Implications of Oil Price Shocks for Monetary Policy in Ghana: A Vector Error Correction Model

Tweneboah, George and Adam, Anokye M.
School of Management, University of Leicester

2008

Implications of Oil Price Shocks for Monetary Policy in Ghana: A Vector Error Correction Model

George Tweneboah

School of Management, University of Leicester, UK. E-mail: gt56@le.ac.uk

Anokye M. Adam

School of Management, University of Leicester, UK. E-mail: ma262@le.ac.uk

---

Abstract

We estimate a Vector Error Correction Model to explore the long run and short run linkages between the world crude oil price and economic activity in Ghana for the period 1970:1 to 2006:4. The results point out that there is a long run relationship between the variables under consideration. We find that an unexpected oil price increase is followed by an increase in price level and a decline in output in Ghana. We argue that monetary policy has in the past been with the intention of lessening negative growth consequences of oil price shocks, at the cost of higher inflation.

Key words: Oil price shock, cointegration, vector error correction, impulse response

JEL Classification: E31, E52, Q43

---

1. <u>Introduction</u>

The world crude oil market has witnessed profound fluctuations over the past few decades, rocketing to a record $147 per barrel in July 2008. This persistent oil price shocks could have severe macroeconomic implications and present crucial challenges for policymaking, and makes it essential to empirically understand their effects on economic activity in especially oil-importing developing countries such as Ghana.

The effect of oil prices on economic activity has received a plethora of theoretical and empirical research in the past few decades. According to an influential contribution by Hamilton (1983), all but one of U.S. economic downturns since World War II had been preceded by oil price hikes, indicating an inverse relationship between oil price shocks and aggregate economic activity as documented in most earlier studies on the U.S. economy (see, *inter alia*, Rasche and Tatom, 1977; Mork and Hall, 1980). Other studies report similar inverse relationships for other countries (See, for example, Papapetrou (2001) for Greece, Cunado and Perez de Gracia (2003) for EU and de Miguel, Manzano, and Martin-Moreno (2003) for Spain.

It was assumed that since oil price increases slow down economic activity, falling oil prices should stimulate macroeconomic performance until it was established by some studies that economic activity reacts asymmetrically to oil price shocks (see, Mork, 1989; Ferderer, 1996). Others have attributed this to the contractionary monetary policy pursued by most central banks in response to oil price hikes (Bernanke, Gertler and Watson, 1997).

The literature has made several attempts to explore the mechanisms through which oil price shocks affect the macroeconomy. These include the *supply-and demand-side effects*. As a basic input to production, an increase in oil price give rise to increased production costs which causes productivity to decline. Oil price hikes reduces the spending power of consumers and encourage producers to substitute less energy intensive capital for more energy intensive capital. The literature predicts that the magnitude of this effect depends on whether the shock is transitory or permanent in nature. Consequently, the different authors have assigned weights to the supply and demand channels (see, for example, Rasche and Tatom, 1977, 1981; Kim and Loungani, 1992; Rotemberg and Woodford, 1996; Abel and Bernanke, 2001). Other channels include *the real balance effect* (see Pierce and Enzler, 1974; Mork, 1994), and *the transfer of income* from oil importing countries to oil exporting countries through deteriorating terms of trade (Dohner, 1981). This transfer of wealth leads to a decrease in global demand in the oil-importing countries which outweighs the increase in the oil-exporting countries because of the assumed low propensity to consume in the latter.

The objective of this paper is to explore the effects of oil price shocks on macroeconomic variables such as output and prices in Ghana and how monetary policy has in the past contributed to the impact of this shock. The rest of the paper is set out as follows. Section 2 gives a brief overview of the role of oil prices and the recent performance of the Ghanaian economy. Section 3 presents the methodology while Section 4 discusses the empirical results. Section 5 is the summary and conclusion.

2. Oil Prices and Recent Economic Performance in Ghana

Researchers have argued that oil prices chiefly affect the macroeconomy as an import price, through the terms of trade; as an input price, through the production function either by increasing costs or by increasing uncertainty which lead to deferral of irreversible investment; as a shock to the aggregate price level which reduces real money stock, and as a relative price shock which leads to costly reallocation of resources across sectors. These are further influenced by such country specific factors as price controls, taxes on petroleum products, exchange rate fluctuations and variations in domestic price index. From this one can argue that understanding the relationship between the world oil price and economic activity is important because oil price increases lead to a rise in prices of petroleum products which serve as a key production inputs and as an essential consumer goods. These price increases are considerable enough that they normally become temporary rise in the general rate of inflation. To the extent that increases in the oil price lead to a rise in price level, purchasing power is also reduced through a reduction in the real money stock. The energy intensity which measures the total primary energy consumption per dollar of gross domestic product (using purchasing power parities) stayed at 4381 in 2005.

