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The relationship between energy consumption and value added in Iranian economy

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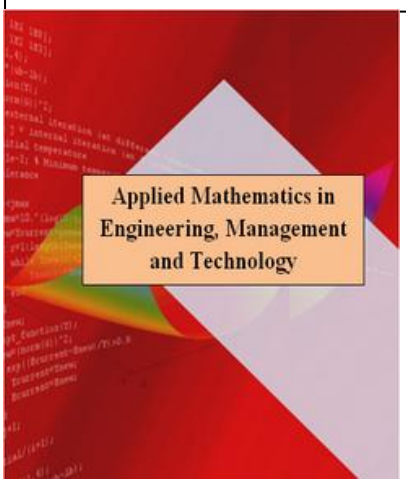


Abstract

An analysis of the impact of energy consumption on value added in Iranian economy can be of great importance. Accordingly, the purpose of the present study was to evaluate the effects of oil, coal, and gas consumption on value added in Iranian economy using the Vector Auto Regressive (VAR) Model and impulse response functions. The results of this study suggested that oil consumption with a lag has a significant and negative effect on the value added. Besides, other variables (gas and coal consumption) do not have a significant effect on value added in Iranian economy. Finally, it was noted that the impulses exerted by value added have a significant effect on oil, gas, and coal consumption and shocks generated by the amount of energy consumption (oil and gas consumption) affects value added.

Key words: coal, oil, and gas consumption, value-added

1.Introduction

Since their creation, human beings realized the worth of energy for their survival so they have always spend a considerable part of their power and time to provide energy resources they need. The energy consumption varies in different countries according to the degree of their development and given that all countries are not equally developed so the relatedness of energy consumption and its efficiency to economic growth is different among various countries.

Developing countries that are in the early stages of development (the transition stage), their energy consumption is growing faster than that of developed countries. In addition, developing countries are different from developed countries in terms of access to energy resources such as oil, gas, and coal. Some countries have a higher level of energy consumption than others due to its easy access to energy resources. In contrast, some countries do not have the needed energy resources so they undergo considerable costs incurred due to energy imports. As a result, it can be said that energy sector is one of the important parts of economy which plays a vital role in the development and the growth of other sectors.

There are different views on energy consumption and economic growth. Nevertheless, different views about the relationship between energy consumption and economic growth can be divided into two general categories. The first category includes those views that are based on the assumption that there is a basic and sustainable relationship between energy consumption and economic growth. However, the latter group which was introduced in the eighties focuses on views that emphasize the lack of a sustainable relationship between the two variables.

The first approach assumes a maximum growth rate of the economy whose fulfillment is in the need of a high level of energy so considerable investment should be done to meets the need for energy in the future. Consequently, the limited energy supply will stop the economic growth or even may cause a negative economic growth. Opponents of this approach argue that there is no sustainable relationship between economic growth and energy consumption. Because economic indicators such as GDP that show the value of tradable economic activities in a community are a mixture of highly diverse economic activities within a country. Besides, this economic indicator is not closely associated with physical factors that may determine the level of energy consumption. Therefore underlying investments within a country may have a more significant relationship with energy consumption.

