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Energy Consumption and Economic Growth: Kalman Filter Approach

Mohsen Mehrara
University of Tehran
Email: mmehrara@ut.ac.ir

Fatemeh Rafiei
MA in Economics University of Tehran
Email: Fatemeh_rafiei@ut.ac.ir

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Abstract

This paper studies the relationship between energy consumption and economic growth for Iran during 1967-2008.we use time varying parameter (TVP) Approach to estimate effect of energy consumption on GDP over time. Our main finding is theenergy consumptionhas a positive sign and it is statistically significant .the final coefficient is 0.037. This parameter varies trivially over time and fluctuations are rather stable.

Introduction

Impact of energy consumption on economic growth is as one of the most popular issues after the first oil shock in the field of energy economic. Studying this topic determines the relationship between energy consumption on economic development and provides the basis for discussion of energy policy and environmental conservation. Although economic theoriesdon't explicitly specify this relationship, but there are many empirical studies in this area.Yu and Choi (1985), Ferguson et al. (2000) ,Toman and Jemelkova (2003) and Chontanawat et al.(2008) explain the lack of any clear results on the relationship between energy use and economic growth couldbedue tovarying energy consumption patterns, the heterogeneity in climate conditions, , the structure and stage of economic development within a country, different econometric methodologies employed and the presence of omitted variable bias along with varying time horizons of the studies conducted.

Kraft and Kraft (1978) ispioneering research for the years 1947 to 1974 were examined energy consumption and economic growth in America. The results show unidirectional causality from GDP to energy consumption dominates the economy of America. Akarca and Long (1980), Yu and Hwang (1984) found that energy consumption andGDP were independent in the United State.Lee and Chang (2005) examined the effect of energy consumption on economic growth in Taiwan from 1955 to 2003. Results of this study showed that economic growth and energy consumption have nonlinear dependence between variables. StudyingNarayan and Smith (2007) also showed that investment, real GDP and energy consumption in G7 countries, are integrated. Capital and energy in the long term causedto economic growth. Stern (1993, 2000), Lee (2006),Morimoto and Hope (2004), Glasure and Lee (1997), Yang (2000), Oh and Lee (2004), Paul and Bhattacharya (2004) found bidirectional causality between GDP and energy consumption.Cheng (1997), Masih and Masih (1997), Yemane (2004)and Lee (2005) found causality runs from energy consumption to GDP.Cheng and Lai (1997)found that a unidirectional causality runs from economic growth to energy consumption, thus suggested that an energy conservation policy is feasible. NicholasApergis& James E. Payne (2008) also investigatedrelationship between energy consumption and economic growth for six Central American countries over the period 1980-2004.this study showed the presence of long run causality from real GDP and economic growth.

The rest of paper is structured as follows. Section 2 providesmethodology, TVP approach and state space model Section 3 discusses the data, and empirical result. Concluding remarks are given in section 4.

Methodology

TVP approach and State-Space model

In this section we use time varying parameter approach (TVP) for estimating the effect of energy consumption on economic growth over period 1967-2009in Iran.

This approach is a new method in econometric literature that provides estimating unobserved variable in the equationssystem. It can show different external shock such as change of regime, economic reform,politicaluncertainty and etc.So in this approach the parameter can vary over time.In addition, this doesn't need unit root test so it is oneadvantage ofthis methodcompared with othermethodsof time-series like OLS .State space model can estimateby kalman- filter. It can evaluate maximum loglikelihood, forecasting and Smoothing state variable. Eq. (1, 2) is the generalformofstate - space the model.

$$Y_t = A'X_t + H'\xi_t + \omega_t \quad (1)$$

$$\xi_{t+1} = F\xi_t + \upsilon_{t+1} \quad (2)$$

Equation (1) is observation Equation and has the structure of linear regression model that the coefficient vector ξ variesovertimeand equation (2) is a state equation. It represents a first order vector autoregressive model, the Markovian nature of which accounts for many of the elegant properties of state space model. (Durbin andKoopman, 2001)

Where$Y_t$is a p×1 vector of observations and $X_t$is a p×k matrix of explanatory variables is a ξ vector of unobservable variables called state vector. ω_t And$v_{t+1}$are noises .So that:

$$\mathrm{var}(\omega_t) = K_t,\ \mathrm{var}(v_t) = Q,\ E(\omega_s v_t) = 0 \quad (3)$$

$X_t$in eq. (1) contains exogenous variables that don't explain any information about ω_{t+s}, ξ_{t+s} for $s = 0,1,\ldots,N$.on the other hand X_t can include lag of depended variables whichdon't correlation with $\omega_{t+s}$and ξ_{t+s}. Moreover, we assume:

$$E(v_t \xi_t') = 0,\ E(\omega_t \xi_t') = 0 \quad (4)$$

Based on the above, two major application filter – Kalman are:

1- The first application of this filtering isproviding an algorithm for forecasting the least squares state vector based on T observations. So:

$$\xi_{t+1|t} = E(\xi_{t+1}|Y_t),\ Y_t = (y_t', y_{t-1}', \ldots, y_1', x_t', x_{t-1}', \ldots, x_1') \quad (5)$$