The economy of Ghana has grown at an average annual rate of about 4.7% over 1990-2007. This growth rate has assumed an upward trend averaging around 6% from 2003-2007 following a growth rate of 3.7% in 2000. This improving macroeconomic performance has translated into an average annual per capita GDP growth of around 2.6% over 2000-2005 compared to 1.8% for sub-Saharan Africa over the same period. The growth expansion has been driven principally by significant boost in the agriculture sector, leading to an increased contribution to GDP of nearly 38% in 2006, supported by productivity increases and favourable international market cocoa prices (see Table 1).

Inflation in Ghana has also decreased over the years from a high of around 71% in 1995 it has to as low as around 10.9% at the end of 2006. Particularly, this decrease in inflation has been achieved in the last six years due to tighter monetary policy following the increasing independence of the Bank of Ghana. The exchange rate seems to be relatively stabilised considerably against the major trading currencies over the years, translating into a substantial reduction in annual depreciation rates much lower than inflation rates. This has raised some concerns regarding the effects of the real appreciation of the exchange rate on the real economy (particularly the manufacturing sector).

The implications of an oil price shock on an economy depend to a large extent on the importance of oil as factor of production (LeBlanc and Chinn, 2004) and the state of the macroeconomy. Crude oil is a very important factor of production which has led the government to subsidize petroleum product prices to an estimated annual average of 2.3 percent of GDP until 2005. This is reflected in the table as the consumption of oil has increased from about 27 thousand bbl per/day in 1995 to 47 thousand bbl/day in 2005. Out of this about 39 thousand bbl were imported per day which accounted for up to over 21% of total imports for the fiscal year, implying that unexpected increases in world oil prices can adversely affect the terms of trade and the real economy.

3. Data and Methodology

3.1. Data Description

Most studies that examine the oil price-macroeconomy relationship include a measure of economic activity, domestic price of goods and services, nominal exchange rate and a measure of monetary policy stance. We follow that practice and analyse quarterly data for Gross Domestic Product (GDP), Consumer Price Index (CPI), Interest rate (INT), bilateral U.S. dollar per Ghana cedi Exchange Rate (NER) and World Crude Oil Prices (POIL) covering the period 1970:1-2006:4. With the exception of the Gross Domestic Product, all the data were quarterly and obtained from the International Monetary Fund's *International Financial Statistics* (IMF IFS) July 2008 edition. Annual GDP data (at constant 2000 USD prices) was obtained from the April 2008 *World Development Indicators* (WDI) published by the World Bank and interpolated by the technique suggested by Lisman and Sandee (1964). Opinions diverge on the best specification of oil price including different and advanced stances such as "oil prices by themselves do not have significant macroeconomic effects" (Bohi 1991), "oil price increases matter but decreases do not" (Mork 1989), "oil price increases matter if they are large enough relative to past experience" (Hamilton 1996), and "the effects oil price increases are a function of their size relative to their current degree of variability" (Lee, Ni and Ratti 1995). This has led to different measures of oil price shocks in the literature including the logarithm of oil price series in levels, the first differences of oil prices, the positive oil price changes and the Net Oil Price Increase (NOPI) proposed by Hamilton (ibid). The NOPI takes into account oil price changes only if the percentage increase in price is above the observed values for the previous four periods and zero otherwise. This measure eliminates price increases that simply correct price volatility to capture more effectively the surprise element, which may be at the origin of a change in spending decisions by firms and households. In this study, we include the logarithm of the average U.S. dollar price of world crude oil to capture the linear oil-output relationship.

