Chapter 5: Empirical Results for Responses to Oil Price Volatility

This chapter discusses the impact of oil price volatility on industrial production, interest rates and stock returns. The results have implications on macroeconomic responses to unanticipated oil shocks.

5.1. The Estimated GARCH Model

The results of the estimated GARCH model for $\Delta lnppi$ is presented in Table 5.1. The F-statistic shows that the overall model is significant. An autoregressive process of order 6 or, AR(6) is fitted for the mean process. Only lags 1 and 4 are significant for the mean equation. The other lags are dropped and the final model is presented in Table 5.2. In this case, the overall model and all the coefficients are significant.

Table 5.1 GARCH (1,1) for modeling oil price growth: Preliminary Model

	Coefficient	Standard Error	z- statistics
Constant	0.0005	0.0027	0.1921
$\Delta lnppi_{t-1}$	0.2935*	0.1147	2.5575
$\Delta lnppi_{t-2}$	0.0580	0.1214	0.4781
$\Delta lnppi_{t-3}$	0.0445	0.1065	0.4179
$\Delta lnppi_{t-4}$	- 0.1920 **	0.1034	- 1.8561
$\Delta lnppi_{t-5}$	- 0.0603	0.1066	- 0.5657
$\Delta lnppi_{t-6}$	0.0054	0.0906	0.0603
Variance Equation			
Constant	0.0002***	0.0001	1.9225
ε^2_{t-1}	0.2281	0.1415	1.6116
h_{t-1}	0.6266*	0.1503	4.1686
R –Squared		0.1902	
F – Statistics (p value)		0.0030 ***	

*, **, *** denote significance at 10%, 5% and 1% levels.

Table 5.2 GARCH (1,1) for modeling oil price growth: Final Model

	Coefficient	Standard Error	z- statistics
Constant	0.0004	0.0026	0.1384
$\Delta lnppi_{t-1}$	0.3462*	0.1015	3.4112
$\Delta lnppi_{t-4}$	- 0.1922*	0.0780	- 2.4655
Variance Equation			
Constant	0.0001*	0.0000	1.8101
ε^2_{t-1}	0.1843*	0.1035	1.7808
h_{t-1}	0.7486***	0.1020	6.8074
R –Squared		0.2133	
F – Statistics (p value)		0.0000***	
LM ARCH Test	**nR^2 (p value)**		
Lag 1	0.7919		
Lag 2	0.8441		
Lag 3	0.8939		
Lag 4	0.9565		
Lag 5	0.8487		
Lag 6	0.8779		

*, **, *** denote significance at 10%, 5% and 1% levels.

The LM ARCH test is conducted for lags 1 to 6 for the residuals of the final model. The results indicate that the final model is free from ARCH effect. This is satisfactory that v_t is computed as discussed in Chapter 3. The analysis in Chapter 4 is repeated for this chapter, where *Δlnipi* is now replaced by v_t.

5.2. The Estimated Vector Autoregression (VAR)Model

The VAR(p) model is estimated for the four-variable system consisting of v_t, *Δlnipi, Δlntbill and rsr* with p = 1 to 6. The results of the AIC and BIC for each lag value are presented in Table 5.3.

Table 5.3. Akaike Information Criterion (AIC) and the Bayesian Schwarz Criterion (BIC) for VAR(p).

Lag (p)	AIC	BIC
1	- 4.2605	- 3.8103*
2	- 4.4678	- 3.6532
3	- 4.4799*	- 3.2972
4	- 4.4691	- 2.9144
5	- 4.4596	- 2.5289
6	- 4.4218	- 2.1112

* minimum value

As suggested by the results, lag length 3 is optimal based on AIC. Again, the BIC has the tendency towards a more parsimonious model at lag 1. The VAR(3) with the volatility variable is fitted and the estimated VAR model with its coefficients and standard errors are presented in Table 5.4.