2.Literature review

Several studies have been conducted to examine the relationship between energy consumption and economic growth, some of which are addressed here as follows:
Stern (1993) examined the relationship between GDP and energy consumption during the period from 1947 to 1990 in the United States using Vector Auto Regressive (VAR) Model. In addition, he explored the relationship of energy consumption with capital and labor. The results of the study indicated that economic growth energy consumption is not a granger cause of economic growth. However, both workforce and capital growth are the granger cause of economic growth. On the other hand, it was noted that GDP is the granger cause of three production factors i.e. capital, labor (workforce), and energy. Besides, there is two-way granger causality between labor and capital.
Messiah (1996) studied the relationship between energy consumption, real income, and prices using data from 1961 to 1991 for South Korea and Taiwan through the error correction model and the VAR Model. The results indicated that short-term price changes in Taiwan cause changes in income level and energy consumption. However, it was noted that changes in the income level are caused by energy consumption changes. Finally, the findings indicated that in the long run there is a two-way causality relationship between the variables in question in both countries and that in fact these three variables are endogenous variables.
Cheng and Lai (1997) analyzed the relationship between energy consumption and economic growth and the relationship between energy consumption and employment, using integration techniques in Taiwan using annual data collected from 1955 to 1993. The results of their study suggested that an increase in the level of energy consumption will lead to an increase in the level of employment and there is a one-way causal relationship from economic growth to energy consumption, implying that the economic growth in Taiwan requires a rise in the energy consumption rate. Accordingly, a rise in the energy consumption rate will reduce the unemployment rate.
Glasher and Lee (1997) studied the relationship between energy consumption and GDP in South Korea and Singapore using the data collected from 1961 to 1961 by co-integration techniques and error correction models. They found that there is no causal relationship between energy consumption and GDP in South Korea. However, they only observed a one-way relationship from energy consumption to GDP in Singapore.
Asafo (2000) studied the relationship between energy consumption, prices, and economic growth for developing countries in Asia. Analysis of the annual data since 1971 to 1995 from India, Indonesia, the Philippines, and Thailand indicated there is a one-way relationship from energy consumption to income in India and Indonesia in the short term while there is a two-way relationship between energy consumption and income in the Philippines and Thailand.
Many studies have been also performed in Iran to find out how energy consumption and economic variables are related. For instance, Zibaee and Tarazkar (2004) studied short and long-term relationships between value added and the utilization of different energy carriers in agriculture from 1967 to 2000 using Johansen- Juselius' Co-integration Test based on Vector Auto Regressive Model. They observed that there is a long-term causal relationship from value added to the consumption of electricity and petroleum products. Besides, it was noted that value added has the potential of increasing electricity consumption in the short term. However, they found there is no long-term causal relationship from value added to the consumption of petroleum products (Zibaee and Tarazkar, 2004).

3.Research Methodology

To examine the effects of the consumption of oil, coal, and gas on value added in Iranian economy, the date on the following variables were used in the present study:

- VA: Value added (million Rials)
- OIL: Oil consumption (million tons of crude oil)
- GAS: Gas consumption (million tons)
- COAL: Coal consumption (million tons)

Simultaneous equation model system is used generally to assess the interaction of several time series variables. There is a structural pattern within the system based on which virtually every one of the equations is determined on the basis of economic theories. Indeed, in such systems there should be a decision to determine each

endogenous variable is theoretically a function of which variable(s). Vector Auto Regressive Model has some positive features as follows:

1. The work procedure is very simple in this model as with the exception of intercept and dummy variables that sometimes are added into the model, other variables are endogenous.
2. Model coefficients can be easily estimated using OLS technique.
3. The model has been reduced. In other words, the values with Y_t intervals determine Yt = A1Yt-1 + A2Yt-2 + … + ApYt-p + Ut (1)

However, the main drawbacks of VAR models are as follows:

1. Unlike simultaneous equation models whose structural equations are based on economic theories, VAR models follow no economic theoretical basis.
2. One of the major problems with VAR models is to determine the number of optimal lags for the variables used in the model.
3. The estimated coefficients of VAR models are hard to interpret, especially when the sign of coefficients of a variable or an interval change.

The matrix form of a VAR model is as follows:

$$x_t = \alpha_0 + \sum_{i=1}^{k} \alpha_1 x_{t-i} + \sum_{i=1}^{k} \alpha_2 y_{t-i} + \sum_{i=1}^{k} \alpha_3 z_{t-i} + \sum_{i=1}^{k} \alpha_4 w_{t-i} + u_{1t} \quad (2)$$

$$y_t = \beta_0 + \sum_{i=1}^{k} \beta_1 y_{t-i} + \sum_{i=1}^{k} \beta_2 x_{t-i} + \sum_{i=1}^{k} \beta_3 z_{t-i} + \sum_{i=1}^{k} \alpha_4 w_{t-i} + u_{2t} \quad (3)$$

$$z_t = \gamma_0 + \sum_{i=1}^{k} \gamma_1 z_{t-i} + \sum_{i=1}^{k} \gamma_2 x_{t-i} + \sum_{i=1}^{k} \gamma_3 y_{t-i} + \sum_{i=1}^{k} \alpha_4 w_{t-i} + u_{3t} \quad (4)$$

$$w_t = \gamma_0 + \sum_{i=1}^{k} \gamma_1 z_{t-i} + \sum_{i=1}^{k} \gamma_2 x_{t-i} + \sum_{i=1}^{k} \gamma_3 y_{t-i} + \sum_{i=1}^{k} \alpha_4 w_{t-i} + u_{3t} \quad (5)$$

Where, Y_t and its intervals along with U_t are k×1 vectors while A_is are matrices of the model coefficients.

