Environmental Energy and Economic Research 2020 4(4): 250-261
DOI 10.22097/eeer.2020.220667.1142

*Research Article*

# Investigation of Non-Linear Impacts of Factors Affecting Greenhouse Gas Emissions

**Seyed Ehsan Hosseinidoust *, Mohsen Khezri, Asma Shiri**

Faculty of Economics and Social Science, Bu-Ali Sina University, Hamedan, Iran

Received: 27 February 2020 /Accepted: 15 August 2020

**Abstract**

The link between economic growth and environmental pollution has been extensively and statistically analyzed over the past two decades. The present study investigates the non-linear effects of variables affecting greenhouse gas emissions. To this aim, a Time Varying Parameters Vector Autoregression (TVP-VAR) model has developed using annual data which covers the period 1972-2018. Moreover, the associated Impulse Response Function (IRF) of the selected influential variables such as GDP (oil, without oil) and electricity consumption on the greenhouse gas emissions (carbon dioxide) has computed. Findings revealed the non-linear impact of GDP on the greenhouse gas emission, so that until 2002 it had a positive effect on reducing greenhouse gas emission; whereas, from 2002 onwards it had a negative impact and led to escalating the greenhouse gas expansion. Besides, the positive shock of electricity consumption and GDP (without oil) on greenhouse gas emissions during the entire period was positive. Furthermore, the emission of greenhouse gas on itself is positive throughout the study period.

**Keywords:** Greenhouse Gas Emission; Electricity Consumption; Economic Growth, TVP-VAR

## Introduction

One of the most significant issues in the global society is reducing CO2 emissions of industrial activities and its consequences. Therefore, the exploitation of clean energy sources is one of the requirements of the international community. In this regard, the researchers investigated the impact of renewable energy utilization to achieve the low carbon economy and they concluded that it could significantly reduce the CO2 emissions of transportation and industry sectors (Yousefi et al., 2019). Examining the probable relationships among usage of energy, greenhouse gas emissions and economic development, goes back to the early of 1970s when policymakers and researchers were informed about the possible linkages among the energy utilization, greenhouse gas emissions and economic development (Payne, 2010). There is ample evidence of a positive association between energy consumption and improvement of macroeconomic variables which causes pollution to spread. The relationship between economic variables and environmental pollution is similar to the one between these variables and energy consumption. Gross domestic product (GDP) is one of the prominent economic

* Corresponding author E-mail: hosseinidoust@basu.ac.ir

variables that is a criterion of economic growth. The relationship between economic growth and environmental pollution has been extensively analyzed statistically over the last two decades. The practical framework for the above evaluation is based on the assumption of the Kuznets environmental curve (EKC) (Fotros, 2011). One of the objectives of present study is to explore the dynamic linkages between electricity consumption, greenhouse gas emissions, and real GDP in Iran. To do so, two types of GDP has considered namely GDP by inclusion and once by exclusion of the oil incomes (that is due to the dependence of Iran's growth model on oil exports). Although developmental programs tend to emphasize on the promotion of the private non-oil sector, the importance of this objective has highlighted as oil prices continue to fall currently. This study aims to provide a dynamic and comprehensive review of energy-environment GDP on one hand and energy-environment-non-oil GDP on the other hand. Therefore, the dichotomy between the issue of oil and non-oil sectors and its implications for the efficiency of energy policies and sustainable developments will be demonstrated (Mezghani and Ben Haddad, 2016).

One of the problems that lead to inefficiency in investigating the factors affecting GDP, energy consumption and carbon dioxide emissions, is the inability of linear models to detect asymmetries (including structural failures) during the periods. The history of conducted researches in this matter illustrates that linear models with fixed coefficients have been applied, investigating such a connection between model variables in empirical studies in the Iranian economy; in contrast, the relations between variables may change depending on the conditions of the country's economy. It shows the necessitates the use of newer models which provide more accurate estimations in different periods, which is investigated in this article as a research innovation. Present study is based on the application of a Time Varying Parameter Vector Autoregressive model (TVP-VAR) an extension of Korobilis (2013) model. It is examined the dynamics among the economic growth (oil and non-oil), electricity consumption and greenhouse gas emissions during 1972-2014. Present study has arranged in five sections. The research background of the study has reviewed in the second section, the research methodology is studied in the third section also the analysis of the experimental results is presented in section four. Finally, the results are presented and the policy proposals of the paper are discussed in the fifth section.

## Research Background

Menyah and Wolde-Rufael (2010), studied the causal connection between carbon dioxide emissions, nuclear and renewable energy consumption, and real GDP of the United States during 1960-2007. Although using a modified method of the Granger causality test, they discovered a one-way causal relationship between nuclear energy consumption and carbon dioxide emissions (without feedback), no causal link between renewable energy and carbon dioxide emissions was found. Apart from that, the causal relationship between nuclear energy consumption and economic growth has not been obtained at any level, albeit there is a one-way causal relationship between GDP and renewable energy consumption. Acaravci and Ozturk (2011), implemented an ARDL test method to assess the issues of short- and long-run relationships between power consumption and economic growth in 11 MENA countries (the Middle East and North Africa), their study observed one-way relationship between per capita power consumption and real GDP in Saudi Arabia. It confirms the role of energy conservation policies in encouraging the economic growth. In addition, Arouri et al. (2012) investigated the relationship between the energy consumption of economic growth and carbon dioxide production in the Middle East and North Africa during 1981-2005. Their findings support the negative dynamics between economic growth and carbon dioxides emissions.