Table 5.4. Unrestricted VAR(3).

	v	Δlnipi	Δlntbill	rsr
v_{t-1}	- 0.8234*** (-8.7324)	0.0018 (0.4909)	- 0.0153*** (-2.1703)	0.0009 (0.1152)
v_{t-2}	- 0.5667*** (-5.0100)	0.0023 (0.5546)	-0.0033 (-0.4033)	0.0090 (0.9610)
v_{t-3}	- 0.2506*** (- 2.6217)	0.0020 (0.5588)	0.0002 (0.0260)	0.0017 (0.2137)
Δlnipi $_{t-1}$	2.7983 (1.1499)	- 0.5872*** (- 6.3340)	-0.0278 (-0.1530)	-0.0071 (-0.0349)
Δlnipi $_{t-2}$	0.7689 (0.2866)	- 0.2906*** (-2.8457)	-0.1358 (-0.6782)	0.2349 (1.0420)
Δlnipi $_{t-3}$	2.5382 (1.0567)	0.1095 (1.1972)	0.1287 (0.7177)	- 0.1622 (- 0.8038)
Δlntbill $_{t-1}$	-0.2042 (-0.1615)	0.0528 (1.0970)	0.3625*** (3.8403)	-0.05478 (-0.5155)
Δlntbill $_{t-2}$	0.13809 (0.1051)	0.0011 (0.0229)	-0.1035 (-1.0549)	-0.1446 (-1.3094)
Δlntbill $_{t-3}$	-0.9146 (-0.7516)	-0.0566 (-1.2213)	- 0.1552* (-1.7091)	-0.0237 (-0.2318)
rsr $_{t-1}$	-1.81436 (-1.6103)	-0.0411 (-0.9583)	- 0.2847*** (-3.3847)	0.1321 (1.3952)
rsr $_{t-2}$	-0.4837 (-0.4307)	-0.0319 (-0.7470)	0.1666** (1.9871)	0.2063** (2.1860)
rsr $_{t-3}$	2.4611** (2.1716)	0.1079** (2.5002)	0.0456 (0.5387)	-0.2408** (-2.5290)
Constant	0.0020 (0.0188)	0.0128*** (3.1434)	-0.0047 (-0.5901)	-0.0031 (-0.3470)
R - Squared	0.4261	0.3753	0.2621	0.1576
F - Statistics	6.8676***	5.5569***	3.2851**	1.7306

t-statistics in parentheses.
* significant at 10% level
** significant at 5% level
*** significant at 1% level

Prior to the analysis of IRF and VDC techniques, the variance-covariance and the correlation matrices from the unrestricted VAR(3) are computed and the results are presented in Tables 5.5 and Table 5.6, respectively.

Table 5.5. Variance-covariance matrix of residuals of VAR(3)

	v	Δlnipi	Δlntbill	rsr
v	1.0178	0.0050	0.0024	0.0126
Δlnipi	0.0050	0.0015	- 0.0001	0.0001
Δlntbill	0.0024	- 0.0001	0.0057	- 0.0009
Rsr	- 0.0126	- 0.0001	- 0.0009	0.0072

Table 5.6. Correlation matrix of residuals of VAR(3)

	v	Δlnipi	Δlntbill	rsr
v	1.0000	0.1292	0.0315	- 0.1474
Δlnipi	0.1292	1.0000	- 0.0472	- 0.0222
Δlntbill	0.0315	- 0.0427	1.0000	- 0.1365
Rsr	-0.1474	- 0.0222	- 0.1365	1.0000

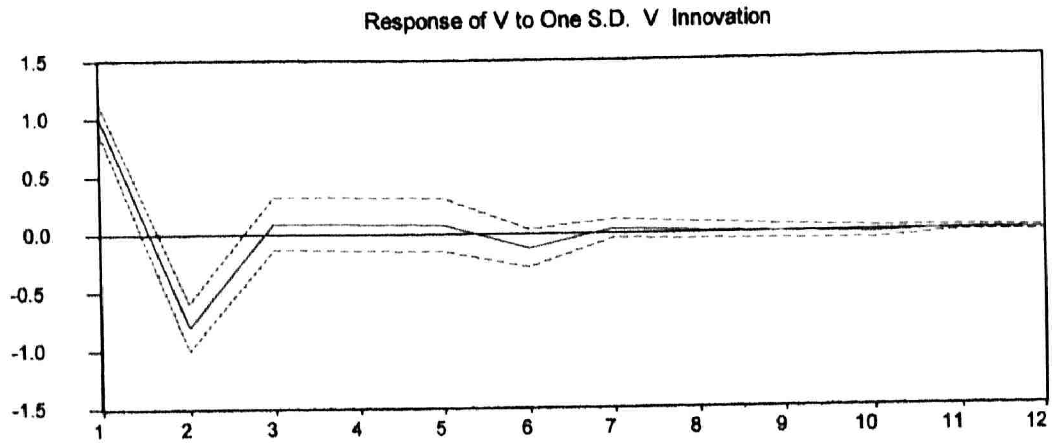
As before, both matrices indicate weak dependence between the four residual series. This suggests that the ordering of variables will have little impact on the IRF and VDV analysis.

