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Energy consumption in Iran: past trends and future directions

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Abstract

Energy is one of the most significant presented factors in economic literature. Today, the consumption and efficiency of energy have affected all the economical and industrial activities. Our world is the world of economical and industrial development and the process of this development has even been accelerated through the recent decades. Considering the especial situation of Iran in the world and in the region as well, energy sector is more important in this country. The energy of Iran, as one of the most powerful import-export energy of the world, is very potent in the world economy. While Iran is benefited from energy exportation, it can also affect the economy of importer countries. Energy resources in Iran consist of the third largest oil reserves and the second largest natural gas reserves in the world. Iran is in a constant battle to use its energy resources more effectively in the face of subsidization and the need for technological advances in energy exploration and production. The energy consumption in the country is extraordinarily higher than international standards. Iran recycles 28 percent of its used oil and gas whereas the figure for certain countries stands at 60 percent. With an economy which is expected to maintain a rate of growth of 2 to 5 percent for decades, Iran’s role in the world energy market becomes increasingly influential. This makes it important to predict Iran’s future demand and supply for energy. The objective of this paper is to apply the Bayesian vector autoregressive methodology to forecast Iran’s energy consumption and to discuss potential implications. The slower growth reflects an expected slower economic growth and the decline in energy consumption due to structural changes in the Iran economy. Iran’s dwindling crude oil production will also put pressure on the internal use of refined products, as consumption and exports come to vie for the same barrel.

Keywords: Iran, Energy consumption, Bayesian vector autoregression.

1. Introduction

Energy is considered as the most important commercial goods having the most application in the world trade and it is of the utmost importance for human activities. After the industrial revolution and formation of machine industry, energy was considered as the first and most applied factor of production. With the continuing economic development process and modernization of the industrial sectors, the significance of consuming energy in the industry and economic growth process of different countries was revealed more than before. Energy productivity and improved energy consumption are the most consequential points that can be affected economy in each country. Furthermore, it is essential that industry researchers, programmers and economic politicians contribute to energy issues as an international factor in the world.

Iran has the third large oil reserves and the second largest natural gas reserves in the world. Iran is in a constant competition to use its energy resources more effectively in the face of subsidization and the need for

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technological advances in energy exploration and production. The energy consumption in this country is extraordinarily higher than international standards. With an economy which is expected to maintain a rate of growth about 1 to 4 per cent for decades, Iran’s role in the world energy market becomes increasingly influential. This makes it important to predict Iran’s future demand and supply for energy. The objective of this paper is to apply the Bayesian vector autoregressive methodology to forecast Iran’s energy consumption and to discuss potential implications. The slower growth reflects an expected slower economic growth and the decline in energy consumption due to structural changes in the Iran economy (Abbasinejad and Gudarzi, 2012).

Oil, gas and electricity, as resources of energy with their ever growing role in world economy and their multi-purpose application in production and consumption, have gained special attention. Through the development of societies and growth of economical activities these sources become more effective on corporations and their services. Corporations use these sources as production factors. Also, families directly or indirectly rely on gas and oil and electricity. Thus energy consumption determines their and the society’s economic welfare.

Forecasts of growth in Iran’s energy consumption are important for two reasons. First, continuation of the strong growth in energy consumption in recent decades will see underlying demand and supply imbalances in Iran increasingly affect global energy markets, particularly oil and natural gas. Second, long term forecasts are required to assess needed for future policy strategies supply and demand of oil and gas.

In this paper, we intend to examine the prediction energy consumption for Iran according to Paul Crompton and Yanrui Wu (2005) article.

This paper uses macroeconomic Bayesian vector autoregression models (BVAR) to forecast the consumption of coal, oil, natural gas and electricity in Iran to 2010. The results suggest that continued mildly growth in consumption can be expected to at least 2010, albeit at a slower rate than that of the period ended to 2000. The composition of energy consumption is also forecasted to change in Iran. Oil, gas and electricity are expected to take larger market shares as growth in electricity consumption slows over time. In this paper we study demand of energy consumption and predict consumption of diverse kinds of energy during 2011 – 2015. In this regard, by applying Bayesian approach and with concern to data of 1980 – 2010 we forecast the trend of energy consumption.

2- Energy Consumption in Iran

Energy resources in Iran consist of the third largest oil reserves and the second largest natural gas reserves in the world. Iran is in a constant battle to use its energy resources more effectively in the face of subsidization and the need for technological advances in energy exploration and production. Energy wastage in Iran amounts to six or seven billion dollars (2008). The energy consumption in the country is extraordinarily higher than international standards. Iran recycles 28 percent of its used oil and gas whereas the figure for certain countries stands at 60 percent. Iran paid $84 billion in subsidies for oil, gas and electricity in 2008. Iran is one of the most energy intensive countries of the world with per capita energy consumption 15 time that of Japan and 10 times that of European Union. Also due to huge energy subsidies, Iran is one of the most energy inefficient countries of the world, with the energy intensity three times higher than global average and 2.5 times the Middle Eastern average.

