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Oil Price Uncertainty in the Iranian Economy[1]

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Abstract

The relationship between the price of oil and the level of economic activity is a fundamental empirical issue in macroeconomics. In this research, by using a multivariate GARCH-in-Mean VAR, we try to investigate direct effects of uncertainty of oil price on macroeconomics of Iran by using annually data from 1965 to 2013.Results show that uncertainty about oil prices had a negative and significant effect on real output in our sample.

Keywords: Real Options, Uncertainty, Oil Price, Multivariate GARCH-in-Mean VAR.

JEL Classification: C32, E10, G31.

1. Introduction

The relationship between the price of oil and the level of economic activity is a fundamental empirical issue in macroeconomics. The theoretical literature suggests the existence of a number of transmission mechanisms through which oil price innovations affect real output: income transfer channel, reallocation channel, monetary policy response channel, effect on the productivity of labor and capital channel, and uncertainty channel.

To investigate empirically the facts, there is a vast literature that examines the effects of oil prices on the real economy. Firstly, James

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Hamilton showed in a paper published in the Journal of political Economy in 1983, at that time 7 out of 8 postwar recessions in the United States had been preceded by a sharp increase in the price of oil. Also, in a paper published in a special issue of Macroeconomic Dynamics in 2011 on oil price shocks, Hamilton continues this line of argument, by saying that fluctuations of price of oil, resulting political and other issues, led to recessions of United States in different recent periods of time. See, also for example, Kilian (2008), Hamilton (2009), Blanchard & Riggi (2009), Edelstein & Kilian (2009), and Blanchard & Gali (2010). Furthermore, to answer the question of how asymmetric the responses of real output are to exogenous oil price shock to support the idea of positive oil price shocks have been the major cause of recessions, different investigation have been performed. Most of the empirical evidence is support of the presence of asymmetries in the transmission of oil price shocks; however, Killian & Vigfusson (2011a) argue that this evidence is invalid.

However, relatively few studies consider the effects of uncertainty about oil prices on real economic activity (the final mechanism). Recently in the state of the art advances in macro econometrics and financial econometrics, to investigate empirically the effects of oil price shocks and uncertainty about the price of oil on the macro economy, focusing are on the direct effects of uncertainty about the future price of oil on the level of economic activity.

In this paper, we move the empirical literature forward by examining the direct effects of oil price uncertainty on real economic activity as well as the response of real GDP growth to oil price shocks by using annually data for economy of Iran. The model is based on a structural VAR that is modified to accommodate GARCH-in-mean errors, as detailed in Engle & Kroner (1995), Grier et al. (2004), Shields et al. (2005), and Elder & Serletis (2010). As a measure of uncertainty about the impending real oil price, we utilize the conditional standard deviation of the forecast error for the change in the real price of oil.

Our principal result is that uncertainty about the price of oil in Iran has had a significant and negative effect on real gross domestic product (GDP) over the post-1965 period.

There are a few notification in the interpreting our results. First, our proxy for uncertainty is the conditional variance of oil prices. This proxy reflects the dispersion in the forecast error generated by an econometric model applied to historical data and may not capture other forward-looking components of uncertainty that are not parameterized in the model. It may also be correlated with some other factor that is driving our result. Autoregressive conditional heteroscedasticity (ARCH-) based measures of uncertainty, however, have been very common, at least since their seminal application by Engle (1982) to inflation uncertainty. Second, our model does not decompose innovations in oil prices into components representing demand and supply as in Kilian (2009a). In this sense, our "oil price shocks" may reflect the average composition of oil demand and oil supply shocks over the sample period.

The paper is organized as follows. Sections 2 and 3 provide a brief description of the theoretical basis and literature review and then section 4 discusses the empirical model. Section 5 presents the data and Identification and sections 6 assess the appropriateness of the econometric methodology by various information criteria, and discuss the empirical results. The final section concludes.

2. Theoretical Basis

As mentioned in the above, the theoretical literature suggests the existence of a number of transmission mechanisms through which oil price innovations affect real output. One of these channels is the income transfer, according to Rubin and Buchanan work (2008) which emphasizes the price of imported crude oil and the change in the purchasing power of domestic households associated with increase in the real price of oil. Other channel as Hamilton (1988) and Kilian & Vigfusson (2011) suggest, is the reallocation which oil price shocks are relative price shocks and can cause inter-sectoral and intra-sectoral reallocations of factors of production throughout the economy. Also, according to Bernanke et al. (1997) through monetary policy response channel, an unexpected increase in the price of oil leads to an increase in the price level, thereby reducing real money balances are held by households and causes declining in aggregate demand through traditional monetary policy effects. Energy prices may also affect economic activity through their effect on the productivity of labor and capital, as in the real business cycle models of Kim & Loungani (1992), Rotemberg & Woodford (1996), and Finn (2000).