5.2.1. Empirical Results: Impulse Response Function

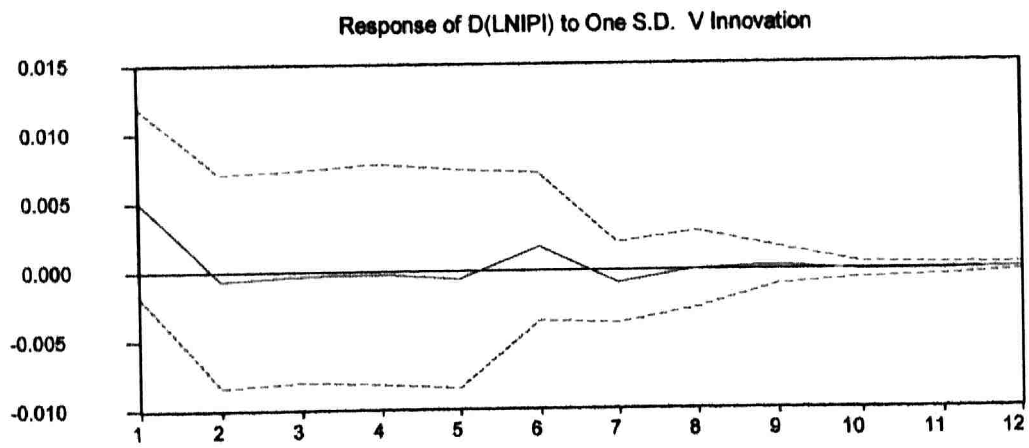
Figure 5.1 plots the IRF and the two standard error band for the responses of all the four variables to one standard deviation change in oil price volatility. The figures show how unanticipated oil price shocks affect itself, industrial production, interest rates and real stock returns.

Figure 5.1 The responses of due to one standard deviation shock to oil price volatility. Ordering: Δlntbill, v, Δlnipi, rsr.

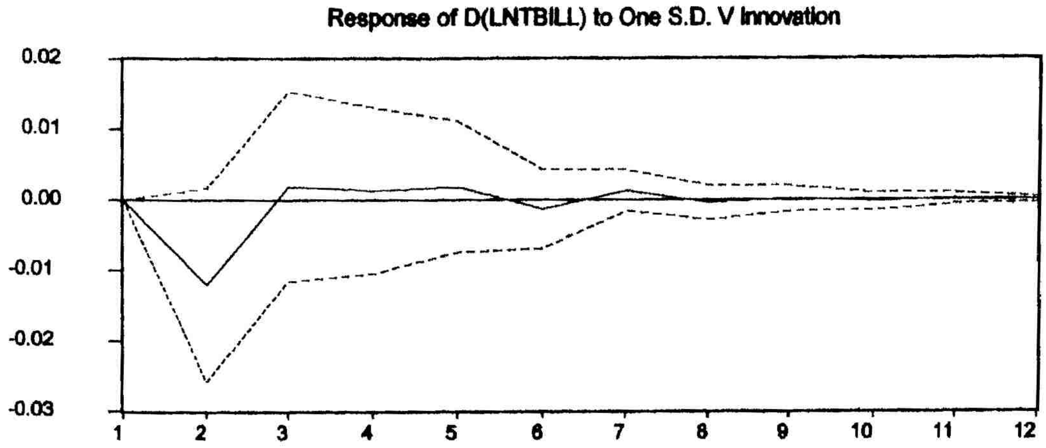
(a)



(b)



(c)



(d)