Multivariate dynamic analysis enjoys a number of advantages. For instance, it addresses the problem of simultaneity among variables in question. It has also been observed that predictions made based on VAR models are more reliable than those provided by simultaneous equation models (Noforsati, 1999).

Accordingly, the present study analyzes the possible relationship between energy (oil, gas, and coal) consumption and value-added using VAR model. Concerning what has been mentioned above; the model used in the study will be as follows:

$$\Delta VA = \alpha_1 + \sum_{i=1}^{n} \beta_i \Delta VA_{i-t} + \sum_{i=1}^{n} \gamma_i \Delta OIL_{i-t} + \sum_{i=1}^{n} \mu_i \Delta GAS_{i-t} + \sum_{i=1}^{n} \lambda_i \Delta COAL_{i-t} + V_t \quad (6)$$

Today, VAR approach is conventionally used to perform economic policy analyses. This approach is a simple but robust method for describing the interactions of several variables. The approach is also able to determine macroeconomic effects resulting from political decisions and politicians' feedback to the volatility of politics. One of the strengths of VAR models is their needs for detection boundary which is at the same time one of the weaknesses of such models.

Vector Auto Regressive Model used to analyze value added as a dependent variable based on the data collected in this study is as follows:

$Y_t = \alpha_{10} + \alpha_{11} Y_{t-1} + \alpha_{12} Y_{t-2} + \alpha_{13} X_{t-1} + \alpha_{14} X_{t-2} + \varepsilon_1$ (7)

$X_t = \alpha_{20} + \alpha_{21} Y_{t-1} + \alpha_{22} Y_{t-2} + \alpha_{23} X_{t-1} + \alpha_{24} X_{t-2} + \varepsilon_2$ (8)

To provide a more detailed explanation of volatility of variables in question, the dynamic behavior of the model can be studied by response functions through imposing an impulse to the VAR response variable. In fact, these functions show the VAR model's dynamic routes by exerting an impulse to a given variable. This change is called *innovation* i.e. an impulse that enters into *white noise*. Impulse response functions show the responses of the system's endogenous variables to shocks that affect the disruption terms. To come up with a better understanding of the issue, consider the following model:

$A(L)\, Y_t = U_t$ (9)

$A(L) = I + A_1L + A_2L^2 + \ldots + A_PL^P$ (10)

The reaction function shows a shock effect of one standard deviation to the current and future values of the endogenous variables. If the disruption terms ε_1 and ε_2 are uncorrelated. In this case, ε_1 will show sudden changes in Y_t while ε_2 shows abrupt changes in X_t. Then due to the changes in ε_2, the reaction function shows a shock effect of one standard deviation in X_t to the current and future values of Y_t. The overall shape of the impulse response function is as follows:

$$Y_t = A(L)^{-1}U_t = \sum B_s U_{t-s} \quad (11)$$

$$\frac{\partial Y_{ti}}{\partial U_{(t-s)j}} = b_{ij}^{(s)} \Rightarrow \Delta Y_i = \Delta U_{(t-s)j} b_{ij}^{s} \quad (12)$$

The above model is an auto regressive model with order of p. However, if A(L) is to be reversed, the model will change into an auto-regressive moving average model as follows:

Where, bij is the response for the impulse of *i*th variable after *s* periods to the initial shock in *j*th variable.
The data used in the present study were collected from Iran Central Bank Database for the time period from 1965 to 2004 and were analyzed by Eviwes5 and Microfit 4.1 software packages.