Heidari et al. (2011) analyzed the relationship between electricity consumption and costs of economic growth utilizing the Iranian bounds test approach. The results indicated a unilateral functional long-run direction from economic growth to electricity consumption with negative coefficients and a bilateral positive short-run functional direction from electricity consumption to economic growth in the both of supply-side and demand-side modelling. The findings also demonstrated a positive relationship between non-renewable energy consumption and carbon dioxide production, in the long run.

Kulionis (2013), studied the causal relationship between renewable energy consumption, GDP, and greenhouse gas emissions in Denmark using annual data of 1993-2012. Inexistence of long-run relationship is proved by the outcomes of Johansen cointegration test. Likewise, the unilateral functional direction from energy consumption to greenhouse gas emission has confirmed by the Granger causality test. Min Lim et al. (2014), examined the issues of short- and long-run causality in oil consumption, greenhouse gas emissions and economic growth in the Philippines using time series techniques and annual data during 1965-2012. Significant findings of the study suggest a unilateral functional direction from oil consumption to greenhouse gas emissions, which appears to imply the Philippines necessity of improving its oil consumption efficiency to reduce greenhouse gas emissions. Torabi et al. (2015), studied the relationship between greenhouse gas emissions and energy consumption, income and foreign trade of Iran from 1971 to 1909 using Kuznets curve. The result reveals that per capita energy consumption, GDP of the actual per capita and openness rate of the economy exert a significant impact on the per capita emissions of CO2. Mezghani and Ben Hadad (2016) studied the relationship between real GDP (Oil, Non-Oil) of Saudi Arabia, power consumption and carbon dioxide emission Rate, using the time-varying parameter vector autoregressive model (TVP-VAR), during 1971-2010. The findings suggest the use of TVP-VAR model in the investigation of the dynamic linkage between power consumption, real GDP and carbon dioxide emissions. Additionally, the analysis of consecutive time-varying responses of real GDP (oil and non-oil), electricity consumption and carbon dioxide emissions to the structural shocks demonstrates that such responses are reliant on the structural fluctuations in actual GDP (oil, non-oil), power consumption and carbon dioxide emission shock.

The influence of urbanization on $CO_2$ emission is examined at different development levels by Zhengxia et al. (2017). They focused on the stochastic impacts using regression on population, affluence and technology (STIRPAT) model on provincial for China. To investigate the regional differences of impacts of urbanization on $CO_2$ emission based on the development levels, the 29 provinces of China are divided in three areas according to their per capita real GDP. The panel estimation for the whole dataset and the three areas showed an inverted U relationship between urbanization and $CO_2$ emission in the major regions of China. Specifically, the effects of urbanization vary significantly across the regions. The results did not confirm the environmental Kuznets Curve relationship between income and $CO_2$ dispersion, where $CO_2$ emission increases monotonically with income.

Xue-ting et al. (2018) adopted the modified Geographical Detector tool to investigate the main drivers of carbon emission from the perspective of stratified heterogeneity. The results of the analysis showed that human economic activities in China were the dominant effect of carbon emission changes; at the same time, energy intensity contributed to control the carbon emission in China. Furthermore, population growth was the most significant driving force, followed by energy intensity toward controlling the carbon emission of the USA. All these factors are mutually enhancing in changing carbon emissions, while oil share with energy intensity and coal share are more significantly reinforced in China's carbon emission than other interactions. The factors of human activities and energy mix posed a more powerful effect when they mutually enhanced each other to change carbon emission compared to other enhancing interactions.

Zafeiriou et al. (2018) studied the relationship between agricultural carbon emissions equivalents and income per capita for the agricultural sector in different EU countries. Findings of NARDL model validated the existence of a strong relationship between greenhouse gas emissions and agricultural income. The long-run relationship between variables is obtained and the asymmetric impact of the agricultural income on carbon emission has achieved.

Vasylieva et al. (2019) investigate the relationships between economic, social, and environmental dimensions of sustainable development based on the concept of the Environmental Kuznets Curve hypothesis, that is about the non-linear relationship between economic growth and environmental pollution. Panel data of EU countries including Ukraine from 2000 to 2016 has employed. Results confirmed the Environmental Kuznets curve hypothesis for the EU and Ukraine. The findings proved that increasing renewable energy (RE) by 1% led to a decline of greenhouse gas (GHG) in the interval of 0.166103 to 0.220551, and an increase of the Control of Corruption Index by 1% provoked a decrease of GHG by 0.88%.