Final mechanism is the uncertainty channel which focuses on the effects of uncertainty about the price of oil in the future on investment spending and delaying it according to real options theory, which the opinion was developed by Henry (1974), Bernanke (1983), Brennan & Schwartz (1985), Majd & Pindyck (1987), Brennan (1990), Gibson & Schwartz (1990), Triantis & Hodder (1990), and Aguerrevere (2009).

There are two traditional and new views about it. Traditional view includes theories of acceleration investment, Tobin'sq investment, and neoclassic investment. In these theories, making decision about investment depends on past and present variables such as interest rate, profit, amount of sale, and previous capital. In other words, firms which follow maximizing their profit, choose optimal investment with full information. However, in real world as information is not complete, finding optimal point is so difficult and most of the time, amount of investment is more or less than it. In additions, firms encounter different uncertainty recourses such as uncertainty of cost of factors and uncertainty of changes of exchange rate. So, new investment theories consider two points. First, investment is non-returnable and second, making decision about investment will be delayed until uncertainty will be eliminated. So, new theories attend to uncertainty.

3. Literature Review

Recently in the state of the art advances in macroeconometrics and financial econometrics, to investigate empirically the effects of oil price shocks and uncertainty about the price of oil on the macroeconomy, focusing are on the direct effects of uncertainty about the future price of oil on the level of economic activity.

Elder & Serletis (2010) by using multivariate GARCH-in-mean VAR, investigated the relationship between the price of oil and investment, focusing on the role of uncertainty about oil prices. They found that volatility in oil prices had a negative and statistically significant effect on several measures of investment, durables consumption, and aggregate output.

Rahman & Serletis (2011) investigated the effects of oil price uncertainty and its asymmetry on real economic activity in the United States, in the context of a bivariate vector auto-regression with GARCH-in-mean errors. The model allows for the possibilities of spillovers and asymmetries in the variance-covariance structure for real output growth and the change in the real price of oil. They found that oil price uncertainty negative effect on output, and those shocks to the price of oil.

Rahman & Serletis (2012) also investigated the relationship between oil price uncertainty and the level of economic activity, using quarterly Canadian data over the period from 1974:1 to 2010:1. In doing so, they used a bivariate VARMA, GARCH-in-Mean, asymmetric BEKK model and showed that the conditional variance−covariance process underlying output growth and the change in the real price of oil exhibits significant non-diagonally and asymmetry. They also presented evidences that increased uncertainty about the change in the real price of oil is associated with a lower average growth rate of real economic activity in Canada.

Samadi et al. (2013) investigated the impact of oil price volatility on macroeconomic variables such as investment, unemployment and production, based on quarterly data during the period 1369:1-1386:4. To achieve this, permanent and transitory volatility of OPEC oil price were estimated by component GARCH model (CGARCH). Results indicated that permanent uncertainty arising from changes in oil prices led to decline investment and production and to raise unemployment.

4. The Empirical Model

As indicated above and same as Elder & Serletis (2010), we measure uncertainty about real oil prices as the standard deviation of the one-step-ahead forecast error, conditional on the contemporaneous information set. The standard deviation of this forecast error is a measure of dispersion in the forecast, and as such, is a measure of uncertainty about the impending realization of the price of oil. Such time-series measures of uncertainty have been very common, at least since Engle (1982) and Bollerslev (1986) applied univariate ARCH and GARCH models to measure inflation uncertainty. We follow the same method as Elder & Serletis (2010).

Our empirical model is a multivariate annually GARCH-in-Mean model in real GDP growth and the change in the real price of oil and was first developed in Elder (1995, 2004). The operational assumption is that the dynamics of the structural system can be summarized by a linear function of the variables of interest plus a term related to the conditional variance. According to the basic GARCH framework which was extended by Engle et al. (1987), the conditional mean, $\mathrm{y_t}$, depends on the conditional variance, δ_t^2. Following it and imposing some restriction, the conditional mean is as follows:

$$By_t = C + \sum_{i=1}^{p} \Gamma_i y_{t-i} + \Lambda(L)\sqrt{H_t} + e_t \qquad (1)$$

$$\dim(B) = dim(\Gamma_i) = (n * n), \qquad e_t |\, \Omega_{t-1} \sim iidN(0\,, H_t),$$

where 0 is the null vector,$\Lambda(L)$ is a matrix polynominal in the lag operator,Ω_{t-1} denotes the available information set in period t-1, which includes variables dated t-1 and earlier.