4.Results and Discussion

Two unit root tests, the Dickey-Fuller Test and the Augmented Dickey-Fuller Test, were used along with the stepwise method to examine the stationary of variables under study. The results of these two tests are presented in Table 1:

Table 1: Results of the variables stationary test

Variables	stationary	Sig.	Stationary
VA	With intercept and without trend	5%	I(0)
CAOL	With intercept and trend	5%	I(0)
GAS	With intercept and no trend	1%	I(0)
OIL	With intercept and no trend	5%	I(0)

Source: Research findings

Before using the stepwise method it is needed to determine the number of optimal lags. The number of optimal lags was determined equal to 1 through Akaike Test as shown in Table 2.
Accordingly, concerning the selected lags by the use of the above indicators, the model under study was estimated by the inclusion of macroeconomic variables of value added and energy (coal, oil, and gas) consumption. Results of these estimations are presented in Table 2:

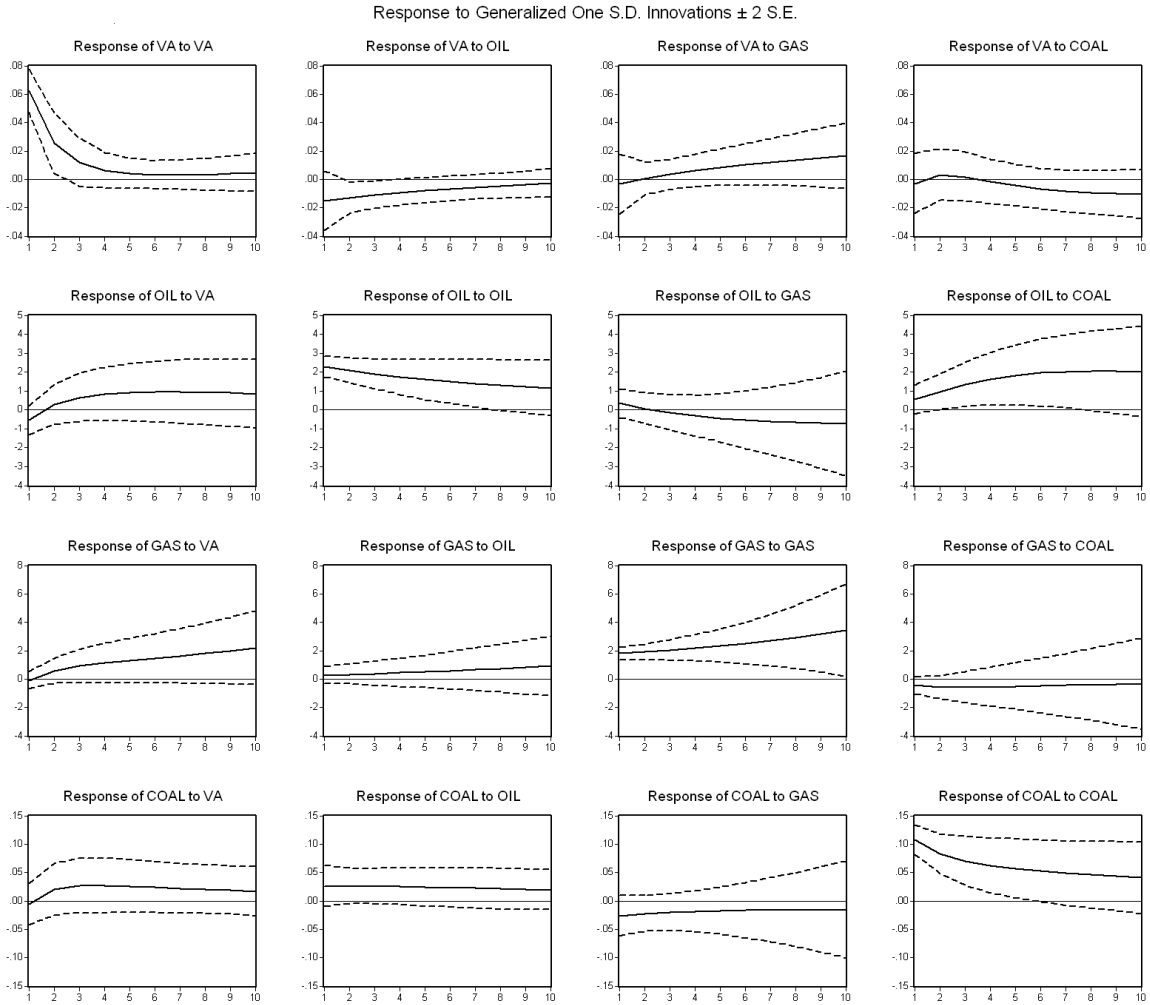
Table 2: Results of VAR Model Estimation

