enterprise, it is said that there is an externality (Varian 1992). The enterprises produce goods and services by exploiting economical resources like raw materials and energy. This process returns a part of the used inputs to the environment as wastage and residues. These wastages which are mostly as CO, CO_2, sulfur or solid wastes and sewage make pollutions or impose external costs (negative external impact) to society. So, each decision in economics entails opportunity costs (Abbaspour 2007). Since the 1960s, the awareness has increased among economists and policy-makers about the diminishing quality of environment and its increasing, destructive impact on climate change (Shahbaz *et al.* 2013). Given the fact that there is a trade-off between environment quality conservation and economical growth, human activities cannot be expected to continue if the constraints of natural resources and environmental pollution are neglected. In this respect, environmental economics studies the impact of economical activities on nature on the basis of the principles of economics, examines how to handle and develop environmental resources, and tries to help mankind take care of environmental considerations and sustainable development in decision-making processes aimed at technological development (Abbaspour 2007).

Atmosphere, especially CO_2, is the main source of concern about the global warming because CO_2 prolongs the durability of water vapor in atmosphere (Andrews *et al*. 2013). Carbon dioxide in metroploitan areas has posed many problems like air pollution and respiratory diseases that, in turn, can lead to the increased level of diseases and health as well as relevant expenses. Thus, studies on factors that affect its emission can help policy-makers reduce these unwanted expenses and alleviate air pollution. The aim of the present study was to study factors affecting CO_2 emission through examining the effect of fuel price, gross domestic production (GDP) and energy consumption on CO_2 emission in Iran.

CO_2 emission has been already studied in Iran, but these studies have mostly focused on the relationship between carbon emission and production as well as the Kuznets hypothesis test, ignoring the impact of the pricing of energy carriers as one major cause of pollution. In addition to examining the effect of production on carbon emission, the present work focuses on the impact of fuel price on it.

The relationship between economic growth and environment quality has been subjected to a lot of studies, of those the environmental Kuznets curve (EKC) can be mentioned as the most famous one. The concept of the curve has been derived from Kuznets (1995) idea about the presence of an ∩-shape relationship between per capita income and income distribution inequality. It was first introduced in the 1990s when Grossman & Krueger (1991) studied the potential environmental impacts of North American Free Trade Agreement (NAFTA) and also a report by Shafik & Bandyopadhyay (1992) was published on global development in 1992 (Behbudi *et al.* 2010).

The foundation of EKC is reflected in Beckerman's idea about the effect of economic growth on the quality loss of environment (Kaika & Zervas 2013). Beckerman (1992) holds that although environment quality may be lost during the early stages of the economic growth, finally the best and maybe the only way to attain clean environment in most countries is their prosperity. The environmental Kuznets curve (EKC) shows a positive relationship between income and the loss of environment quality. The situation gets worse with economic growth. The trend of environment degradation is accelerating at first, but the slope of the curve gradually decreases and finally, economic growth mitigates the environment degradation as technology develops.

According to Roca *et al*. (2001), the relationship between income and pollutants is affected by many factors and it cannot be reasonable to assume that economic growth by itself will solve environmental problems. In this respect, a paper on the economic growth and atmospheric pollutions in Spain studied the annual emissions of six pollutants and found that only the gradual trend of SO_2 was consistent with the Kuznets curve hypothesis (Vaseghi & Esmaeili 2010)

The comparison between gas consumption and the induced pollution well shows that Iran produces more pollution that what is expected from its gas consumption, whereas most neighboring countries and even European nations produce less pollution in spite of their higher gas consumption.

Energy consumption rate is another factor influencing CO_2 emission rate. CO_2 emission is directly related to energy consumption and there is a strong correlation between the use of fossil fuels and CO_2 emission (Lotfalipour & Ashena 2010)

With the commencement of industrial evolution in 1830 and the increasing growth of human knowledge, human life has transformed drastically. The demand for energy and the consumption of various fossil fuels including coals, oil, and natural gas has considerably increased the level of such materials as CO_2 and water vapor in atmosphere (Vaseghi & Esmaeili 2010). The combustion of the fossil fuels releases oxidized carbon into the atmosphere. Fuels differ in the rate of CO_2 emission as per thermal energy unit. With the fast growth of industrial activities and urbanization, the consumption of different forms of energy plays an important role in affecting local environment and global climate change. Air pollution in urban areas has been mainly caused byintercity transportation in recent years. Fossil fuels consumed by transportation and raw materials consumed by industrial processes are among the main causes of urban pollution (Lotfalipour & Ashena 2010).