The system is identified by imposing a sufficient number of exclusion restrictions on the matrix B, and assuming that the structural disturbances, e_t, are uncorrelated. This specification allows the matrix of conditional standard deviations, denoted $\sqrt{H_t}$, to affect the conditional mean.

Testing whether oil price uncertainty affects real economic activity are the tests of restrictions on the elements of Λ(L) that relate the conditional standard deviation of oil price, given by the appropriate element of $\sqrt{H_t}$, to the conditional mean of y_t. That is, if oil price uncertainty has positively affected output growth, we will expect to find a positive and statistically significant coefficient on the conditional standard deviation of oil in the output equation. In our application, the vector y_t includes real output growth and the change in the real oil price.

In other words,

$$y_t = \begin{bmatrix} \Delta \ln oil_t \\ \Delta \ln y_t \end{bmatrix};\ e_t = \begin{bmatrix} \mathrm{e}_{\Delta \ln\ \mathrm{oil},t} \\ \mathrm{e}_{\Delta \ln \mathrm{y},t} \end{bmatrix};\ h_t = \begin{bmatrix} h_{\Delta lnoil\Delta lnoil,t} \\ h_{\Delta lny\Delta lny,t} \end{bmatrix};$$

$$B = \begin{bmatrix} 1 & 0 \\ \mathrm{b}_{\Delta \ln\ \mathrm{oil}} & 1 \end{bmatrix};\ C = \begin{bmatrix} \mathrm{c}_{\Delta \ln\ \mathrm{y}} \\ \mathrm{c}_{\Delta \ln\ \mathrm{oil}} \end{bmatrix};\ \Gamma_i = \begin{bmatrix} \gamma_{11}^{(i)} \gamma_{12}^{(i)} \\ \gamma_{21}^{(i)} \gamma_{22}^{(i)} \end{bmatrix};\ \Lambda(\mathrm{L}) = \begin{bmatrix} 0 \\ \Lambda(L)_{22}^{(j)} \end{bmatrix}.$$

The conditional variance$\mathrm{H_t}$ is modeled as multivariate GARCH on the base of Elder (2004),which shows that imposing a common identifying assumption in structural VARs greatly simplifies the variance function written in terms of the structural disturbances. That is, given the zero contemporaneous correlation of structural disturbances, the conditional variance matrix $\mathrm{H_t}$ is diagonal, substantially reducingthe requisite number of variance functions parameters. Therefore, the variance function is as follows:

$$\mathrm{diag}\,(\mathrm{H_t}) = \mathrm{C_v} + \sum_{j=1}^{f} F_j\, diag(H_{t-j}) + \sum_{k=1}^{g} G_k\ (e_{t-k}e_{t-k}{}') \qquad (2)$$

where diag is the operator that extracts the diagonal from a square matrix. If we impose the additional restriction that the conditional variance of $\mathrm{y_{i,t}}$depends onlyon its own past squared errors and its own past conditional variances, the parameter matrices F_j and $G_k$will bealso diagonal. Given the focus of this paper, this assumption is not restrictive, and it can be relaxed if we have particular interest in how the lagged uncertainty of one variable may interact with the conditional variance of another. We therefore estimate the variance function given by equation (2), with f = g = 1.

The multivariate GARCH-in-mean VAR, equations (1) and (2), can be estimated by full information maximum likelihood (FIML), which avoids Pagan's (1984) generated regressor problems associated with estimating the variance function parameters separately from the conditional mean parameters, as in Lee, Ni, & Ratti (1995).The procedure is to maximize the log likelihood with respect to the structural parameters B, C, Γ_i,Λ ,$\mathrm{C_v}$,F_j, and G_k, where

$$l_t = -\left(\frac{n}{2}\right)\ln(2\Pi) + \frac{1}{2}\ln|B|^2 - \frac{1}{2}\ln|\,\mathrm{H_t}| - \frac{1}{2}\left(\mathrm{e_t H_t^{-1} e_t}'\right).$$

We set the pre-sample values of the conditional variance matrix H_0 to their unconditionalexpectation and condition on the pre-sample values $y_0, y_{t-1}, \ldots, y_{t-p+1}$. To ensure that H_t is positive definite and $\mathrm{e_t}$ is covariance stationary, the followingrestrictions are imposed: $\mathrm{C_v}$ is element-wise positive, F and G are element-wise non negative and the eigenvalues of (F + G) are less than one in modulus. Provided thatthe standard regularity conditions are satisfied, FIML estimates are asymptoticallynormal and efficient, with the asymptotic covariance matrix given by the inverse of Fisher's information matrix.

