Effects of Oil Price Shocks and Macroeconomic Conditions on Output Fluctuations for Korea

Wen-jen Hsieh*
National Cheng Kung University

Abstract Applying the simultaneous-equation model, this study finds that the output elasticity with respect to the real oil price is estimated to be -0.042, indicating that if the real oil price rises 10%, real GDP would decrease by 0.42%. In addition, real output in Korea is positively associated with the money supply, real deficit spending, and the real stock price and negatively influenced by real depreciation of the won.

Keywords: Oil price, monetary policy, fiscal policy, exchange rate, open economy

JEL Codes: Q43, F41

1. Introduction

Recently, the average crude oil price per barrel rose from US$37.76 in 2004 to US$64.27 in 2006 and had reached almost $100 in November 2007. This has caused concerns about its potential negative impacts on economic activities for large oil-importing countries such as the Republic of Korea (hereafter called Korea). Korea does not produce crude oil domestically and is totally dependent on oil imports to meet the need of domestic oil consumption. According to the U.S. Energy Information Administration, Korea’s oil consumption was 0.537 million barrels per day in 1980, reached a peak of 2.255 million barrels per day in 1997, declined to a low of 1.917 million barrels per day in 1998, and then leveled off between 2.08 - 2.18 million barrels per day during 1999-2006. In 2006, Korea consumed 2.157 million barrels of crude oil per day, was the 9th largest oil consuming nation in the world, and was the 5th largest net oil-importing country. Seventy-five percent of Korea’s oil import came from the Persian Gulf region, and Saudi Arabia is the largest oil supplier and accounted for 29% of total oil imports. To protect potential disruptions of oil supply, Korea has established strategic oil reserves with a maximum capacity of up to 116 million barrels of oil. As of April 2007, it held 76 million barrels of oil, which is equivalent to 34 days of oil imports. To further ensure the supply of oil, the Korean government, through the state-owned oil company, has invested in 32 overseas exploration and production projects in fifteen countries. Currently, six of the 32 projects are producing crude oil.

This paper examines output response to higher oil prices and changing macroeconomic conditions in Korea and has several focuses. First, the equilibrium in the commodity market, the equilibrium in the money market, and an augmented aggregate supply curve are considered simultaneously to determine the equilibrium output. Second, the money demand function considers the real stock price and the real exchange rate in order to test whether the substitution effect would be greater or less than the wealth effect (Friedman, 1988; Hsing,
Third, comparative-static analysis is employed to assess the effect of a change in one of the exogenous variables on real GDP.

Several articles examined the related subjects for Korea and selected countries. Dick, Gupta, Vincent, and Voigt (1984) examined the impacts of higher oil prices on macroeconomy performance for four countries including Korea. Assuming a 100% increase in the crude oil price and 80% increase in the price of petroleum products, relative to other commodities, they found that real GDP for Korea would decline 6.12% in the short run and 4.41% in the medium run and that the consumer price index would first rise 3.44% in the short run and then decline 3.38% in the medium run partly because the decrease in real GDP would reduce aggregate spending.

Bhattacharya (1997) indicated that oil price shocks have negative impacts on output in two oil-importing countries of India and Korea and that exports and non-oil world supply shocks are more important for Korea, Malaysia and Singapore than for the Philippines and India in affecting output fluctuations and accounted for less than 20% of the variation in output. Domestic supply shocks can explain a significant percent of output change. Exports are not the single factor in causing economic growth for these countries.

Abeysinghe (2001) considered both the direct and indirect impacts of oil price increases on output growth for 12 countries including Korea. He revealed that a 50% increase in the crude oil price would reduce Korea’s GDP growth by 2.3% after four quarters and by 3.6% in the long run. He also showed that if the crude oil price rises 50%, there will be a negative effect on output growth in the long run even for oil-exporting nations such as Indonesia and Malaysia.

Glasure (2002) showed that the oil price is an important factor in determining energy consumption and output in Korea and that the two energy crises have adverse impacts on output in Korea. Chiou-Wei and Zhu (2002) reported that oil price shocks have the most significant impacts on exports in Korea and Taiwan, that monetary shocks have temporary effects on exports for both Korea and Taiwan, and that shocks from the U.S. have significant impact on Taiwan’s exports but insignificant short-run effect on Korea’s exports.

Huntington (2004) found that when the oil share is considered, a doubling of the oil price would cause Korea’s GDP to decline by 2.8% and that when the initial GDP gap is taken into consideration, a doubling of the oil price would reduce Korea’s real GDP by 3.6%. Both of these percent decreases in real GDP are higher than those estimated for Japan and the U.S. Based on the World Macroeconomic Model of the Oxford Economic Forecasting, Ltd., the Asian Development Bank (2004) predicted that a sustained $10 increase in the oil price would reduce Korea’s GDP by 0.6% and raise Korea’s CPI by 0.8% and that a sustained $20 increase in the oil price would cause Korea’s GDP to decline by 1.2% and raise Korea’s CPI by 1.4%. For Asia as a whole including Japan, the percent decline in GDP due to a sustained 10% and 20% increase in the oil price would be 0.6% and 1.2%, respectively. Thailand, the Philippines, and Singapore are among the hardest hit countries.

2. The Model

Korea’s economy may be affected by a higher oil price via several channels. As a net oil-importing country and given a relatively stable oil import, a higher oil price would reduce net
exports and aggregate expenditures, which, in turn, would cause the won to depreciate. An increased oil price is expected to cause the domestic price level to rise because prices of many petroleum-related products would rise. A higher price level would cause real money supply and real wealth to decline, leading to less consumption spending and a lower real output.