3.2 Stationarity and Cointegration Analysis

Analysis of the long-run relationship between non-stationary variables has become very critical in multivariate time series literature. As revealed by Engle and Granger (1987), if the linear combination of two or more non-stationary variables is stationary, then there is a long-run relationship among the variables. The presence of cointegrating vector forms the basis of the vector error correction model. In this study we utilize the Johansen (1991, 1995) methodology to estimate the long-run cointegrating relation from a vector error correction model of the form:

$$(1) \qquad \Delta Z_t = \sum_{j=1}^{k-1} \Gamma_j \Delta Z_{t-j} + \Pi Z_{t-k} + \mu + \varepsilon_t$$

where Z_t is a vector of endogenous I (1) variables/a ($p \times 1$) vector of variables integrated of order 1, Δ is the first difference lag operator, Γ_j is a ($p \times p$) matrix that represents short-term adjustments among variables across p equations at the j *th* lag, $\Pi = -(I - A_1 - ...... - A_k)$, I is an identity matrix whose rank determines the number of distinct cointegrating vectors. It could be decomposed into the ($n \times r$) matrix α and β such that $\Pi = \alpha\beta'$. α is a ($p \times r$) matrix of the speed of adjustment parameters to/speed of error correction mechanism, β' is ($p \times r$) matrix of cointegrating estimates of the long-run cointegrating relationship between the variables in the model, μ is a ($p \times 1$) vector of constants, and ε_t is a($p \times 1$) vector of white noise error terms.

Johansen (1988) and Johansen and Juselius (1990) derived the likelihood ratio test for the hypothesis that $\Pi = \alpha\beta'$. The cointegrating rank, *r*, can be formally tested with the trace test and maximum eigenvalue test statistics proposed by the Johansen methodology. The short run mechanics of the error correction model can be analysed through the impulse response and the error correction term (ECT). The ECT determines the speed of adjustment due to each of the variables to revert the system to its equilibrium relationship.

4. Empirical Results

4.1 Stationarity and Long-Run Relationships

The objective of this paper is to explore the effects of oil price shocks on macroeconomic variables such as output and prices in Ghana and how monetary policy has in the past contributed to the impact of this shock. Since the cointegration methodology assumes that the variables be integrated of the same order, we begin the empirical analysis with unit root tests in order to identify the stochastic trends of the series. We employ the Augmented Dickey-Fuller and Phillips-Perron tests which are two of the most widely applied unit root tests. The results as shown in Table 2 indicate that all the variables are integrated of order one, [I (1)]. This means that we can utilize the cointegration technique to investigate whether there is a common stochastic trend between the variables. The existence of cointegration would imply a long-run equilibrium relationship between the variables under consideration. On the other hand, if we find no cointegration we can specify a VAR in levels to investigate the short-run dynamics of the variables.

As a key requirement in cointegration test, we proceed with the selection of the optimal lag length for the specification of the model. In this study we accept the SIC as a guide to select the lag length. The selection of this common lag length comes with it the misspecification hitch as there are some trade-offs associated with the various information criterion employed in its selection. This includes the choice between strongly consistent criteria such as the SIC and the HQC on the one hand, and the less parsimonious AIC. The SIC is inclined to underestimation, while there is increased cost for loss of degrees of freedom on the addition of more lags. In this study, we accept the 3 lags selected by the SIC.

Following the lag order selection, we proceed to the cointegration analysis which is performed by specifying an intercept with no trend for the cointegrating equations. The cointegration test as reported in the Table 3a reveals that all the variables under consideration; prices, GDP, interest rates, exchange rate and world crude oil prices, share a common stochastic trend. This implies that the following Vector Error Correction Model (VECM) can be estimated to capture the long run as well as the short run dynamics:

$$\Delta y_t = \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + ...\Gamma_{p-1} \Delta y_{t-p+1} + u_t \quad (2)$$

This is obtained by subtracting y_{t-1} from both sides of a reduced form standard VAR (p) model:

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + u_t \quad (3)$$

where y_t is a $k \times 1$ vector of time series and $A_1,......., A_p$ are $k \times k$ coefficient matrices. The reduced form disturbance u_t is an $k \times 1$ unobservable white noise process.

Table 3 indicates that there exists a long-run equilibrium relationship among the variables. In both cases, all the coefficients are statistically significant. Interest rate and crude oil prices are negatively correlated with GDP in the long run as shown in the following equation (standard errors are in parentheses):

$$\underset{}{gdp_t} = 0.3\underset{(0.07)}{cpi_t} - 0.5\underset{(0.08)}{\text{int}_t} + 0.1\underset{(0.05)}{ner_t} - 0.4\underset{(0.07)}{poil_t} \quad (4)$$

With this relationship, we can interpret that, in the long run a one percent increase in oil price causes the output level to fall by 0.4%.