This procedure is computationally intensive, as it estimates all the structural parameters simultaneously, unlike the conventional procedures for a homoscedastic VAR. In a homoscedastic VAR, the reduced-form parameters are typically estimated by OLS and the structural parameters are recovered in a second stage either by a Cholesky decomposition or a maximum likelihood procedure applied to the reduced-form covariance matrix, requiring numerical optimization over as few as n (n − 1)/2 free parameters in B. Such simplified estimation schemes are not possible with this model, however, in part because the information matrix is not block diagonal.

5. Data and Identification

We use annually data for the economy of Iran over the period from 1965 to 2013, a total of 48 observations. We estimate our model, using real GDP and the real price of oil; so, we have two variables - the real GDP (y_t) and the real price of oil (o_t). We use the real price of oil, as many other studies do, including Mork (1989), Lee, Ni, & Ratti (1995), Elder & Serletis (2010), Herrera, Lagalo, & Wada (2011a), and Kilian & Vigfusson (2011a). Furthermore, we use data for nominal GDP and GDP Deflator from WDI, and for exchange rate from Indicators Clio Infra, data sets.

We use Statista data set for annual data on nominal price of OPEC oil basket[5]. Then, we covert the nominal price of oil to local currency and divide it by the GDP deflator index to get the real price of oil.

Figure 1 plot the logged levels and the first differences of real GDP and the real price of oil (lny_t/ lno_t series) for Iran. A battery of unit root and stationary tests are conducted in Table 1 in the natural logs of real GDP and the real oil price for each country. In particular, we used the Augmented Dickey–Fuller (ADF) test [see Dickey and Fuller, 1981] and the Dickey–Fuller GLS test [see Elliot, Rothenberg, and Stock, 1996], assuming both a constant and trend, to determine whether the series have a unit root. Moreover, given that unit root tests

5.The reasons using the price of OPEC oil basket instead of the price of Iran light oil are that first, pricing of the Iran light oil is on the base of the OPEC oil basket and so fluctuations are the same; second, since the price of Iran light oil have been affected from all economic, political, and environmental issues(not just economic issues), to present real modeling, we use the OPEC oil basket price in the analysis same as Samadi et al. (2013).

have low power against trend stationary alternatives, we also use the KPSS test [see Kwiatkowski, Phillips, Schmidt, and Shin, 1992] to test the null hypothesis of stationarity. As shown in Table 1, the null hypothesis of a unit root cannot be rejected at conventional significance levels by both the ADF and DF-GLS test statistics in all data. Moreover, the null hypothesis of stationarity can be rejected at conventional significance levels by the KPSS test in some series; however, it can be accepted to be rejected approximately in all series. We thus conclude that real GDP and the real oil price for Iran are nonstationary, or integrated of order one, I(1).

In panel Table 1 also, we repeat the unit root and stationarity tests using the first differences of the logs of the series. Clearly, the null hypotheses of the ADF and DF-GLS tests are rejected and the null hypothesis of the KPSS test cannot approximately be rejected, suggesting that the logarithmic first differences are stationary, or integrated of order zero, I(0).

Due to the presence of unit roots in the logged levels, in the next section we estimate all models using the first differences of the logarithms of the series.

6. Empirical Evidence

We estimate a multivariate GARCH-in-mean VAR with two lags, using annually observations on the log change in the real price of oil and the log change in real GDP over 1965 to 2013 for the economy of Iran. To ensure that our specification is consistent with the data, we calculate the SIC for the conventional homoscedastic VAR and our multi variate GARCH-in-mean VAR. The Schwarz criterion includes a substantive penalty for the additional parameters required to estimate GARCH models, and so an improvement in the Schwarz criterion suggests strong evidence in favor of our specification. The values of the Schwarz criterion reported in table 2 indicate that the multi variate GARCH-in-mean VAR captures important features of the data, with the Schwarz criterion for the multi variate GARCH-in-mean VAR being considerably lower than that for the conventional homoscedastic VAR. Also, it is valuable to mention that different lags were considered and only in two lags model integrated.