Fukui & Miyoshi (2017) used ordinary least squares method to study the effect of fuel tax on fuel price and CO_2 emission in the US from 1995 to 2013. They reported that the increase in fuel tax decreased fuel consumption and air pollution. Also, higher tax increased fuel price. In other words, fuel tax had a favorable impact on fuel price and a negative impact on air pollution and CO_2 emission.

In a study on prediction of the effect of alternative transport fuels on CO_2 emission in Italy, Nocera & Cavallaro (2016) revealed that pollution induced by CO_2 emission was reduced by 59% as the price of alternative fuels was increased.

In a study on the relationships among energy consumption, air pollution, and economic growth in Nepal using ARDL method, Bastola & Sapkota (2015) found a long-run unidirectional relationship between energy consumption and CO_2 emission and causality from economic growth to CO_2 emission and energy consumption. They reported that growing energy consumption does not always reflect economic growth; rather, it is more likely to be an indication of negative impacts on environment. So, policies should be based on alternative energies to both help environment protection and lead to economic growth in long run.

Gurtu *et al.* (2015) analyzed the impact of the fuel price variations and carbon tax on greenhouse gas emissions by transportation sector in Canada. They found that fuel should be priced on the basis of transportation costs and carbon tax. Also, fuel price and environmental awareness considerably influence pollutant emissions, and transportation sector may force the government to increase emission tax.

Kohler (2013) examined the impact of energy consumption, income, and foreign trade on carbon emission in South Africa and found a long-run relationship among foreign trade, per capita energy consumption, and carbon emission. According to this study, energy consumption is directly related to carbon emission, but higher foreign trade results in lower carbon emission.

Hatzigeorgiou *et al.* (2011) run a causality analysis on GDP, energy intensity, and CO_2 emissions in Greece. They used Johansen co-integration test and vector error correction model. According to their results, there was bidirectional causality among energy intensity and CO_2 emission, so that energy intensity improvement alleviated carbon emissions and vice versa. Casualty analysis between GDP and carbon emission showed unidirectional causality from production to CO_2 emission.

Virley (1993) focused on the impact of fuel price increase on CO_2 emission by road transport in the UK and found that the increase can reduce CO_2 emission.

In a study on the influence of fuel price changes on greenhouse gas emissions from road transport sector of Iran from 1991-2013 using RLS method, Delangizan *et al.* (2015) reported that fuel price had negative impact on pollutant emissions. Investment in transportation desirably influenced greenhouse gas emissions. Also, pollutant emissions by car subsector were negatively and significantly affected by per capita GDP and urbanization rate, whilst their impact was positive and significant on other subsectors.

Behbudi *et al.* (2010) evaluated the effect of economical and social parameters on per capita CO_2 emission in Iran from 1967 to 1994 using vector error correction model and found that CO_2 emission has been positively related to energy consumption, economic growth, trade liberalization, and urbanized population.

In an analysis of CO_2 emission fluctuations in terms of energy intensity, pollution coefficient, structural changes, and economical activity, Lotfalipour & Ashena (2010) revealed that economic growth was the most important factor in the increasing rate of CO_2 emission and that economic structure was less effective on it.

Pollution coefficient and energy intensity were not so effective on CO_2 emission, either. Barghi Osgooyi (2008) studied the impact of trade liberalization on CO_2 emission in four income categories using panel data and found that trade liberalization and per capita income would alleviate CO_2 emission in countries with high and moderate-to-high per capita income, while would deteriorate its emission in countries with low and moderate-to-low per capita income. In most of the studies in this field, only the effect of growth economic and GDP on pollutants emission were investigated, while the impact of higher fuel price on pollutants emission has not been evaluated.