Zhi Li et al. (2019) surveyed the effect of the rationalization and upgrading of manufacturing structure on carbon dioxide emissions in China, based on the perspective of natural resource dependence. The results of the STIRPAT model on provincial panel data of the manufacturing sector from 2003 to 2014 show that manufacturing structure rationalization and upgrading will help curb $CO_2$ emissions, while such effects are restricted by a region's reliance on natural resources. The panel threshold model estimations further indicate that the higher the ratio of industrial output to GDP, the weaker the restricting effect of resource dependence on the emissions reduction of manufacturing structure.

Daryaei et al. (2019), examined the empirical effects of stocks traded-total value, foreign direct investment, number of students, and fossil fuel energy consumption on nitrogen dioxide ($NO_2$) emissions in Iran using time series data for the period 1978-2012. Findings indicated that foreign direct investment, fossil fuel energy consumption, and the number of students stimulate $NO_2$ emissions in the long run. The study recommends Iran economy to reduce emissions $NO_2$ by implementing forests preserving and supporting policies; investment on solar and wind energy; investment on energy researches to achieve expertise for higher efficiency in electricity generation.

## Material and Methods

The statistics used in this study are annual, related the years 2014-1972. Iran's actual GDP variables (oil, non-oil), $CO_2$ emissions and electricity consumption (KW/h) are employed as the model variables. Data of electricity consumption and carbon dioxide emissions are downloaded from the International Energy Agency (IEA) database and the actual GDP (oil and non-oil) data collected from the time series database of the Central Bank of Iran.

The standard approach to examine the effects of variables on the economy is to estimate a structural VAR on some key variables. Models of this form have the following reduced-form representation:

$$Y_t = b_1 Y_{t-1} + \cdots + b_p Y_{t-p} + v_t \tag{1}$$

Where $y_t' = (\pi_t \; y_t \; R_t)'$, $y_t$ is a $(l \times 1)$ vector of variables? The coefficients $b_i$, $i = 1, \ldots, p$ on each lagged value of $y_t$ are of dimensions $l \times l$, and $v_t \sim N(0, \Omega)$ with $\Omega$ a $l \times l$ covariance matrix. By allowing the parameters of the VAR to vary over time, more complex dynamics can be modelled, and the effects of monetary policy actions can also be assessed over time. The Time-Varying Parameters VAR (TVP-VAR) takes the form of:

$$Y_t = b_{1t}Y_{t-1} + \cdots + b_{pt}Y_{t-p} + v_t \tag{2}$$

Eq. (2) is a VAR system on the variables with drifting coefficients and stochastic volatility based on the recent literature on efficiently parametrizing large covariance matrices, Primiceri (2005), Cogley and Sargent (2005) and Canova and Gambetti (2009) use a decomposition of the VAR error covariance matrix of the form:

$$A_t\Omega_t A_t' = \Sigma_t \Sigma_t' \tag{3}$$

Which equivalently:

$$\Omega_t = A_t^{-1}\Sigma_t\Sigma_t'(A_t'^{-1}) \tag{4}$$

Where $\Sigma_t = diag\ (\sigma_{1,t}, \dots, \sigma_{k+1,t})$ and $A_t$ is a unit lower triangular matrix with ones on the main diagonal:

$$A_t = \begin{bmatrix} 1 & 0 & \cdots & 0 & \\ \alpha_{21,t} & 1 & \ddots & \vdots & \\ \vdots & \ddots & \ddots & & 0 \\ \alpha_{m1,t} & \cdots & \alpha_{m(m-1),t} & & 1 \end{bmatrix} \tag{5}$$

Stacking all the parameters of Eq. (2) in the vectors$B_t = (vec(b_{1t})', \dots, vec(b_{pt})')', \log\sigma_t = (\log\sigma_{1t}', \dots, \log\sigma_{mt}')$'' and $\alpha_t = (\alpha_{j1,t}', \dots, \alpha_{j(j-1),t}')'$ for $j = 1, \dots, m$. For each time period, the innovations of the random walk evolution of the parameters are defined as a mixture of two normal components, see Koop et al. (2009) and take the following form:

$$\begin{aligned} B_t &= B_{t-1} + J_t^B \eta_t^B \\ \alpha_t &= \alpha_{t-1} + J_t^\alpha \eta_t^\alpha \\ \log\sigma_t &= \log\sigma_{t-1} + J_t^\sigma \eta_t^\sigma \end{aligned} \tag{6}$$

where $\eta_t^\theta \sim N(0, Q_\theta)$ are innovation vectors independent with each other, as well as $u_t$ and $v_t$, while $Q_\theta$ are innovation covariance matrices associated with each ofthe parameter vectors $B_t$, $\alpha_t$, $\log\sigma_t$, where for brevity define $\theta_t \in \{B_t, \alpha_t, \log\sigma_t\}$. Some correlation can be allowed between the disturbance terms appearing in equation (6), which could permit modelling more complex dynamics. However, this flexibility comes at the cost of the proliferation of the parameters that need to be estimated, and the assumption made here is that all error components appearing are uncorrelated with each other.