The point estimates of conditional mean and conditional variance-covariance function parameters of the multi variate GARCH in-mean VAR are reported in tables 3 and 4 for Iran and provide high support for the specification.

The primary coefficient of interest relates to the effect of real oil price uncertainty on real GDP. This is the coefficient on the conditional standard deviation of real oil price changes in the output growth equation, which is reported in the $\Lambda\ (L)$ matrix in table 3. The null hypothesis that the true value of this coefficient is zero is rejected in economy of Iran at the 5% level in the period, thus providing evidence to support the hypothesis that higher oil price uncertainty tends to decrease real economic activity. Hence, uncertainty about the real price of oil has tended to reduce real GDP over our sample and that effect is statistically negative significant at conventional levels about -0.738.

On the base of variance-covariance function, there are no evidence of GARCH in real GDP in Iran and evidence of ARCH in the real price of oil; however, there is only evidence of ARCH in real GDP in Iran. At an annually frequency, the volatility process for the real price of oil is not apparently persistent in Iran, as most of the coefficient are not significant.

7. Conclusion

The theories of investment under uncertainty and real options predict that uncertainty about, for example, oil prices will tend to depress current investment and consumption. In this paper, we examined the effects of oil price uncertainty on real economic activity in the economy of Iran, in the context of a dynamic multivariate framework in which a structural vector auto-regression has been modified to accommodate multivariate GARCH-in-mean errors, as in Elder & Serletis (2010). In this model, oil price uncertainty is the conditional standard deviation of the one-period-ahead forecast error of the change in the price of oil. On the basis of information criteria, we find that the multivariate GARCH-in-mean VAR embodies a better description of the data and is preferred over a homoscedastic VAR in Iran.

Our main empirical result is that uncertainty about the price of oil has had a significant and negative effect on real output in Iran in our sample. Further research might investigate whether our measure of oil price uncertainty might be a proxy for precautionary demand shocks as defined in Kilian (2009a).

Finally, our results provide some additional evidence that uncertainty about oil prices could help to explain the relationship between oil prices and output in the economy of Iran, which policymakers by attending it in their information, can more precisely predict the events in the future.

Moreover, they should try to decrease the negative effects of the uncertainty by performing some policies which impede transferring the uncertainty to the economy. In other words, since the control of fluctuations of the oil price is not possible and as achieving to the stationary growth is not possible unless decreasing the uncertainty, the Iranian government must more attend to the policies related to the National Development Fund of Iran and try to decrease Iranian economy's independency of the oil income and input. In this way, as a result, economic players encounter less uncertainty in their planning and the negative effects of the uncertainty on the economy of Iran can be trivial.

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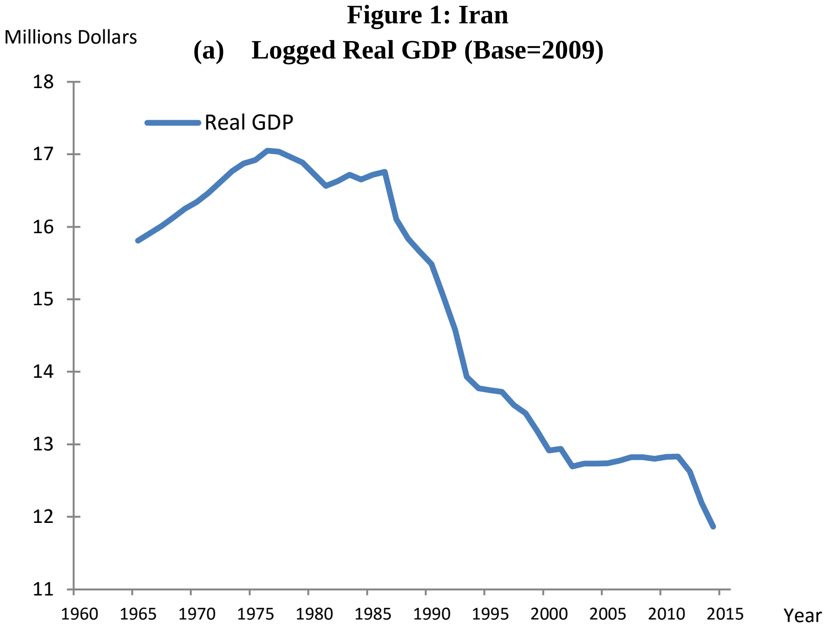
Figure 1: Iran