With inflation as the dependent variable, we find that all the variables are positively correlated with inflation except exchange rates which is negatively correlated in the long run relationship shown below (with standard errors in parentheses):

$$cpi_t = 2.9gdp_t + 1.6\,\text{int}_t - 0.3ner_t + 1.2\,poil_t \qquad (5)$$
$$\qquad (0.83) \qquad (0.29) \qquad (0.11) \qquad (0.13)$$

With this one can say that, in the long run, a percentage increase in oil price causes the price level to rise by 1.2%.

4.2 Impulse Response Functions and Speed of Adjustment

In this section we follow the impulse response function to examine the short-run dynamics of the model. This can be achieved by investigating the dynamic effects of a generalised one standard deviation innovation on oil price, and the effects of a contractionary monetary policy response on the other variables. In this case we expect a central bank mandated to stabilize prices to increase interest rates in response to oil price hikes at the expense of output growth. The generalized impulse response function employed in this study does not take into consideration the order of the variables is the VECM and covers up to 24 quarters.

The impulse response functions displayed in Table 4 indicate that a generalised one standard deviation shock to oil price causes prices to rise instantly to about 0.001% within two years. Although prices react instantly and persists over a long horizon, output does not fall until after 4 quarters, which continues for a very long time hovering around 0.02% below its baseline. On the response of monetary policy, the figure indicates that interest rates decline initially indicating that the stance of monetary policy is eased in response to the shock but increases quickly to curtail further inflationary consequences of the oil price shock. The accumulated response (not reported) shows that output falls by 0.36% while prices rise by almost 1% in 6 years. We argue that the response of monetary authorities is not enough to mitigate the inflationary pressure caused by the oil price shocks.

On the response of prices to a generalised one standard deviation shock to interest rates we can say that contrary to our expectations, while output falls instantly prices rise. Prices rise from 0.006% in the first quarter to just about 0.05% within 6 years. The fall in output increases to 0.01% in 6 years. The accumulated response displays a 0.20% fall in output. Interestingly, exchange rate appreciation does not lead to a fall in prices.

Since the impulse response function traces the effect of a one-time residual shock to an innovation on current and future values of the endogenous variables, we consider the speed of adjustment of the variables towards the equilibrium relationship **a**s part of the short run analysis. From the table, we find that the adjustments due to GDP and nominal exchange rates play significant roles in restoring the cointegrating relationship.

5. Summary and Conclusion

In this study we have estimated a vector error correction model to explore the long run and short run linkages between the world crude oil price and economic activity in Ghana for the period 1970:1 to 2006:4. The results indicate that there is a long run relationship involving oil prices, prices, GDP, exchange rate and interest rate in Ghana in which oil price positively impact the price level while negatively impacting output. In the short run, we find that an unexpected oil price shock is followed by an increase in inflation rate and a decline in output in Ghana. On the response of interest rate to a surge in the price of oil, we argue that monetary policy has in the past been with the intention of lessening any growth consequences of oil price shocks, but at the cost of higher inflation.

The fact that oil price shocks impact the Ghanaian economy and the recent decision of the government to eliminate subsidies on petroleum products and bring domestic petroleum prices closer to world prices has important implications for monetary policy. For an effective inflation targeting in Ghana, the credibility of monetary and fiscal policies should be improved and properly coordinated so as to anchor inflationary expectations and mitigate any external shocks on the economy.

References

Abel, A.B. and Ben S. Bernanke. 2001. *Macroeconomics*. Addison Wesley.

Bank of Ghana. Annual Report (various issues). Accra-Ghana.

Bernanke B.S., M. Gertler, and M. Watson. 1997. "Systematic Monetary Policy and the Effects of Oil Price Shocks," *Brookings Papers on Economic Activity*, 1, 91-142.

Bohi, D.R. 1991. "On the Macroeconomic Effects of Energy Price Shocks," *Resources and Energy*, 13, 145-62.

Cuñado, J. and Gracia, P. 2003. "Do oil price shocks matter? Evidence for some European countries," *Energy Economics*, 25 (2), 137-154.

De Miguel, C., B. Manzano and J.M. Martin-Moreno. 2003. "Oil Price Shocks and Aggregate Fluctuations," *The Energy Journal*, Cambridge MA Then Cleveland Ohio.

Dohner, R.S. 1981. “Energy prices, economic activity and inflation: survey of issues and results,” in K. Mork (ed.) Energy Prices, Inflation and Economic Activity. Cambridge, MA: Ballinger.