The random variables $J_t^\theta$ can only take two values, one and zero, at each period $t$ making the state errors a mixture of a Normal component with covariance $Q_\theta$ and a second component which places all probability point mass at zero. As was explained in section III, the variables $J_t^\theta$ are assigned with a prior distribution and are subsequently updated from the data likelihood. That way the mixture innovation specification is flexible as it allows the information in the data to determine either one of the two extreme specifications of constant parameters ($iff\ J_t^\theta = 0 \forall t = 1, \dots, T$) and of time-varying parameters ($iff\ J_t^\theta = 1 \forall t = 1, \dots, T$) . In between those two extremes, that is, when $J_t^\theta = 1$ for only some $t$, lie several specifications which can be interpreted as if only a few breaks occur over the sample. This flexible mixture innovation specification might be necessary when no prior opinion about the amount of variation in the parameters is available, and when marginal likelihoods are hard to obtain (as it is the case with time-varying parameters models). For instance, Sims and Zha (2006) using a Markov-switching VAR find evidence for time variation only on the covariance matrix of their VAR and not on the mean equation coefficients $B_t$. Finally, notice that the TVP-FAVAR model nests also the TVP-VAR model of Primiceri (2005), by simply setting the number of factors, $k$, equal to zero. Therefore, a large class of models-ranging from small (V)ARs with constant parameters to their Time-Varying Parameters counterparts using hundreds of variables can be examined using the single specification in this study. The random variables $J_t^{\theta}$ can only take two values, one and zero, at each period $t$ making the state errors a mixture of a Normal component with covariance $Q_{\theta}$ and a second component which places all probability point mass at zero. According to Korobilis (2013), we use the Minnesota prior, for the parameters of the VAR equation we set $B_0 \sim N(\underline{B}, \underline{V})$, $\alpha_0 \sim N(0,4I), \log \sigma_0 \sim N(0,4I), Q_B^{-1} \sim W\left(0.005 \times (\dim(B)+1) \times \underline{V}, (\dim(B)+1)\right)$, $Q_{\alpha}^{-1} \sim W(0.01 \times (\dim(\alpha)+1) \times I, (\dim(\alpha)+1))$, and $Q_{\sigma}^{-1} \sim W(0.0001 \times (\dim(\sigma)+1) \times I, (\dim(\sigma)+1))$, where: $\dim(B) = m \times m$, $(p, \dim(\alpha)) = m(m-1)/2$ and $\dim(\sigma) = m$. Here $\underline{B}$ is set to 0.9 on the coefficient of the first own lag of each dependent variable and $\underline{0}$ elsewhere, and $\underline{V}$ is a diagonal prior covariance matrix with diagonal elements defined from a Minnesota-type specification of the form:

$$\underline{V}_{ij} = \begin{cases} \dfrac{1}{c^2} \text{ for parameters on own lags} \\ \dfrac{0.001 s_i^2}{c^2 s_j^2} \text{for parameters on variable } j \neq i, \text{for lag } c = 1, \dots, p \end{cases}$$

Where $s_i^2$ is the residual variance from the $p$-lag univariate autoregression for dependent variable $i$, and $i = 1, \dots, m\, j = 1, \dots, mp$. The 'nonstandard' parameters in this model are the ones related to the mixture innovation extension. The 0/1 variables $J_t^{\theta}$ are assumed to come from a Bernoulli distribution, $p(J_t^{\theta} = 1) = \pi_{\theta} = 1 - p(J_t^{\theta} = 0)$,for $\theta \in \{B_t, \alpha_t, \log \sigma_t\}$. The probabilities $\pi_{\theta}$ control the transition of the index $J_t^{\theta}$ between the two possible states (1: break $-0$: no break), and an additional hierarchical prior has introduced to update them from the information in the data. A Beta prior of the form $\pi_{\theta} \sim Beta(\tau_0, \tau_1)$ is placed on this hyper-parameter, which controls the prior belief about the number of breaks through the choice of $\tau_0$ and $\tau_1$. We set these hyper-parameters to be $(\tau_0, \tau_1) = (1,1)$, which is an uninformative and uniform choice, with $E(\pi_{\theta}) = 0.5$ and $std(\pi_{\theta}) \cong 0.29$. Note that for simplicity and in the absence of prior information, $\tau_0$ and $\tau_1$ are the same for all three drifting parameters defined in Eq. (6).

### TVP-VAR Model Estimation

Subsequently, following the estimation of TVP-VAR model using MATLAB software and two model endogenous variable intervals, the results of the variable impulse response of greenhouse gases ($CO_2$) due to the shock in the model variables, up to 9 periods, are presented. To apply impulse response function, Cholesky's decomposition was used by imposing a particular recursive structure on the model, which is updated form of Kup et al. (1996), Sons and Shane (1998) models who introduced the generalized impulse response function approach and the generalized variance decomposition function in which the results are not sensitive to the order of the variables. The results of the impulse response function of the present study vary over time and are thus different from previous studies; in a way that they are plotted in 3D. Response values of the variables to the incoming shocks are indicated in the vertical axis of the impulse response function; also, the time of the shock and impulse response periods (up to 9 periods) are illustrated in the horizontal axis.