(a) Logged Real GDP (Base=2009)



(b) Logged Real Oil Price (Base=2009)

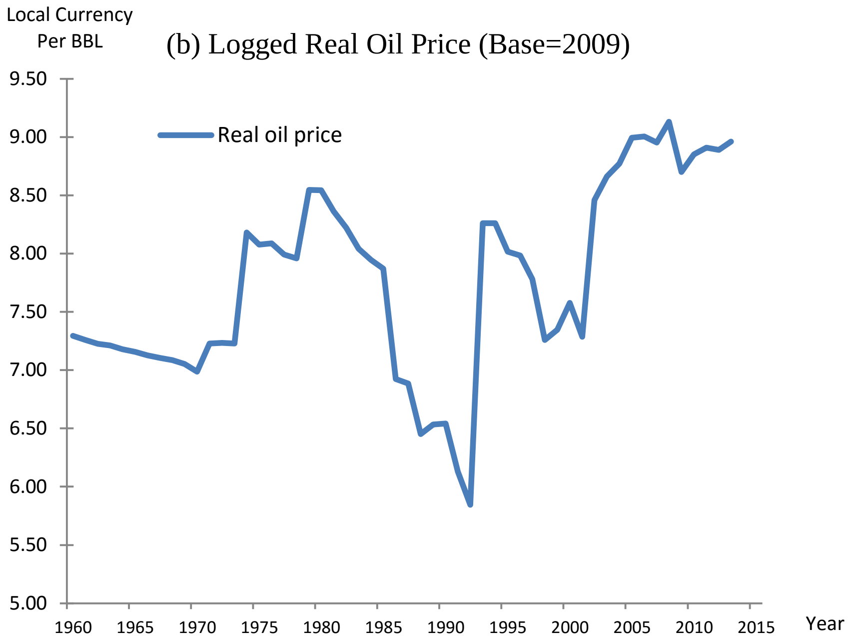


Table 1: Unit Root and Stationary Tests

	Log levels				First differences of log levels			
	$ADF(\tau)$	$DF-GLS(\tau)$	$KPSS(\hat{\eta}_{\mu})$	$KPSS(\hat{\eta}_{\tau})$	$ADF(\tau)$	$DF-GLS(\tau)$	$KPSS(\hat{\eta}_{\mu})$	$KPSS(\hat{\eta}_{\tau})$
A. Real GDP								
	-2.443	-1.509	0.790	0.146	-3.548	-3.611	0.329	0.169
B. Real oil price								
	-2.270	-2.331	0.352	0.120	-7.075	-7.234	0.055	0.047
%CV	-3.500	-3.190	0.463	0.146				

Table 2: Model Specification Tests

Country	Sample	VAR	GARCH-M VAR
Iran	1965-2013	904.227	902.515

Table 3: Conditional Mean Equation (Equation1 with p=2)

$$B=\begin{bmatrix} 1 & 0 \\ 0.043\ (1.005) & 1 \end{bmatrix};\ C=\begin{bmatrix} -0.314 \\ (-2.463) \\ 0.247 \\ (5.139) \end{bmatrix};\ \Gamma_1=\begin{bmatrix} -0.436 & 0.435 \\ (-3.639) & (1.509) \\ 0.032 & 0.532 \\ (0.775) & (4.635) \end{bmatrix};$$

$$\Gamma_2=\begin{bmatrix} -1.602 & 7.720 \\ (-5.163) & (1.074) \\ 0.069 & 32.640 \\ (0.670) & (1.832) \end{bmatrix};\ \Lambda(L)=\begin{bmatrix} 0.000 \\ -0.738 \\ (-2.127) \end{bmatrix}$$

Note: Numbers in parentheses are t-statistic.

Table 3: Conditional Variance-Covariance Structure (Equations2 with f=1 and g=1)

$$C_v=\begin{bmatrix} 1540 \\ (2.542) \\ 28.468 \\ (1.046) \end{bmatrix};\ F=\begin{bmatrix} 0.438 \\ (1.75) \\ 0.560 \\ (2.037) \end{bmatrix};\ G=\begin{bmatrix} 0.000 \\ 0.285 \\ (1.208) \end{bmatrix}$$

Note: Numbers in parentheses are t-statistic.