variables	VA	OIL	GAS	COAL
VA(-1)	0.382962	13.20597	11.71151	0.435824
S.E	-0.16969	-6.21552	-4.87437	-0.2916
t	[2.25689]	[2.12468]	[2.40267]	[1.49458]
OIL(-1)	-0.04298	0.951651	0.111347	0.006091
S.E	-0.0025	-0.0916	-0.07184	-0.0043
t	[-2.71871]	[10.3888]	[1.54997]	[1.41736]
GAS(-1)	0.002806	-0.06497	1.042654	-0.00202
S.E	-0.00172	-0.06301	-0.04941	-0.00296
t	[1.63153]	[-1.03111]	[21.1009]	[-0.68157]
COAL(-1)	0.075486	4.188615	-1.50723	0.742937
S.E	-0.08306	-3.04257	-2.38607	-0.14274
t	[0.90878]	[1.37667]	[-0.63168]	[5.20471]
C	0.07436	0.431932	-2.58814	0.016626
S.E	-0.03602	-1.31943	-1.03473	-0.0619
t	[2.06436]	[0.32736]	[-2.50126]	[0.26858]
R-squared	0.400685	0.97961	0.985241	0.903969
Adj. R-squared	0.320776	0.976891	0.983273	0.891165
Sum sq. residuals	0.117435	157.5654	96.90434	0.346808
S.E. equation	0.062566	2.291763	1.79726	0.107519
F-statistic	5.014281	360.3214	500.6746	70.59992
Log likelihood	50.03854	-75.9915	-67.4844	31.08794
Akaike AIC	-2.573631	4.628084	4.141968	-1.49074
Schwarz SC	-2.351438	4.850276	4.36416	-1.26855
Mean dependent	0.040774	36.76857	17.99714	0.771429
S.D. dependent	0.075916	15.07575	13.89658	0.325912

Source: Research findings

Table 2 presents the results of VAR model estimation. When value added is selected as the dependent variable, it can be said that oil consumption with a lag has a significant and negative effect on value added which is due to energy consumption subsidies granted in Iran. On the other hand, other variables (gas and coal consumption) do not significantly affect value added in Iran. Besides, in cases that oil and gas consumption is considered as the dependent variable, value added with a lag has a positive and significant effect on oil and gas consumption but its effect is not significant for the coal consumption.

But what is of high important from the economic interpretation standpoint is impulse functions. Of 12 impulse functions estimated from the whole variables under study, some impulses are discusses for a ten year period. As shown in Fig. 1, the impulses generated by value added have a significant effect on the consumption of oil, gas, and coal at the beginning of the period in question. This effect is more intense for the consumption of gas and oil and eventually become fixed. In addition, the energy consumption (oil and gas consumption) affects value added. Furthermore, oil consumption is influenced by the impulses exerted on gas consumption to the extent that the effects are in work until the second period and then the oil consumption assume a more stable pace.



Source: Research findings

Fig. 1: Responses of the system variables to impulses

Given that Iran is in the development stages; its energy consumption rate is rapidly increasing. Besides, the access to energy resources such as oil, gas, and coal is also different from other countries. The energy consumption is very high in Iran due to easy access to energy resources. Iran has also a high level of energy imports due to the high consumption of gasoline. Therefore, energy sector is an economically important sector that plays a vital role in the growth of other economic sectors.

There is not a clear view on energy consumption and economic growth in Iran. However, it can be acknowledged that there is no sustainable relationship between energy consumption and economic growth in Iran because economic indicators such as GDP which show the value of tradable economic activities consist of a diverse mixture of economic activities within a community and these economic indicators are not closely related to physical factors that determine the level of energy consumption.

Finally, energy consumption in Iran is not directed at fundamental and structural investments but is mainly allotted for consumption purposes, which is attributable to several reasons; the most important of which is the inexistence of purposeful energy subsidies especially those assigned for oil consumption.

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