Research Journal of Applied Sciences 11 (12): 1513-1516, 2016
ISSN: 1815-932X

Calculation of Government's Fiscal Policy Index in TVP-FAVAR Models

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Abstract: This study attempted to calculate the government's fiscal policy index in the Iranian economy using the quarterly data from 1988-2012 in a model consisting of a combination of the Factor-Augmented Vector Autoregressive (FAVAR) and the Time-Varying Parameter (TVP) models. In this modeling, the variables of GDP growth, investment growth, inflation, exchange rate changes, private consumption expenditure growth and the government's fiscal policy entered the model as latent variables. Based on the results of the study, it was found that the proposed model led to better accuracy in modeling the Iranian fiscal policy index compared to the two-stage FAVAR Model proposed by Doz and the Principal Component Analysis (PCA) Model.

Key words: Fiscal policy, economic growth, state-space equation, (PCA), Iran, FAVAR

INTRODUCTION

In experimental studies, there is no consensus on the effects of fiscal policy. The results of different studies indicate different effects of fiscal policy on the macroeconomic variables in the developing countries. With the publication of Giavazzi and Pagano (1990), the subject of the efficiency of fiscal policy entered a new stage and the non-keynesian effect of fiscal policy was stressed in different studies. Based on the results of the prior research, the adoption of a contractionary fiscal policy may have an expansionary effect on consumption, investments and/or production (Giavazzi and Pagano, 1990, 1996; Perotti, 1999; Giavazzi *et al*., 2000). Some of the studies rejected the non-keynesian effect of fiscal policy (Hjelm, 2002; Schclarek, 2005). Since 1990, most studies conducted examined the effects of fiscal policy in the industrial nations, the results of which cannot be certainly generalized for the developing nations and there is no robust evidence supporting these results in such countries (Giavazzi *et al*., 2000; Schclarek, 2005). Based on the experimental literature, main reasons for the lack of agreement on the efficiency of fiscal policy in different time and space circumstances can include interruptions in the identification, decision making, implementation and the efficiency of fiscal policy. According Stock and Watson (2008), one of the main problems of the previous models was that they could not provide a proper analytic framework over time. The theoretical and experimental literature indicated that one cannot study the efficiency of fiscal policy without the key features the general atmosphere of the national economy; therefore, the linear models show a weakness in examining the effects of fiscal policy.

This study made use of the Factor-Augmented Vector Autoregressive (FAVAR), proposed by Bernanke *et al*. (2005) and the Time-Varying Parameter (TVP) models together to calculate the fiscal policy index. Different econometric models have been introduced in order to assess FAVAR and TVP-FAVAR Models (Bernanke and Mihou, 1998; Korobilis, 2009, 2013). Due to the large volume of programming, it is difficult to calculate such assessment methods (Bayesian Models used in the Markov Chain Monte Carlo (MCMC). Therefore, new experimental studies have used the Kalman Filter and other filtering algorithms in order to assess the models. The TVP-FAVAR Model in this study is a new algorithm, which is an expansion by Doz *et al*. (2011). It used the variables of GDP growth, investment growth, inflation, exchange rate changes, private consumption expenditure growth and the government's fiscal policy in order to model the Iranian economy. It also used the determining variables of the government's fiscal position in order to assess the latent variable of fiscal policy.

MATERIALS AND METHODS

TVP-FAVAR Model: The TVP-FAVAR takes the form:

$$x_t = \lambda_t^y y_t + \lambda_t^f f_t + u_t \begin{bmatrix} y_t \\ f_t \end{bmatrix}$$

$$= c_t + B_{t,1} \begin{bmatrix} y_{t-1} \\ f_{t-1} \end{bmatrix} + \ldots + B_{t,p} \begin{bmatrix} y_{t-p} \\ f_{t-p} \end{bmatrix} + \varepsilon$$

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With:

$$\lambda_t = \lambda_{t-1} + v_t$$
$$\beta_t = \beta_{t-1} + \eta_t$$

where, $\lambda_t = ((\lambda_t^f)', (\lambda_t^y)')'$ and $\beta_t = (c_t', \text{vec}(B_{t,1})', ..., \text{vec}(B_{t,p})')$ and f_t the latent factor. All ersrors in the equations above are uncorrelated over time and with each other, thus having the following structure. We write the TVP-FAVAR compactly as:

$$x_t = z_t \lambda_t + u_t \quad u_t \sim N(0, V_t)$$
$$z_t = z_{t-1}\beta_t + \varepsilon_t \quad \varepsilon_t \sim N(0, Q_t)$$
$$\beta_t = \beta_{t-1} + \eta_t \quad \eta_t \sim N(0, R_t)$$
$$\lambda_t = \lambda_{t-1} + \upsilon_t \quad \upsilon_t \sim N(0, W_t)$$

where, $\lambda_t = (\lambda^y_t, \lambda^f_t)$. Note that as speciÖed in the body of the study, we identify λ^f_t by setting its first element to 1 and this restriction is maintained at all time periods. We also use notation where $\tilde{f}_t$ is the standard principal components estimate of f_t based on x_t (using data up to time t), $z_t = [y_t/f_t]$ and $\tilde{z}_t = [y_t/\tilde{f}_t]$, if is a vector then is the $a_{i,t}$ th element of that vector and if $A_{ii,t}$ is a matrics $A_{ii,t}$ is its (i, ith element. The algorithm below requires priors for the initial states. We make the relatively diffuse choices 0~(0,100), f_0~(0,10), λ_0~(0, I), β_0~(0, I). For the EWMA estimates of the error covariance matrices, we initialize them with $\hat{V}_O = 0.1 \times I$, $\hat{Q}_O = 0.1 \times I$, $\hat{R}_O = 10^{-5} \times I$ and $W_O = 10^{-5} \times I$. Note that setting R_0 and W_0 to small values is motivated by the fact that R_t and Q_t control the degree of evolution in the coefficients. Even apparently small variances such as 10^{-5} will allow for a large degree of coeficient variation in a relatively short time period.

The algorithm extends the one derived by Doz *et al*. (2011) to the TVP-FAVAR and involves two main steps which are repeated for t = 1, ..., T.

Step 1: Conditional on f_t, estimate the parameters in the TVP-FAVAR.

Step 2: Conditional on the estimated TVP-FAVAR parameters from Step 1, use the Kalman Filter to produce an estimate of f_t which is used as our FCI.

Step 2: Requires no additional explanation, being just a standard application of Kalman Filtering in a state space model. We provide exact details of Step 1 here.

Step 1: Involves using the priors/initial conditions above for t = 0 values and then for t = 1, ..., T proceeding as follows: 1: calculate the residuals for the state equations $\hat{\eta}_{t-1}$ and $\hat{\upsilon}_{t-1}$, using the equation:

$$\hat{\upsilon}_{t-1} = \hat{\lambda}_{t-1} - \hat{\lambda}_{t-2}$$
$$\hat{\eta}_{t-1} = \hat{\beta}_{t-1} - \hat{\beta}_{t-2}$$

2: Estimate the state covariances R_t and W_t using:

$$\hat{R}_t = \kappa_3 \hat{R}_{t-1} + (1 - K_3)\tilde{\eta}_{t-1}\tilde{\eta}'_{t-1}$$
$$\hat{W}_t = \kappa_4 \hat{W}_{t-1} + (1 - K_4)\hat{\upsilon}_{t-1}\hat{\upsilon}'_{t-1}$$

3: Calculate the quantities in the Kalman filter prediction equations for and given information at:

$$\lambda_t \sim N\left(\lambda_{t|t-1}, \Sigma^{\lambda}_{t|t-1}\right)$$
$$\beta_t \sim N\left(\beta_{t|t-1}, \Sigma^{\beta}_{t|t-1}\right)$$

Where:

$$\lambda_{t|t-1} = \lambda_{t-1|t-1} \text{ and } \Sigma^{\lambda}_{t|t-1} = \Sigma^{\lambda}_{t-1|t-1} +$$
$$\tilde{W}_t \text{ and } \beta_{t|t-1} = \beta_{t-1|t-1} \text{ and } \Sigma^{\beta}_{t|t-1} = \Sigma^{\beta}_{t-1|t-1} + \hat{R}_t$$

4: Compute the measurement equation prediction errors as:

$$\tilde{u}_t = x_t - \tilde{x}_{t|t-1}$$
$$\tilde{\varepsilon}_t = z_t - \tilde{z}_{t|t-1}$$

where, $\tilde{x}_{t|t-1} = \tilde{z}_t \lambda_{t|t-1}$ and $\tilde{z}_{t|t-1} = z_{t-1}\beta_{t|t-1}$. 5: Estimate the measurement equation error covariance matrices, Q_t and V_t using EWMA specifications:

$$\hat{V}_t = \kappa_1 \hat{V}_{t-1} + (1-\kappa_1)\hat{u}_t \hat{u}_t$$
$$\hat{Q}_t = \kappa_2 \hat{Q}_{t-1} + (1-\kappa_2)\hat{e}_t \hat{e}_t$$