Engle, R.F. and C.W.J. Granger. 1987. “Co-integration and error-correction: Representation, estimation and testing,” *Econometrica*, 55, 251-276.

Ferderer J.P. 1996. “Oil Price Volatility and the Macroeconomy,” *Journal of Macroeconomics*, 18, 1-16.

Hamilton, J. 1983. “Oil and the Macroeconomy since World War II,” *Journal of Political Economy*, 91, 228-248.

Hamilton, J.D. 1996. “This is What Happened to the Oil Price-Macroeconomy Relationship,” *Journal of Monetary Economics,* 38, 215-220.

International Monetary Fund. 2008. *International Financial Statistics (IFS) April 2008*. ESDS International, University of Manchester.

Johansen, S. 1988. “Statistical analysis of cointegrating vectors,” *Journal of Economic Dynamics and Control*, 12, 231-254.

Johansen, S. 1991. “Statistical Analysis of Cointegrating Vector,” in: Engle R. F., and Granger C. W. J. (eds), Long-Run Economic Relationships. Oxford: Oxford University Press.

Johansen, S. 1995. “A Statistical Analysis of Cointegration for I (2) Variables,” *Econometric Theory*, 11, 25–59.

Johansen S. and K. Juselius. 1990. “Maximum Likelihood and Inference on Cointegration with Applications to the Demand for Money.” *Oxford Bulletin of Economics and Statistics*, 52, 169-210.

Kim, I. and P. Loungani. 1992. “The Role of Energy in Real Business Cycle Models.” *Journal of Monetary Economics*, 29, 173-189.

LeBlanc M. and M.D. Chinn. 2004. "Do High Oil Prices Presage Inflation? The Evidence from G-5 Countries," *UC Santa Cruz Economics Working Paper No. 561*, SCCIE WP 04-04.

Lee, K., S. Ni, and R. Ratti. 1995. “Oil Shocks and the Macroeconomy: The Role of Price Variability,” *The Energy Journal,* 18, 39-56.

Lisman, J.H.C. and J. Sandee. 1964. “Derivation of quarterly figures from annual data,” Applied Statistics, 13, 87–90.

Mackinnon J.G., A.A. Haug and L. Michelis. 1999. “Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration,” *Journal of Applied Econometrics,* 14, 563-577.

Mork K.A. 1989. “Oil Shocks and the Macroeconomy when Prices Go Up and Down: an Extension of Hamilton’s Results,” *Journal of Political Economy,* 97 (51), 740-744.

Mork, K.A. 1994. "Business Cycles and the Oil Market," *Energy Journal*, 15, 15-38.

Mork, K.A. and R.E. Hall. 1980. “Energy Prices, Inflation, and Recession, 1974-75.” *The Energy Journal*, 1(3): 31-63.

Papapetrou, E. 2001. “Oil price shocks, stock market, economic activity and employment in Greece,” *Energy Economics*, 23 (5), 511-532.

Pierce, J.L. and J.J. Enzler. 1974. “The Effects of External Inflationary Shocks,” *Brookings Papers on Economic Activity*, 1, 13-61.

Rasche, H. R. and J. A. Tatom. 1977. "Energy resources and potential GNP," *Review of Federal Reserve Bank of St. Louis,* June, 10-24.

Rotemberg, J.J., M. Woodford. 1996. “Imperfect Competition and the Effects of Energy Price Increases on Economic Activity,” *Journal of Money, Credit, and Banking*, 28 (4), 550-577.

World Bank. 2008. *World Development Indicators (WDI) April 2008*. ESDS International, University of Manchester.