The variable impacts of GDP (non-oil) on greenhouse gas emissions, which is positive in all periods studied is illustrated in figure (1), as observed. The relationship between economic growth and the quality of environmental life in the long-run can be directed or inversed and/or a mixture of the both. Examining the process of modelling and formation of variables indicated that there have been two general trends in over the last few decades; which have finally been transformed into a third approach. The first approach is a trade-off between economic growth and maintaining environmental standards. Meaning that, economic growth in principle (as a result of rise in production and consumption) would inevitably require more raw materials and energy (as inputs) and consequently lead to increase the byproduct and wastes production. It is also believed by some that the path to improving ecological quality is parallel to economic growth and that economic growth should be stepped up to improve environmental-ecological standards; which is the second approach on the other side of the spectrum. The third approach, introduced since the early 1990s, proposed an inverted U-shaped relationship between economic growth and environmental biodiversity pollution, which is known as the environmental transition hypothesis. That relationship derives its name from Simon Kuznets (1995), the Nobel laureate (who found a U-shaped connection between income inequality and per capita income). In the Grossman and Kruger studies, the relationship between different indices of environmental degradation and per capita income, as an inverted U-shaped relation (the Kuznets environmental curve), was presented in environmental researches. Environment vulnerability is by reason of the development of economic activities, derived from static assumptions about environmental technology and investment, given that when revenue increases, demand for environmental quality also increases (Beckerman, 1992; and Panayouto, 1997).

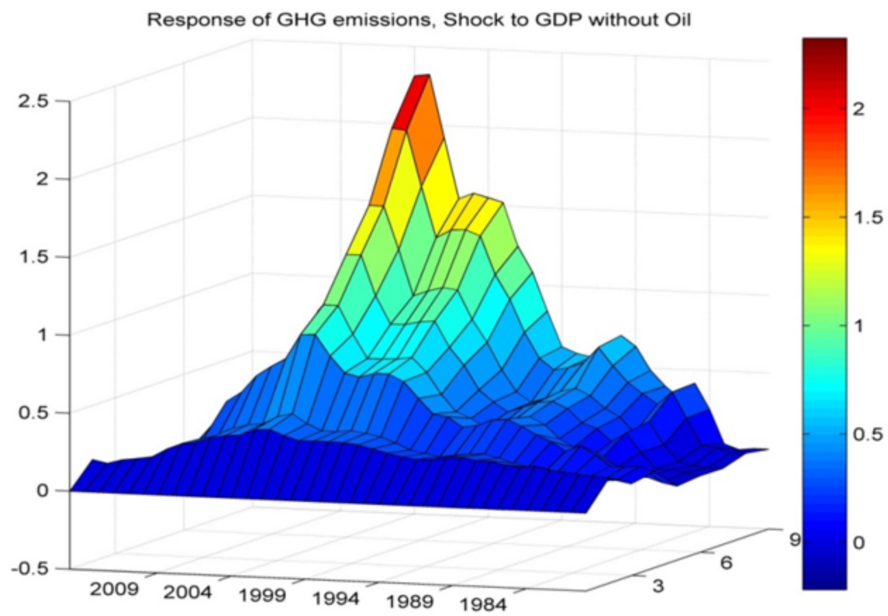


**Figure 1.** Impulse Response of Greenhouse Gases to Shocks of GDP (Oil Excluded)

The scale effect, the income effect and the composition effect play a crucial role in this relation increasing in the scale of economic activity. It leads to more pollution at the early stages of development; therefore, the curve slope will be positive (scale effect). Also, the increase in per capita income contributes the demand for higher environment quality, causing additional severe environmental regulations and to guide the replacement of outdate technologies with cleaner ones (income effect). The income effect also shifts application of the traditional industrial activities to modern ones and creation of a decreasing trend of pollution and emissions. Consequently, when per capita income rises to a certain extent, the scale effect is outweighed by the composition and income effects and descending the curve. The results of the present study indicate the scale effect being more substantial than the income effect in Iran, bringing about the exerted impact of economic growth on greenhouse gas emissions to be positive.

The effect of economic growth on greenhouse gas emissions is presented in figure (2). As can be observed, GDP has a non-linear impact on the greenhouse gas (GHG) emission, which is positive up to 2002, causing a reduction in GHG emission. But, it became negative from 2002 onwards, bringing about an increase GHG emission. Referring to Figure (2) the positive impact of GDP on the reduction of air pollution by 2002 can be accounted for to the expansion of the petrochemical sector and the changes in the composition of produced energy for consumption. Initially, petroleum products (furnace oil, etc.) were used more frequently in power plants; however, later on, and with the expansion of the petrochemical sector, natural gas was replaced due to the lighter constituents and less pollution of the furnace oil. The natural gas positive effects on the reduction of air pollution have been apparent since 2002 due to the complete replacement of the natural gas for furnace oil. According to Energy Department's balance sheet data, furnace oil consumption rate was 16.3 million liters per day at the beginning of 1976, which increased to 36.7 million liters per day in 2014. It reflects not so much growth, while natural gas consumption, which was 6.9 million liters per day at the beginning of 1976, has risen drastically to 471.1 million liters per day in 2014. Therefore, replacing natural gas with other petroleum products with high levels of air pollution, has been witnessed by all.