Total energy consumption (oil, gas and electricity) in Iran increased from 1953 to 1996 (see Figure 1). Despite the continuation of strong growth in GDP, energy consumption fell unexpectedly in 1997 to 137 MtCE, and by 1999 had fallen to 130 MtCE, sparking fears of a permanent structural shift in Iran energy consumption. By 2001, however, consumption in Iran had recovered to 134 MtCE and by 2010 had risen further to 167 MtCE. Oil was the most export energy source, accounting for 23 per cent, while natural gas and electricity accounted for 3 and 5 per cent respectively.

Iran’s energy consumption since 1953 has several distinct characteristics. First, growth in energy consumption has been accompanied by a dramatic decline in energy intensity of use. This change is even more obvious in an international context. When Iran initiated its economic reform programme in the late 1970s, Iran’s energy intensity was a Quarter that of the US and one-fifth that of Japan (see Table 1). Technical and structural
changes have been identified as the main factors that caused the fall in energy intensity in Iran. It can also be argued that the fall in end-use energy intensity is partially the result of an improvement in energy efficiency and development of new materials. These explanations have also been supported by a recent study involving firm-level data (Fisher-Vanden et al. 2004).

Second, energy consumption in Iran is highly unbalanced between the rural and urban sectors as well as across the Iran provinces. This catching-up effect will also affect Iran’s overall energy demand in the future. Finally, Iran’s energy demand has also been influenced by the growth in demand for energy-intensive products such as automobiles and air-conditioners. The number of registered car in Iran has increasing 175 for 1000 per people in 2010 (Bima.ir. Retrieved 2011-07-26).

3- A Bayesian VAR Model of Energy Consumption

In this study, we propose an alternative approach that uses Bayesian vector autoregression models and key macroeconomic variables to forecast energy consumption in Iran to 2015.
An unrestricted vector autoregression model (UVAR) containing \( n \) time series variables and a lag length of \( k \) has the general form:

\[
y_t = A_0 + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_k y_{t-k} + u_t
\]  

(1)

where \( y_t = (y_{1t}, y_{2t}, \ldots, y_{nt})' \) is an \((n \times 1)\) vector of endogenous variables, \( A_0 \) is an \((n \times 1)\) vector of intercept terms, \( A_i, i > 0 \), are \((n \times n)\) coefficient matrices and \( u_t \) is an \((n \times 1)\) vector of white noise residuals. The vector \( A_0 \) contains \( n \) intercept terms and each matrix \( A_i \) contains \( n^2 \) coefficients, hence \( n + kn^2 \) coefficients must be estimated, which increases exponentially with the number of variables in the system. The \( n \) variables included in the system are all assumed to be endogenous. A major problem in the estimation of VAR models when \( k \) is large is over parameterization, where too many coefficients must be estimated relative to sample size. Estimation of the system will typically yield numerous insignificant coefficients that can be properly excluded from the model. The imposition of zero restrictions on such coefficients however, implies a level of certainty regarding the validity of the exclusion restrictions that is often not held by the modeller (see e.g., Crompton and Wu, 2005).

An alternate approach has been offered by the Bayesian vector autoregression (BVAR) methodology of Litterman (1980, 1986), Doan, Litterman, and Sims (1984), Sims (1992). A BVAR model avoids the rigid inclusion/exclusion restrictions of VAR models by allowing the modeller to include many coefficients while simultaneously controlling the extent to which they can be influenced by the data. This reduces the extent to which spurious correlations are captured by the model, thereby improving forecasting performance. The BVAR approach modifies the OLS estimates of equation (1) by treating all coefficients as random variables around their Bayesian prior mean, such that the modeller has the flexibility to impose these priors, to varying degrees, on the coefficient estimates (see e.g., Crompton and Wu, 2005).

The system of priors most commonly used in the specification of BVAR models is the Minnesota prior, which has its origins at the University of Minnesota and the Federal Reserve Bank of Minneapolis. To illustrate, we express the BVAR as:

\[
y_t = B_0 + B_1 y_{t-1} + B_2 y_{t-2} + \cdots + B_k y_{t-k} + \nu_t
\]  

(2)

Where \( B_i, i > 0 \), are \((n \times n)\) coefficient matrices, each element of which now has a Bayesian prior. Each element in the lagged coefficient matrix \( B_i \) is assumed to be an independent, normally distributed random variable, with the prior mean on the first lag matrix, \( B_1 \), equal to an identity matrix and the prior mean on matrices \( B_i, i > 1 \), equal to zero. While this random walk specification may describe well many macroeconomic variables, there is no need to impose the restriction exactly on the BVAR. Rather, the parameters in the system are estimated such that the priors are overridden where significant statistical evidence to the contrary exists.