Appendix

Table 1: Selected Economic Indicators

	1999	2000	2001	2002	2003	2004	2005	2006
Real GDP growth (%)	4.4	3.7	4.2	4.5	5.2	5.8	5.8	6.2
Nominal GDP (US$ billion)	7,710	4,978	5,309	6,160	7,624	8,869	10,694	12,249
Nominal GDP (cedi billion)	20,580	27,153	38,071	48,862	66,158	79,803.7	97,018	114,903
Inflation (CPI, %)	13.8	40.5	21.3	15.2	23.6	11.8	14.8	10.9
Bank of Ghana prime rate (%)	27.0	27.0	27.0	24.5	21.5	18.5	15.5	12.5
Cedi/US$	3,535	7,048	7,322	8,439	8,852	9,051	9,131	9,180
Cedi/€	3,577.3	6,343.5	6,500.5	8,511.6	10,986.3	12,309.0	10,814.9	11,574
Oil, IPE Brent Crude (US$/barrel)	18.6	28.4	25.0	25.0	28.4	37.8	55.4	66.1
Total Oil Production[a]	6	7.13	7.18	7.43	7.48	8.57	7.57	7.57
Consumption	31	37	36	39	42	45	47	49
Net Exports[b]	-25	-30	-29	-31	-34	-37	-39	-42
Oil imports (US$ million)		520	517	510	563	775	1,129	1,416
Oil imports/Merchandise imp.		18.8	17.4	18.8	17.4	18.0	21.0	21.7
Energy Intensity[c]	4535	5383	5117	4527	4102	4510	4381	NA

Sources: Bank of Ghana

[a] Production of crude oil including lease condensate, natural gas plant liquids, and other liquids, and refinery processing gain/loss. (Negative value indicates refinery processing loss)

[b] Total Oil Production minus Consumption (Negative numbers are Net Imports)

[c] Total primary energy consumption per dollar of gross domestic product using purchasing power parities (Btu per (2000) U.S. dollars)

Table 2: Unit Root Tests

a. Augmented Dickey Fuller Test

	Levels			First differences		
Variable	**Constant**	**Constant and trend**	**None**	**Constant**	**Constant and trend**	**None**
CPI	-1.762184	-0.164293	-0.387853	-5.242049	-8.241501	-2.312094**
GDP	1.051035	-2.210721	-0.315810	-4.303010***	-5.148314***	-3.368369***
INT	-1.869860	-0.929947	0.331326	-10.51102	-10.65552	-10.51122
NER	0.733880	-1.107014	1.589207	-11.26765	-11.48394	-11.05938
POIL	-2.569060	-2.648436	0.691604	-8.937401	-8.954951	-8.792605

b. Phillips-Perron Unit Root Test

	Levels			First differences		
Variable	**Constant**	**Constant and trend**	**None**	**Constant**	**Constant and trend**	**None**
CPI	-1.428148	-0.417978	-0.008713	-8.196200	-8.251094	-6.180220
GDP	1.674827	-0.956769	-0.533622	-3.788965***	-4.064048***	-3.395073***
INT	-1.849231	-0.567564	0.418058	-10.46023	-10.87244	-10.45590
NER	0.693130	-1.129998	1.530337	-11.26539	-11.48394	-11.09418
POIL	-2.367128	-2.347831	0.918654	-8.937401	-9.008223	-8.720965

Note: The null hypothesis for the ADF and PP tests is that the data process in question contains a unit root. Critical values with constants (at the 1%, 5 % and 10% levels) are -3.4788, -2.8818 and -2.5777 respectively for ADF, and -3.4765, -2.8817 and -2.5776 respectively for PP (see MacKinnon, 1996). ***, **,* indicates significance at the 1%, 5% and 10% levels respectively. The maximum lag length was used for the ADF, whereas the Newey-West bandwidth was used in the case of PP.

Table 3: Long Run Relationships

a. Johansen Cointegration Test

Number of CEs	λ_{trace}	$\lambda_{\max}$
None	91.07637[0.0004]*	38.81049[0.0119]*
At most 1	52.26588[0.0182]*	23.61213[0.1488]
At most 2	28.65375[0.0673]	18.10890[0.1258]
At most 3	10.54485[0.2411]	10.32438[0.1915]
At most 4	0.220480[0.6387]	0.220480[0.6387]

Note: The λ_{trace} and $\lambda_{\max}$ give the trace statistic and the maximal-eigenvalue statistic respectively. The null hypothesis for the tests is that there is no cointegration between the data generating processes under consideration for 3 lags. Critical values for both trace and maximum-eigenvalue statistics at the 5% level are given by MacKinnon-Haugh-Michelis(1999).