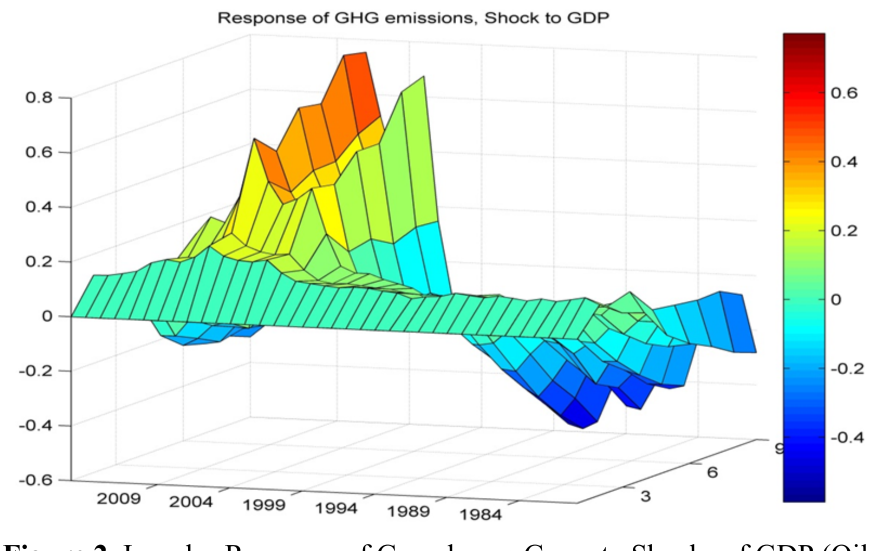


**Figure 2.** Impulse Response of Greenhouse Gases to Shocks of GDP (Oil Included)

The impact of variable power consumption on greenhouse gas emissions is presented in figure (3). As observed, the effect of electricity consumption on greenhouse gases, throughout the period under review, is positive. Power generating plants are one of the most effective axes on which the country's economy is developing. Pollutants are released in the environment during the conversion of primary fuels, which are required by power plants, causing significant damages to agriculture, the environment, and especially human health.

Human beings are becoming more and more reliant upon energy these days, especially on electricity, and therefore considering the electricity power to be the basis of all the developments of the new century is not far from mind. Most of the power plants, in Iran, are thermal ones using fossil fuels as a result of its enormous oil and gas reserves. Fossil fuels (such as natural gas and diesel) are burnt by thermal power plants in order to obtain required energy for generating electricity. Therefore, the power consumption is required to be increased and the consumption of fossil fuel will also increase (to keep the power plants operational).

The variable impact of greenhouse gas emissions ($CO_2$) on itself is observed in figure (4), exerting a positive effect throughout the period, which is on the increase in some years.