MATERIALS AND METHODS

Research data

After a review of CO_2 emission theories and the related studies, the relevant variables in Iran, factors affecting CO_2 emission were included in econometrics model. One important parameter in CO_2 emission is the government revenues which are in different forms. According to Maghelal (2011) and similar studies, the following model WAS used in the present study:

$$PCO = f(P, PGDP, PEN) \tag{1}$$

Where, *PCO* = per capita CO_2 emission rate (expressed in 1000 kg per person); *PGDP* = price-based GDP excluding oil (expressed in 1000 IRR per person with reference to constant price of 1997); *P* = real fuel price (expressed in IRR with reference to constant price of 1997); and *PEN* = per capita energy consumption (expressed in kg crude oil barrier equivalent per person) (Gurtu *et al.* 2015; Delangizan *et al.* 2015).

Data for per capita energy consumption and per capita CO_2 emission were derived from the website of World Bank. Data for per capita GDP were derived from the website of Central Bank of the Islamic Republic of Iran and data for fuel price from the Website of National Iranian Oil Company. All variables were as logarithm for the time period 1981-2015 (fuel price data were expressed as consumer price index based on constant price of 1997).

Methodology

The model was estimated and the long and short-run relations between dependent variable and descriptive variables were studied by auto-regressive distributed lag (ARDL) using Microfit statistics package. ARDL has two steps. At the first step, we test the presence of a long-run relationship between the studied variables. Given the number of observations, the maximum number of lags is considered and given the tendency of the Schwartz-Bayesian criterion to brief specification. It shows better results in less than 100 observations. Immediately after dynamic (short-run) equation estimation, the test should be run on the presence/absence of a long-run relationship. Now, to make sure that the resulting long-run relationship is not false, we test the following hypothesis. The null hypothesis assumes the lack of auto regression or a long-run relationship, because the condition for the tendency of a short-run dynamic relationship towards a long-run equilibrium is that the sum of coefficients be smaller than 1. To test the condition, 1 should be subtracted from the sum of lagged coefficients of dependent variable and the result should be divided by the sum of standard deviations of these coefficients.

The second phase of the analysis is the use of ARDL options in estimating the long-run relationships and statistical inference of their values. Noteworthy, it is appropriate to start this phase only once ensuring that the long-run relationships between the variables are not false (Tashkini 2005). After estimation of ARDL model, the following hypothesis is tested:

$$H_0 = \sum_{i=1}^{m} \beta_i - 1 \succ 0 \quad (2)$$

$$H_1 = \sum_{i=1}^{m} \beta_i - 1 \prec 0 \quad (3)$$

Or the relationship is long run because the condition for the tendency of a short-run dynamic relationship towards a long-run equilibrium is that the sum of coefficients be smaller than one. To test the condition by the method developed by Banerjee, Dolado, and Master in 1992, one should be subtracted from the sum of lagged coefficients of dependent variable and the result should be divided by the sum of standard deviations of these coefficients in which the test statistic will be derived from t-statistic (Nowferesti 2008).

$$t = \frac{\sum_{i=1}^{m} \hat{\beta}_i - 1}{\sum_{i=1}^{m} Se(\hat{\beta}_i)} \quad (4)$$

The presence/absence of a long-run relationship between the model variables can be understood by comparing the quantity of calculated t-statistic and the critical value given by Banerjee, Dolado & Master (1992) at a certain confidence level.

The present study used t-statistic test developed by Banerjee, Dolado and Master to test the long-run relationship (Tashkini 2005). At the second phase, the long-run coefficients are estimated and analyzed ant their values are inferred. The optimum number of lags for each descriptive variable can be determined by Akaike Information Criterion, Schwarz Bayesian Criterion, Hannan-Quinn Criterion, or adjusted-coefficient of determination (Nowferesti 2008). This method has more advantages relative to the similar methods, so it is used widely (Tashkini 2005).

The most important advantage of ARDL the ability of ARDL to examine the relationships between variables, regardless of their stationary or non-stationary.

Also in this method, in addition to the ability of calculating long-term relationships between variables, it is possible to calculate the dynamic and short-term relationships.

A short while though quickly adjust imbalances in each period, to achieve long-run equilibrium is also calculated. While the speed of balancing the short-term imbalance of each period also is calculable for achieving balance.