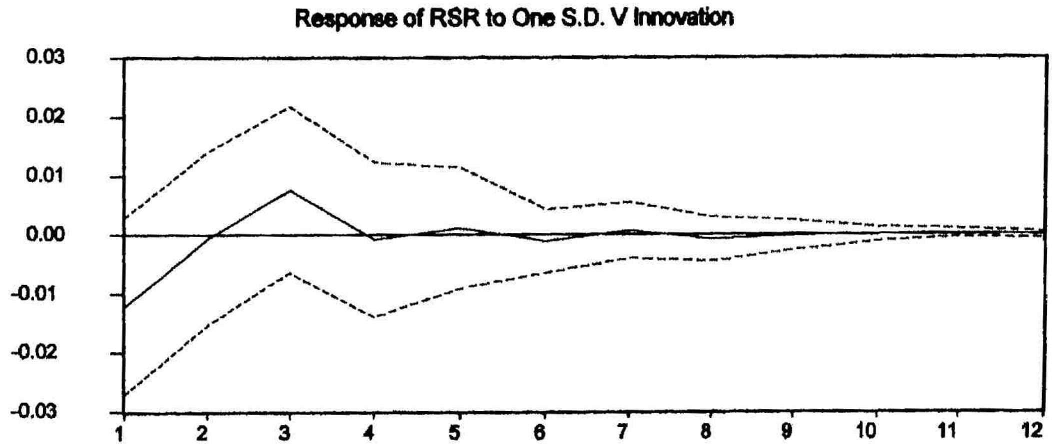


Figure 5.1(a) shows that when price volatility is introduced into the system, it takes about 8 months for oil prices to stabilize. Bigger fluctuations are seen in the first three months but the effects dampen out slowly. Figure 5.1(b) shows that the industrial production could not react within the first month, after the

unanticipated shock. A negative impact is felt in its growth only after the second period and this unsettling effect can take up to 10 months and no more responses thereafter. Figure 5.1(c) shows a sharp dip in interest rates in response to innovations in oil price volatility, presumably due to government intervention to counter negative sentiments of an unexpected oil shock. Although the adjustment magnitude is rather small after the second month, the process of adjustment can go up to 7-8 months.

As for the stock market, the impact of oil price volatility is reflected instantaneously on the Composite Index. From the viewpoint of investors, oil shocks have negative implications on production costs, corporate profits, employment, consumption and the economy in general. It can take up to nearly a year for the market to find stability due to a shock that is unanticipated.

5.2.1. Empirical Results: Variance Decomposition

The reported figures in Table 5.7 indicate the percentage of the forecast error variance in each variable that can be attributed to innovations in other variables for 1-month, 6-months and 1-year ahead forecasts. The ordering of $\Delta lntbill$, v, $\Delta lnipi$, rsr is consistent with the VAR(2) used in Chapter 4. Further testing, using different orderings, presented in Appendix II, indicate that the ordering does not make any difference to the conclusion of this study.

Table 5.7 Variance Decomposition Analysis due to innovations in oil prices volatility, industrial production, interest rates and stock returns.
Ordering: Δlntbill, v, Δlnipi, rsr

Period (months)	Oil Price Volatility	Industrial Production Shock	Interest Rates Shock	Stock Returns Shock
Variance decomposition of:				
v (oil price volatility growth)				
1	99.9009	0.0000	0.0991	0.0000
6	93.2591	2.4289	0.6825	3.6295
12	93.2188	2.4497	0.6871	3.6444
Δlnipi (industrial production growth)				
1	1.7083	98.0689	0.2229	0.0000
6	1.2472	89.7181	3.2582	5.7765
12	1.2846	89.6027	3.2891	5.8236
Δlntbill (interest rate growth)				
1	0.0000	0.0000	100.0000	0.0000
6	2.0268	0.8697	88.2882	8.8153
12	2.0493	0.8967	88.1758	8.8782
rsr (real stock returns)				
1	2.0507	0.0101	1.8636	96.0756
6	2.4572	2.1711	5.4904	89.8813
12	2.4637	2.1890	5.7098	89.6375

The initial impact of oil price volatility comes from shocks within itself. Subsequently, through its effects on other variables, a small proportion of its variation can be attributed to other variables. The proportion is 93%, 2%, 1%

and 4% from its own innovation, industrial output, interest rates and real stock returns, respectively, after 12 months.

Almost 98% of the shocks to industrial production come from itself but this falls to 90% within a year, while the rest of 1%, 3% and 6% is attributed to industrial output, interest rates and real stock returns, respectively, after 12 months.

Within the first period, the forecast error in the variability of interest rates is 100%. After a 12-month period, this falls to 88% with 2%, 1% and 9% of the forecast error variance contributed by innovations in industrial output, interest rates and real stock returns, respectively. As for real returns, 96% of the variability in forecast errors comes from itself in the first period. This drops to 90% at the end of one year with 2%, 2% and 6% attributed to changes in oil price volatility, industrial production, interest rates and real stock returns, respectively.

Implications of the VDC results show that most of the forecast variance comes from innovations in their own movements, rather than other variables in the system. Impact of oil price volatility does not account for more than 3% of the variance of forecast error of the other macroeconomic variables.

When compared to the results to the VDC in Chapter 4, we see that the proportion of the variance in forecast errors of the macroeconomic variables that can be explained by movements in oil prices is higher if oil price, changes are anticipated.