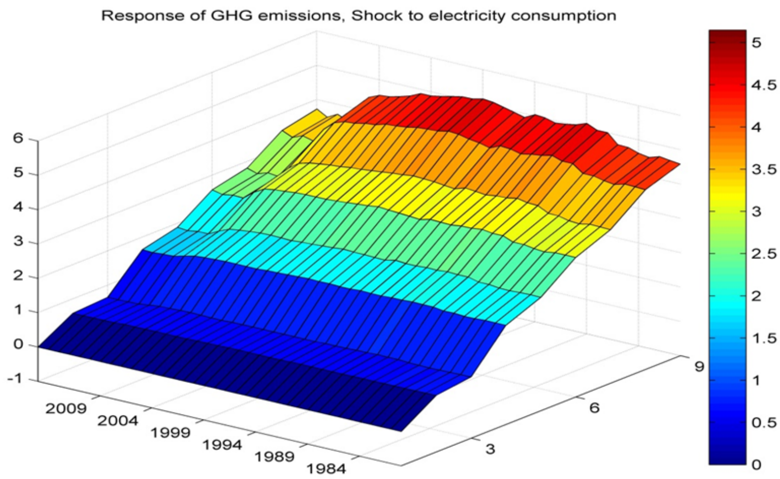


**Figure 3.** Impulse Response of Greenhouse Gases to Shocks Electricity Consumption

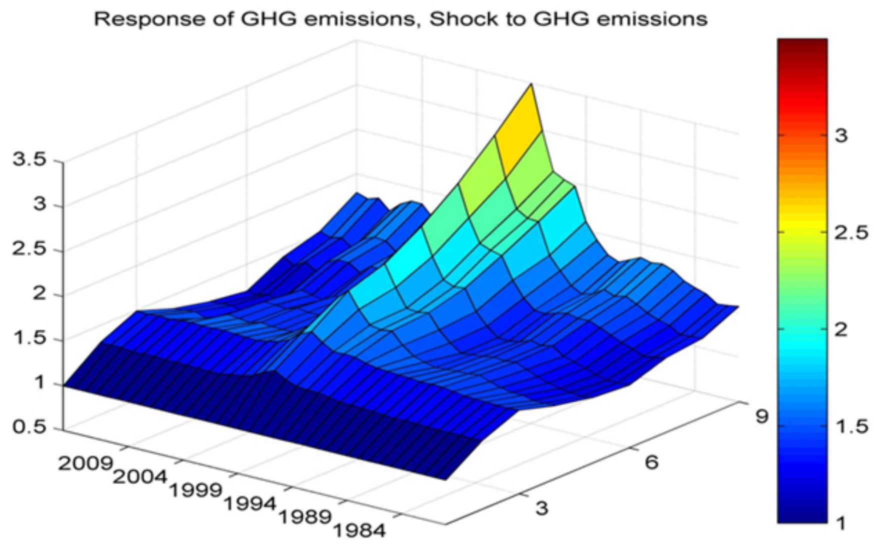


**Figure 4.** Impulse Response of Greenhouse Gases Emissions to Shocks on itself

## Conclusion and Suggestion

This study aims to investigate the influential factors on greenhouse gas emissions using annual data of 1972-2018. Time-Varying Parameters Vector Autoregression (TVP-VAR) model has developed using data of real GDP (oil, non-oil), electricity consumption on the greenhouse gas emissions (carbon dioxide). Findings revealed the non-linear impact of GDP on the greenhouse gas emission so that until 2002 it had a positive effect on reducing greenhouse gas emission; yet, from 2002 onwards it had a negative effect and led to escalating the greenhouse gas expansion. Besides, the positive shock of electricity consumption and GDP (without oil) on greenhouse gas emissions during the entire period was positive. Furthermore, the emission of greenhouse gas on itself is positive throughout the study period, and in some years, this effect has increased. The results indicate the non-linear impacts of the variables on the greenhouse gas emissions, which has not been considered in previous studies and shows the need to use non-linear models in investigating the factors affecting greenhouse gas emissions.

According to the estimations, the growth of energy consumption and GDP, signifying economic growth, leads to increase in pollution as a result of the rise in carbon dioxide emissions. However, it is possible to reduce the amount of energy consumption rate by improving its efficiency in domestic production units, whose responsibility lies with the government to discover new sources of energy, diversifying its economy, to encourage the non-oil private sector to adopt energy-efficient technology. Consequently, to achieve sustainable economic growth and long-run environmental quality, it is recommended to provide investment platforms, in new energy production technologies, that probably will reduce greenhouse gas emissions. Apart from that, it is essential to make use of renewable and less polluting energy in the electricity industry. For instance, wind power can be replaced by electricity generated from fossil fuel power plants, which reduces greenhouse gas emissions. Additionally, results of researches on the ways of electricity generation in the developed countries demonstrate that generating electricity using wind energy reduces social costs compared to the fossil fuel power plants. It clarifies how to reduce the negative exogenous effects of energy generation in the path of sustainable growth of economy to achieve the development. Reduction of Iran's greenhouse gas emission using national energy-efficiency laws depends heavily on the extend that this economy co-operate with the objectives of the conventional and international low-carbon policies. Such targeting can exert a significant impact on reduction of regional $CO_2$ emission and meeting the international standards. Finally, our findings suggest that setting the goal of 8% economic growth in the energy and industrial sections for the next 15 years, Iran can play a strategic role in the region in achieving global goals.

## Reference

Arouri, A., Youssef, B., and H. Mhenni (2012). Energy Consumption, Economic Growth and CO2 Emission Middle East and North African Countries. Energy Policy, (45), 126-135.

Beckerman, W. (1992). Economic Growth and Environment: Whose Growth? Whose Environment?. Journal of World Development, (20), 481-496.

Berndt, E. R. D.O and Wood (1978). Technology, Prices and The Derived Demand For Energy. Review of Economics and Statistics, (57), 259-268.

Cuaresma, J. C., Doppelhofer G. and M. Feldkircher. (2008). The Determinants of Economic Growth in European Region. Working Papers in Economics and Statistics, University of Innsbruck.

Daryaei, A., Bajelan, A., Khodayeki, M. (2019). The Impact of Stocks Traded-Total Value, Foreign Direct Investment, Number of Students and Fossil Fuel Energy Consumption on NO2 Emissions in Iran. *Environmental Energy and Economic Research*, 3(4), 335-348.

Fallahi, F. (2011). Causal Relationship Between Energy Consumption (EC) and GDP: A Markov-Switching (MS) Causality. Journal of Energy, (36), 4165-70.

Fotros, M. (2011). Air Pollution, Energy Consumption and Economic Growth in Iran. *Iranian Energy Economics*, 1(1), 189-211.

Grossman G. M. and A. B. Krueger. (1995). Economic Growth and the Environment. Quarterly Journal of Economics, (110), 353-77.

Grossman, G. M. and A. B. Krueger. (1991). Environmental Impacts of a North American Free Trade Agreement. National Bureau of Economic Research, Working Paper, (3914).