Each \( B_i, i > 0 \), also requires a corresponding matrix of variances, \( \nu_t \), which individually control how far the estimated coefficients are permitted to deviate from their specified prior. The \( pq \)-th element of \( \nu_i, i > 0 \), is \( \lambda_1 \sigma_{pq}/i^3 \) for \( p = q \), and \( \lambda_1 \lambda_2 \sigma_{pq}/i^{3/2}q \) for \( p \neq q \). The parameter \( \lambda_1 \) is the prior variance on the diagonal elements in \( B_1 \), the lagged values of the dependent variable in each equation. The parameter \( \lambda_2 \) is the prior variance on the off-diagonal elements in \( B_1 \) and controls the magnitude of cross equation effects. Lowering \( \lambda_2 \) towards zero will force the estimated parameters on cross lags towards their prior of zero. The parameter \( \lambda_3 \) controls the decay rate of the variances as \( k \) increases. This increasingly forces the estimated coefficients, as \( k \) increases, towards the prior mean of zero, suggesting that observations further into the past are less likely to be useful in forecasting than more recent observations. If \( \lambda_3 \) is set to one, the rate of decay will be harmonic. The ratio \( \sigma_{pq}/\sigma_{qq} \) adjusts the prior variances for differences in the units of measurement of the different variables. The value of \( \sigma_{pp} \), for example, is typically set equal to the error variance of an OLS regression of the \( p \)-th equation on \( p \) own lags.
One important modification of the Minnesota prior reflects the common practice of estimating BVAR models in first differences when the variables contain unit roots in levels. To illustrate, we write the BVAR model in first differences as:

$$\Delta y_t = \Gamma_0 + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \cdots + \Gamma_k \Delta y_{t-k} + \epsilon_t$$

Sims (1984) suggest the use of a sum of coefficients prior which restricts the sum of the coefficients on the lagged values of the dependent variable in each equation equal to one, while the sums of coefficients on other variables sum to zero. Using the notation of Robertson and Tallman (1999), this constraint can written as $\sum_{i=1}^{k} \Gamma_i = I$, where $I$ is an $(n \times n)$ identity matrix.

4- Energy Consumption Forecasts

The forecasts of energy consumption presented in this section are estimated using Bayesian VAR models with unit root and cointegration restrictions imposed. Separate models are estimated for oil, gas and electricity consumption over the sample period 1960 to 2010. The variables included in each model are energy consumption, real fuel price (except for gas and electricity where prices were unavailable), real gross domestic product and population. The inclusion of GDP in the system is intended to capture the derived nature of energy consumption in domestic production, while the population variable captures the effects of residential energy demand. For oil, forecasts of energy consumption include the effects of a continuation of recent increases in the price of these fuels in the energy sector which are expected to result in further price increases.

The forecasts results suggest that total energy consumption will grow at an annual average rate of 1.8 per cent over the forecast period 2011 to 2015. This is significantly lower than energy consumption growth from 1980 to the downturn in consumption in 1996 which averaged 3.4 per cent. Growth in the consumption of natural gas is forecast to be the highest of the energy fuels at an annual average rate of 3.6 per cent. This compares with forecast annual growth rates of 3.7 per cent for electricity, 1.5 per cent for oil. Under these forecasts, the strong growth in the demand for natural gas will increase its share in total consumption, from 1.8 per cent in 2010 to 2.4 per cent in 2015.

| Year | Oil (bbl/d) | Gas (million cu m/d) | Electric (billion Kwh) |
|------|-------------|----------------------|------------------------|
| 2000 | 1.25        | 58.452               | 88.64                  |
| 2001 | 1.27        | 65.950               | 95.84                  |
| 2002 | 1.41        | 72.354               | 111.91                 |
| 2003 | 1.42        | 79.000               | 115.9                  |
| 2004 | 1.51        | 85.540               | 115.9                  |
| 2005 | 1.59        | 93.673               | 119.9                  |
| 2006 | 1.68        | 102.234              | 132.1                  |
| 2007 | 1.6         | 111.800              | 145.1                  |
| 2008 | 1.70        | 119.000              | 149.4                  |
| 2009 | 1.81        | 126.340              | 145                    |
| 2010 | 1.84        | 132.162              | 153.8                  |
| 2011 | 1.85        | 140.000              | 206.7                  |
| 2012 | 1.87        | 142.231              | 212.2                  |
| 2013 | 1.88        | 143.874              | 215.6                  |
| 2014 | 1.83        | 145.376              | 221.3                  |
| 2015 | 1.90        | 148.321              | 226.7                  |

Data Source: Energy Information Administration (2010)

5- Conclusion

The forecasts presented in this paper suggest that significant growth in energy demand can be expected in Iran until at least 2015. Over the forecast period 2011 to 2015, energy demand is forecast to rise at an annual
average rate of 3.8 per cent, which is slightly lower than the growth rate in the last two decades. The forecast slower growth in energy consumption is consistent with the anticipated, relatively modest rate of economic growth in Iran in the coming decades. In addition, the slower growth in energy consumption also reflects the fact that there will be further structural changes in the Iranian economy and that subsequently some energy-intensive sectors in the economy are expected to decline. Concomitant with the slower growth in energy demand will be a continuation of the change in market shares with oil, natural gas and electricity becoming increasingly important energy, reflecting government policies towards the use of cleaner energy in Iran.

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