b. Estimated cointegrating coefficients normalised on output

Variable	**GDP**	**CPI**	**INT**	**NER**	**POIL**
Coefficients	1.0000	-0.341071	0.540057	-0.089498	0.401419
Standard error		(0.06787)	(0.08431)	(0.05253)	(0.07471)
Test statistics		[-5.02525]	[6.40561]	[-1.70376]	[5.37323]
Speed of adjustment	-0.010728	0.016157	-0.075775	0.460305	-0.082236
Standard error	(0.00283)	(0.04195)	(0.06513)	(0.11749)	(0.08520)
Test statistics	[-3.79192]	[0.38519]	[-1.16345]	[3.91773]	[-0.96527]

c. Estimated cointegrating coefficients normalised on the price level

Variable	**CPI**	**GDP**	**INT**	**NER**	**POIL**
Coefficients	1.0000	-2.931944	-1.583416	0.262402	-1.176939
Standard error		(0.83188)	(0.29290)	(0.11853)	(0.12648)
Test statistics		[-3.52449]	[-5.40595]	[2.21389]	[-9.30558]

Table 4: Response of variables to a generalised one S.D. deviation

a. Oil Price Shock

Period	GDP	CPI	INT	NER	POIL
1	0.000603	0.006082	-0.007977	0.035568	0.145415
2	0.001893	0.001060	0.002930	0.034716	0.192784
3	0.002163	-0.002521	-0.001305	0.030080	0.181290
4	0.000299	-0.001429	0.005821	0.044248	0.187209
5	-0.003066	0.001699	0.001874	0.081603	0.195309
6	-0.006757	0.003713	-0.004246	0.111627	0.190520
7	-0.009855	0.006505	-0.011530	0.129635	0.186960
8	-0.012207	0.012658	-0.015322	0.145460	0.185699
9	-0.014160	0.021762	-0.017238	0.161979	0.182070
10	-0.016065	0.031244	-0.016032	0.173820	0.177434
11	-0.017941	0.040051	-0.014425	0.179092	0.174553
12	-0.019568	0.047726	-0.013472	0.179964	0.172881
13	-0.020739	0.053797	-0.012944	0.178344	0.171855
14	-0.021450	0.058451	-0.011766	0.175772	0.171197
15	-0.021873	0.062430	-0.010191	0.173909	0.170385
16	-0.022201	0.065902	-0.008608	0.173150	0.169272
17	-0.022519	0.068583	-0.007402	0.172543	0.168367
18	-0.022799	0.070408	-0.006723	0.171478	0.167925
19	-0.022987	0.071610	-0.006504	0.170260	0.167764
20	-0.023072	0.072426	-0.006392	0.169365	0.167655
21	-0.023096	0.073042	-0.006171	0.168947	0.167498
22	-0.023112	0.073573	-0.005885	0.168907	0.167276
23	-0.023149	0.074015	-0.005678	0.168996	0.167057
24	-0.023199	0.074314	-0.005604	0.168980	0.166937

b. Interest Rate Shock

Period	GDP	CPI	INT	NER	POIL
1	-0.000728	0.006450	0.111166	-0.058901	-0.010434
2	-0.002671	0.022587	0.120191	-0.050898	-0.033184
3	-0.005377	0.025866	0.130773	-0.043794	-0.055836
4	-0.006896	0.020902	0.110125	-0.039965	-0.052815
5	-0.006916	0.018034	0.101390	-0.032511	-0.051256
6	-0.006353	0.021828	0.091087	-0.013832	-0.055405
7	-0.006442	0.026939	0.094729	0.002991	-0.060967
8	-0.007470	0.032820	0.096632	0.011683	-0.063462
9	-0.008893	0.037804	0.097361	0.013397	-0.065209
10	-0.009909	0.040436	0.095093	0.009702	-0.064727
11	-0.010200	0.041224	0.094792	0.004113	-0.063247
12	-0.010029	0.042523	0.095387	0.001343	-0.062885
13	-0.009876	0.044589	0.097261	0.002272	-0.064201
14	-0.009985	0.046449	0.098849	0.003749	-0.065455
15	-0.010269	0.047498	0.099559	0.003617	-0.065866
16	-0.010499	0.047862	0.099090	0.002217	-0.065632
17	-0.010544	0.047810	0.098517	0.000774	-0.065244

18	-0.010449	0.047755	0.098421	0.000119	-0.065052
19	-0.010349	0.047969	0.098801	0.000429	-0.065252
20	-0.010337	0.048344	0.099193	0.001137	-0.065629
21	-0.010402	0.048594	0.099343	0.001488	-0.065832
22	-0.010474	0.048623	0.099209	0.001272	-0.065768
23	-0.010496	0.048537	0.098989	0.000859	-0.065608
24	-0.010471	0.048474	0.098889	0.000648	-0.065523