RESULTS

Before model estimation, the stationary of variables in CO_2 emission model was tested by Dickey-Fuller and augmented Dickey-Fuller method. The results are presented in Table 2.

Table 1. Descriptive statistics of variables used in modeling.

Variable	Mean	Std.Dev	Min	Max
PCO	1.529	0.311	1.027	2.06
PGDP	8.528	0.208	8.156	8.883
P	6.619	0.477	5.69	7.736
PEN	2.048	0.358	1.53	2.65

Table 2. Results of unit root test on the variables of CO_2 emission model.

Variable	Test statistic	Critical level at P < 0.05	Test result
PCO	-2.68	-3.55 (0.25)	Non-stationary
D(PCO)	-4.51	-1.95 (0.00)	Stationary
P	-1.32	-3.55 (0.87)	Non-stationary
D(P)	-4.61	-1.95 (0.00)	Stationary
PGDP	-1.86	-1.86 (0.65)	Non-stationary
D(PGDP)	-5.31	-3.56 (0.00)	Stationary
PEN	-3.00	-3.55 (0.15)	Non-stationary
D(PEN)	-3.17	-1.95 (0.00)	Stationary

According to the results in Table 2, it can be concluded that all variables become stationary after one- differentiating, so, all variables areI (1). As mentioned previously, analysis by ARDL method is based on interpretation of three equations: dynamic, long-run and error correction. Table 3 shows results for the estimation of dynamic equations. The optimum lag can be selected by Akaike, Schawrz Bayesian, or Hannan-Quinn criteria or adjusted-coefficient of determination. The following Table 3 shows results of the dynamic equation estimation. Several diagnostic tests were carried out to ensure the model is an appropriate model, such as the test for serial correlation (LM test), heteroscedasticity (ARCH test) and normality (JB (N)). The statistics reported shows that there are no problems associated with serial correlation, normality or heteroscedasticity. After estimating dynamic equation, a test should be run to ensure the presence of a long-run relationship in regression. In this test, the lagged coefficient of the dependent variable is subtracted from 1 and is divided by its standard deviation.

Then, the calculated t-statistic (in absolute value) is compared with the values in Banerjee, Dolado and Mestre's Table. If the calculated t-statistic is greater than the critical absolute value, it can be concluded that the null hypothesis of the absence of cointegration between the model variables is rejected and it is said that there is a long-run relationship.

Table 3. Results of short-run relationship.

Descriptive variable	Estimated coefficient	Test statistic (probability)
PCO(-1)	0.524	(0.001) 3.876
P	0.068-	(0.089) 1.764-
PGDP	0.770	(0.019) 2.498
PGDP(-1)	0.489-	(0.066) 1.916-
PEN	0.233	(0.008) 2.840
C	2.885-	(0.027) 2.343-
R-Bar-Squared=0.96; DW=1.66; F=139.62 (0.000)		

$\chi2$ = 0.65613 [0.418]	Autocorrelation test
$\chi2$ = 0.59737 [0.440]	Ramsey's RESET Test
χ^2 = 2.1556 [0.340]	Jarque -Bera
χ^2= 4.6506 [0.994]	Engle's ARCH LM

Since in models estimated for consumption and capital expenditure, the dependent variable has emerged just with one lag on the right side, the t-statistic for CO_2 emission pattern is calculated as:

$$T_{1EG} = \frac{0.52374-1}{0.13514} = -3.52 \quad (5)$$

The absolute values of both statistics are greater than the equivalent absolute value in Banerjee, Dolado and Mestre's Table (-3.50).