6: Update $\lambda_{i,t}$ for each i = 1, ..., n from:

$$\lambda_{it} \sim N(\lambda_{i,t} | t' S^{\lambda}_{ii,t|t})$$

Where:

$$\lambda_{i,t|t} = \lambda_{i,t|t-1} + \Sigma^{\lambda}_{ii,t|t-1}\tilde{z}'_t\left(\hat{V}_t + \tilde{z}_t \Sigma^{\lambda}_{ii,t|t-1}\tilde{f}'_t\right)^{-1}$$
$$\Sigma^{\lambda}_{ii,t|t-1} = \Sigma^{\lambda}_{ii,t|t-1} - \Sigma^{\lambda}_{ii,t|t-1}\tilde{z}'_t\left(\hat{V}_t + \tilde{z}_t + \Sigma^{\lambda}_{ii,t|t-1}\tilde{z}'_t\right)^{-1} \tilde{z}\Sigma^{\lambda}_{ii,t|t-1}\tilde{z}'_t$$

Update the estimate of β_t given information at time t using:

$$\beta_t \sim N\left(\chi_{t|t}, S^{\beta}_{t|t}\right)$$

Where:

$$\beta_{t|t} = \beta_{t|t-1} + S^{\beta}_{t|t}\tilde{z}'_{t-1}\left(\hat{Q}_t + \tilde{z}_{t-1}S^{\beta}_{t|t}\tilde{z}'_{t-1}\right)^{-1}\left(\tilde{z}_t - \tilde{z}_t \hat{\beta}_t\right)$$
$$S^{\beta}_{t|t-1} = S^{\beta}_{t|t-1} - S^{\beta}_{t|t-1}\tilde{z}'_{t-1}(\hat{Q}_t + \tilde{z}_{t-1}S^{\beta}_{t|t-1}\tilde{z}_{t-1})^{-1}\tilde{z}_{t-1}S^{\beta}_{t|t-1}$$

RESULTS AND DISCUSSION

This study used the quarterly data from 1988-2012 related to the variables of GDP growth, investment growth, inflation, exchange rate changes and private consumption expenditure growth as the main variables. Moreover, the variables of the government's current

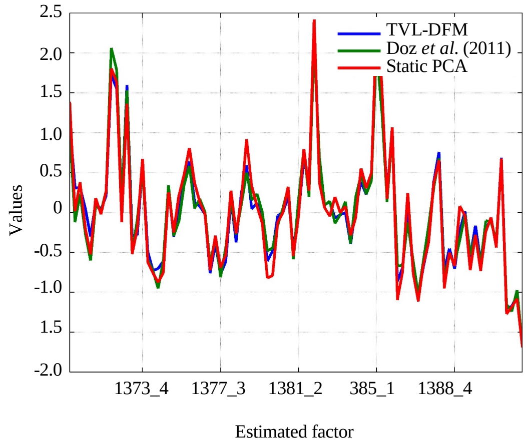

Fig. 1: Assessment of the latent variable of government's

expenditure growth, the government's civil construction growth, oil revenues, the government's tax revenues and its other revenues entered the TVP-FAVAR Model in order to calculate the latent variable of the government's fiscal policy. All the variables were extracted from the Central Bank. After assessing the TVP-FAVAR Model using MATLAB and using two interruptions in the model's endogenous variables, the results of the analysis of the Impulse Response Function (IRF) of the variables as a result of the shock on the latent variable of the government's fiscal policy were presented up to 10 steps. The results of the assessment of the latent variable of government's fiscal policy using the TVP-FAVAR Model, the two-stage FAVAR Model proposed by Doz *et al*. (2011) and the PCA Model are presented in Fig. 1.

CONCLUSION

The increase in the calculation capability of the new computers has led to the development of new models with accurate assessments at different points in time (Koop and Korobilis, 2013). Most studies conducted in the recent years in the area of the effects of the determining conditions of the national economy on the relationships of variables have used the TVP and the MCMC (Nakajima *et al*., 2011). This premise has been also taken into account in this study; the calculation of the government's fiscal policy index within the framework of the general atmosphere of the national economy was done based on the Stock and Watson (1996, 1999, 2007, 2008)'s method. The results of the study showed the robustness of the TVP-FAVAR Model in the calculation of the financial development index. Based on this, a framework is provided for using the proposed model for analyzing and calculating the effects of the financial development index in the future studies.

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