Heidari, H., Najjar Firoozjaee, M., & Saeidpour, L. (2011). Investigating the Relationship Between Electricity Consumption, Electricity Price and Economic Growth in Iran. Journal of Economic Research and Policies, 19(59), 175-200.

Kocaaslan, O. (2013). The Causal Link between Energy and Output Growth: Evidence from Markov Switching Granger Causality. Energy Policy, (63),1196-206.

Korobilis, D. (2013). Assessing the Transmission of Monetary Policy Shocks Using Time-Varying Parameter Dynamic Factor Models. Oxford Bulletin of Economics and Statistics, (75), 157-179.

Kulionis, V. (2013). The Relationship between Renewable Energy Consumption, CO2 Emission and Economic Growth in Denmark. Universit Essay Fromlunds Universitet/Economisk-Historiska Institutionen.

Menyah, K., and Y. Wolde-Rufael. (2010). CO2 Emissions, Nuclear Energy, Renewable Energy and Economic Growth in the US. Energy Policy, (38), 2911-2915.

Mezghani, I., and H. Ben Haddad. (2016). Energy Consumption and Economic Growth: An Empirical Study of the Electricity Consumption in Saudi Arabia. Renewable and Sustainable Energy Reviews, 27(2), 75-93.

Min Lim, L., Ye, K., And S. Khoon Yoo. (2014). Oil Consumption, CO2 Emission And Economic Growth: Evidence from the Philippines. Journal Of Sustainability, (6), 967-979.

Ockwell, D.G. (2008). Energy and Economic Growth: Grounding Our Understanding in Physical Reality. Energy Policy, 36(12), 4600-4604.

Ozturk I, Acaravci A. (2011). Electricity Consumption and Real GDP Causality Nexus: Evidence from ARDL Bounds Testing Approach for 11 MENA Countries. Apple Energy, (88), 2885-2892.

Panayouto, T. (1997). Demystifying the Environmental Kuznets Curve: Turning a Black Box Into A Policy Tool. Journal of Environment and Development Economics, (2), 456-484.

Payne JE. (2010). A Survey of the Electricity Consumption-Growth Literature. Apple Energy, (87), 723-731.

Salai Martin, X., G. Doppelhofer and R. I. Miller. (2004). Determinants of Long-Term Growth: A Bayesian Averaging of Classical Estimates (BACE) Approach. American Economic Review, 94(4), 813-835.

Shafik, N. And S. Bandyopadhyay. (1992). Economic Growth and Environmental Quality: Time Series and Cross-Country Evidence. The World Bank, Working Paper Series, WP 904.

Sharzehi, Gh. and M. Hagani. (2010). Causality Relationship between Energy Consumption and National Income. Journal of Economics Research (87), 75-90.

Solow, R. M. (1965). A Contribution to the Theory of Economic Growth. Quarterly Journal of Economics, 70(1), 65-94.

Swan, T. W. (1965). Economic Growth and Capital Accumulation. Economic Record, 32(4), 334-361.

Torabi, T., Khajooeipour, A., Tarighi, S., & Pakravan, M. R. (2015). The Effect of Energy Consumption, Economic Growth and International Business on Greenhouse Gas Emission in Iran. Economic Modelling, 9(29), 63-84.

Vasylieva, T., Lyulyov, O., Bilan, Y., and Streimikiene, D. (2019). Sustainable Economic Development and Greenhouse Gas Emissions: The Dynamic Impact of Renewable Energy Consumption, GDP, and Corruption. Energies, 12(3289).

Xue-Ting, Jiang., Qiang, Wang., and Rongrong, Li. (2018). Investigating Factors Affecting Carbon Emission in China and The USA: A Perspective of Stratified Heterogeneity. Journal of Cleaner Production, 199(3), 85-92.

Yang, H.Y. (2000). A Note on the Causal Relationship between Energy and GDP in Taiwan. Energy Economics, (22), 309-317.

Yousefi, H., Abbaspour, A., Seraj, H. (2019). Worldwide Development of Wind Energy and CO2 Emission Reduction. *Environmental Energy and Economic Research*, 3(1), 1-9.

Zafeiriou, E., Mallidis, I., Galanopoulos, K., and Arabatzis, G. (2018). Greenhouse Gas Emissions and Economic Performance in EU Agriculture: An Empirical Study in a Non-Linear Framework. Sustainability, 10(3837), 258-271.

Zhengxia, He., Shichun, Xu., Wenxing, Shen., Ruyin, Long., and Hong, Chen. (2017). Impact of Urbanization on Energy Related CO2 Emission at Different Development Levels: Regional Difference in China based on Panel Estimation. Journal of Cleaner Production, 140(3), 1719-1730.

Zhi Li., Shuai, Shao,. Xunpengshi., Yongping, Sun., and Xiao Ling, Zhang. (2019). Structural Transformation of Manufacturing, Natural Resource Dependence, and Carbon Emissions Reduction: Evidence of a Threshold Effect from China. Journal of Cleaner Production. 206(1), 920-927.