Thus, it can be concluded that the null hypothesis about the lack of cointegration among model variables is rejected at the 90% confidence level and so, there is a long-run equilibrium relationship among the variables in carbon emission model. Table 4 shows the results of the estimation of this model. Results presented in Table 4 reflect a negative relationship of actual price of fuel with CO_2 emission and a positive relationship of per capita production and consumption of energy with CO_2 emission. Also, 1% increase in per capita energy consumption will lead to 0.48% increase in CO_2 emission in long run. 1% increase in per capita production will also increase CO_2 emission by 0.59%. In addition, 1% increase in actual price of fuel will reduce carbon emission by 0.14%. Then, error correction model was derived to check the correction of short-run imbalances in carbon emission model towards long-run equilibrium. One important issue in error correction models is the coefficient of ECM(-1) variable. Results of the estimation of error correction model are summarized in Table 5. As shown in Table 5, the coefficient of error correction was -0.476 in carbon emission model, implying that in each period, 48% of imbalance of carbon emission model is corrected and approaches its long-run trend. Except for the actual price of fuel whose coefficient was significant at the 90% confidence level, all coefficients of the model were found to be significant at the 95% confidence level. CUSUM test which has a long history in econometrics literature was used to examine the stability of the model coefficients. In this test, the null hypothesis tests the stability of parameters at the 5% significance level. The confidence interval is two straight lines that show 95% confidence level. If the test statistics is located between these two lines, the null hypothesis about the stability of the coefficients cannot be rejected. Fig.1 shows the results of the test.

The statistic is plotted against time.

Table 4. Results of long-run relationship for CO_2 emission model.

Descriptive variable	Estimated coefficient	Test statistic (probability)
PEN	0.489	2.685 (0.012)
PGDP	0.591	2.017 (0.054)
P	-0.142	-1.867 (0.073)
C	-6.058	-4.793 (0.000)

Table 5. Results of error correction for CO_2 emission model.

Descriptive variable	Estimated coefficient	Test statistic (probability)
DPEN	0.233	2.840 (0.008)
DPGDP	0.770	2.498 (0.019)
DP	-0.068	-1.764 (0.089)
DC	-2.885	-2.343 (0.026)
ECM(-1)	-0.476	-3.524 (0.001)
R-Bar-Squared = 0.48; DW = 1.66		

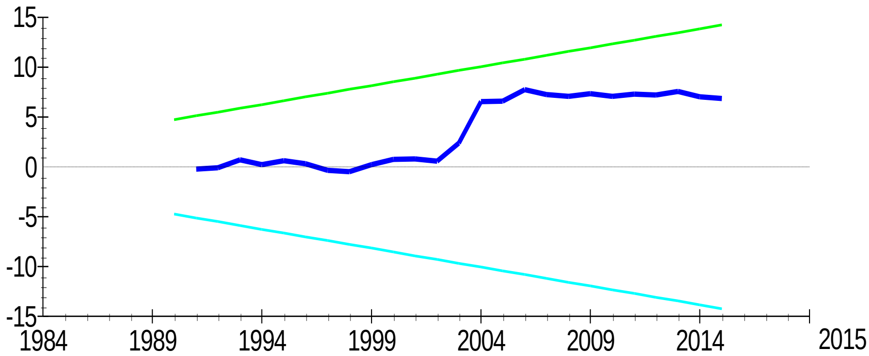

Fig. 1. Cumulative sum control chart (CUSUM) of recursive residual.

As shown in the graph, the test statistic is located inside the straight lines, showing the stability of the coefficients at the 5% significance level. In other words, the null hypothesis about the stability of the coefficients cannot be rejected at the 95% confidence level.

DISCUSSION

The present research studied the factors underpinning CO_2 emission in Iran in 1981-2015, for which the influence of fuel price and per capita production and energy consumption was evaluated on per capita CO_2 emission. Results were consistent with most experimental studies, e.g. Manzoor & Rezaee (2014), Amadeh *et al.* (2015), Bastola & Sapkota (2015), and Fukui & Miyoshi (2017). These findings align with those of Bonney & Jaber (2011), who note: "Perhaps the continued increase in energy prices may result in deglobalisation of markets, if not decentralization. In other words, a move towards smaller self-sustainable markets would be a strategic solution to consider.''

CONCLUSION

Sustainable development depends on concern for environment and its conservation for the next generations. The increasing rate of greenhouse gas emissions, especially CO_2, has raised concerns about environment quality. The increase in the concentration of these gases in atmosphere over the natural levels will accelerate global warming, destroy the protective layer around the Earth against harmful solar radiation, and threaten whole natural life. Since environment is a key part of global policies and most other parts including military, political and economical powers are affected by it, the main prerequisite for all global-level activities is their compatibility with environment. Environment is so important that it is the top priority in most planning and policy-making activities in addition to the global concern for it. The governments always try to develop various policies and plans to overcome environmental issues and/or alleviate the adverse impacts of human functions on environment (pollution and environment degradation).