2- The second application is estimating varying parameter over time.Considerthe following equation:

$$Y_t = X_t'\beta + \omega_t \quad (6)$$

Where X_t is an exogenous vector and independed of ω_t, so Coefficients vector of parameters that varies overtime as follow:

$$\beta_{jt} = \varphi_j \beta_{jt-1} + e_{jt} \quad (7)$$

If we set φ_j=1, eq. (5) can followas random walk thatrepresented as follow:

$$\beta_{jt} = \beta_{jt-1} + e_{jt} \quad (8)$$

The above equation e_{jt} shows the external shocks that entry to system. So it can be result of transition economic regime or changes in economic policy at time t(Song and Witt).
Eq(6) can be written in the form:

$$\beta_{jt} = \beta_{j0} + \sum_{h=0}^{n} e_{jt-k} \quad (9)$$

Structure of state equation is specified by information criteria. For example (Grinslid and Hall, 1996) (kim1993) (song &witt 2000) showed Random walk process for state equation can consider structural changes on economic model. Note for deciding on the appropriate state equation, different information criteria such as Akaike or schwarz criterionand also ARMA should be used. (Harvey, 1987)

Empirical result

If we consider economic output(Y) as a function of labor (L), capital (K) and energy consumption (EC), spired from Lee and Chang (2008) and Stern (2000a, b), the relation is specifies as:

Y_t=f (K_t, L_t, EC_t) (10)

Based on TVP approach and using Kalman- filter approach, the measurement and state equationsare as:

GYt = β0 + β1 GKt + β2 GLt + β3 GECt + εt (11)

$$GEC_t = \varphi_j GEC_{jt-1} + e_{jt} \quad (12)$$

Where GY_t is a domestic production growth, GK_t is a stock capital growth, GL_t is population growth and GEC_t is energy consumption growth.Data are from central bank of Islamic republic Iran. Table 1 show the result of specification.

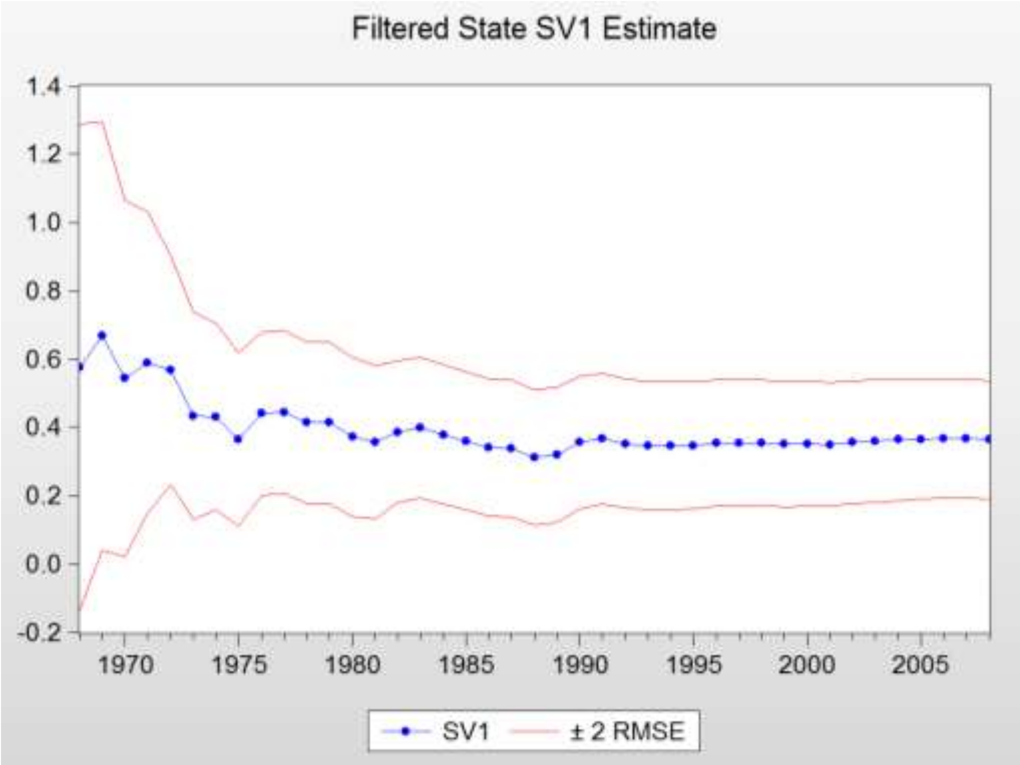
Table1:
Model Estimated With Time Varying Parameter (Tvp)

explanatory				state variable
Constant term	Labor	Capital	gdp(-1)	Final State(ec)
-0.002347	-0.186289	0.079413*	0.40047***	0.370426***
(0.043563)	-(0.10869)	-(1.73695)	(2.935926)	(4.260666)
Log likelihood	54.46528			
Akaike info criterion	-2.355489			
Schwarz criterion	-2.148624			
Hannan-Quinn criter.	-2.279665			

The numbers inparameters are absolute values of the estimated z statistic.*, **, *** denote that the corresponding null hypothesis can be rejected at the 10, 5, 1, percent significant level, respectively.

Preliminary estimations implies that the coefficients for labor growth, capital growth, and lag GDP growth as rather constant. So, we assume just the coeffiecient of growth consumption can vary as a random walk.

Figure 1 show state variable(the coefficient of growth consumption)over time.It is clear this parameter is stable as well as other paremeters over time except the primary years. Ten percent decrease inenergy consumption growth lead toapproximately 0.37 percent decrease in economic growth.



Conclusion and policy implications

This paper provides new empirical insight into the analysis of the relationship between energy consumption and economic growth, considering time varying approach. Result shows TVP approach is suitable for representation of structural changes.The findings indicate energy consumptionhas a positive sign in GDP equation. Moreover, the final coefficient estimated as 0.37 is statistically significant.This parameter varies trivially over time so that thefluctuations are rather stable. The size of coefficient (0.37) implies the energy conservation polices haverestrictive strong effect on economic growth.

Because of importance relationship between economic growth and energy consumption we suggest policy makers to be careful about energy conservation policy.

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