Today, air pollution has gained so much importance in most countries and, especially talking, in large cities in Iran that the governments are forced to take the issue serious and develop short- and long-term plans and policies. One of the recent policies has been the elimination of energy subsidy and gradual increase in fossil fuel prices in a hope of the reform in consumption patterns and movements towards energy efficiency. So, it can be expected to see gradual alleviation of air pollution and greenhouse gas production. Obviously, studies on factors affecting greenhouse gas emissions can help policy-makers make sound decision to overcome environment degradation and reduce the related costs. According to the results, carbon emission is related to actual price of fuel indirectly and to per capita production and energy consumption directly. Also, 1% increase in per capita energy consumption will increase CO_2 emission by 0.48% in long run. One percent higher per capita production will increase carbon emission by 0.59%, and 1% higher actual price of fuel will reduce carbon emission by 0.14%. It should be noted that continuous reduction of the production and emission of pollutants and greenhouse gases depends on optimization and efficiency of energy use. Energy use efficiency can be realized if besides pricing policies; non-pricing policies like the use of energy use saving technologies are taken into consideration too. So, fuel pricing policies should consider environment and health costs of fuel consumption.

Higher fuel price would hinder unnecessary commutes and traffic and would facilitate commutes in larger cities which would alleviate pollution on the one hand and would save commute time and fuel consumption on the other hand resulting in higher efficiency of active people.

From an economical point of view, pollution decrease can enhance work efficiency resulting in higher labor efficiency. Equipping vehicles with bi-fuel system does not reduce fuel consumption, but it changes the type of fuel in use. In light of the increase in global price of natural gas, this transformation will not be economical. Although Iran enjoying huge resources of natural gas as an advantage, these resources will eventually start to deplete in future and also, its global price is a function of unpredictable variables.

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بررسی تاثیر افزایش قیمت بنزین بر میزان انتشار آلودگی در ایران

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چکیده

یکی از محورهای اصلی توسعه پایدار در هر کشور چگونگی تعامل بخش انرژی محیط زیست و اقتصاد است. انتشار گازهای گلخانه‌ای وآثار آن یکی از مواردی است که در مسائل محیط زیست مورد توجه قرار گرفته است. افزایش این گازها در جو زمین بیش از مقدار طبیعی آن، باعث گرم شدن هرچه بیشتر آب وهوا، از بین رفتن لایه محافظ زمین در مقابل اشعه های خطرناک خورشید و به خطر افتادن کل حیات طبیعی میشود. هدف از انجام این پژوهش بررسی عوامل اثر گذار بر انتشار دی اکسید کربن در ایران می باشد. دوره زمانی مورد بررسی ازسال ۱۳۶۰ تا ۱۳۹۴ بوده ومتغیرهای مورد استفاده شامل میزان انتشار سرانه دی اکسید کربن، قیمت بنزین، تولید سرانه و مصرف سرانه انرژی می باشد. بررسی رابطه مذکور با استفاده از مدل خودرو گرسیو با وقفه‌های گسترده (ARDL) صورت گرفت. بر اساس نتایج بدست آمده ، بین متغیرهای قیمت واقعی بنزین وانتشار کربن رابطه معکوس بر قرار بوده و بین متغیرهای تولید سرانه ومصرف انرژی سرانه با انتشار کربن رابطه مستقیم بر قرار می‌باشد. طبق این نتایج، یک درصد افزایش در قیمت واقعی بنزین منجر به۰/۱۴درصد کاهش در انتشار کربن خواهد شد. همچنین یک درصد افزایش در تولید سرانه نیز ۰/۵۹ درصد افزایش در انتشار کربن را در پی خواهد داشت. با توجه به اثر گذاری سیاست هدفمند-سازی یارانه‌ها وافزایش قیمت بنزین در کاهش انتشار گازهای گلخانه‌ای در بخش حمل و نقل جاده‌ای، پیشنهاد می‌شود این افزایش قیمت سوخت به صورت تدریجی تا رسیدن به قیمت فوب خلیج فارس ادامه یابد.

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