Suppose that aggregate spending is determined by real output, the real interest rate, real government spending, real government tax revenues, the real financial stock price, the real exchange rate, and the real oil price, that real money demand is a function of real output, the nominal interest rate, the real financial stock price, and the real exchange rate, and that the price level depends on the core price, the output gap, the real exchange rate, and the real oil price. Extending Romer (2000), the three simultaneous-equation model can be written as:

\[ Y = F(Y, R - \pi^e, G, T, W, E, O) \]  \hspace{1cm} (1)

\[ M / P = L(Y, R, W, E) \]  \hspace{1cm} (2)

\[ P = P^* + \lambda (Y - Y^*) + \phi E + \delta \dot{O} \]  \hspace{1cm} (3)

where

- \( Y \) = real GDP in Korea,
- \( R \) = the nominal interest rate,
- \( \pi^e \) = the expected inflation rate
- \( G \) = real government spending,
- \( T \) = real government revenues,
- \( W \) = the real stock price,
- \( E \) = the real exchange rate (won per U.S. dollar),
- \( O \) = the real crude oil price per barrel,
- \( M \) = nominal money supply,
- \( P \) = the price level,
- \( P^* \) = the core price level,
- \( Y^* \) = potential output, and
- \( \lambda, \phi, \delta \) = parameters with positive values.

Solving three endogenous variables, namely, real output, the nominal interest rate and the price level, we have:

\[ \bar{Y} = \bar{Y}(O, M, G, T, W, E, \pi^e, Y^*, P^*, \lambda, \phi, \delta) \]  \hspace{1cm} (4)

Let

\[ 0 < F_Y < 1, F_{R - \pi^e} < 0, F_G > 0, F_T < 0, F_W > 0, F_E > 0, F_O < 0, \]

\[ L_Y > 0, L_R < 0, L_W > or < 0, L_E > or < 0, P_Y = \lambda > 0, P_E = \phi > 0, P_O = \delta > 0. \]

The Jacobian for the endogenous variables is given by:
\[ J = -L_R(1 - F_Y) - \lambda F_R MP^{-2} - F_R L_Y > 0. \quad (5) \]

A higher real oil price is expected to have an adverse impact on output because of the negative effect on net exports and a possible higher general price level, which leads to a decline in real money supply:

\[ \frac{\partial Y}{\partial O} = \left( -F_O L_R + \delta F_R MP^{-2} \right) / |J| < 0. \quad (6) \]

More money supply is expected to increase real output:

\[ \frac{\partial Y}{\partial M} = -F_R P^{-1} / |J| > 0. \quad (7) \]

More government deficit spending is expected to cause output to rise in the short run:

\[ \frac{\partial Y}{\partial G} - \frac{\partial Y}{\partial T} = \left( -F_G L_R - F_T L_R \right) / |J|. \quad (8) \]

Barro (1989) and Taylor (2000) indicated, however, that the effect of deficit-financed government spending on output may be neutral or uncertain in the long run. An increased real stock price would raise real GDP if real demand for money reacts negatively to a higher real stock price and reduce real GDP if \( |F_R L_{w} > F_R L_{w} | \) (Friedman, 1988):

\[ \frac{\partial Y}{\partial W} = \left( -F_W L_R + F_R L_W \right) / |J| > 0. \quad (9) \]

An increase in the real won/USD exchange rate or real depreciation of the won may cause real output to decrease or increase:

\[ \frac{\partial Y}{\partial E} = \left( -F_E L_R + \phi F_R MP^{-2} + F_R L_E \right) / |J| > 0. \quad (10) \]

As \( -F_R L_R > 0 \) and \( \phi F_R MP^{-2} < 0 \), a major factor to determine the sign of \( \frac{\partial Y}{\partial E} \) is whether real money demand would react to real depreciation positively due to the wealth effect of negatively due to the substitution effect.

### 3. Empirical Results

The data were taken from IMF’s International Financial Statistics. Real GDP is measured in billion won at the 2000 price. The real oil price is the average world oil price per barrel in U.S. dollar divided by the U.S. consumer price index. M2 money measured in billion won. Government spending and revenues in billion won are divided by the CPI and expressed in real terms. To reduce a high degree of multicollinearity, real deficit spending \( G-T \) is used. The real stock price is derived from the nominal share price divided by the consumer price index. The real exchange rate is equal to the nominal exchange rate in terms of the won per U.S. dollar divided by the relative prices in the U.S. and Korea. Hence, an increase in the real exchange rate is a real depreciation. The expected inflation rate is the lagged inflation rate of the consumer price index. Except for negative values, variables are measured in the logarithmic scale. The sample ranges from 1978.Q1 to 2006.Q4 with a total of 116
observations. Earlier data for the share stock price are not available. Because the sample period does not include the first energy crisis during the 1973-74, empirical results may vary with previous findings based on the sample covering the first energy crisis.

In the unit root test, the critical values are -3.488, -2.887, and -2.580 at the 1%, 5%, and 10% levels, respectively. Comparing with the test statistic, one finds that each of the variables has a unit root in level and is stationary in first difference at the 5% level. In the Johansen test, because the trace test statistic of 159.845 is greater than the critical value of 125.615 at the 5% level, the null hypothesis that these variables have at least one cointegrating relationship cannot be rejected.

The estimated regression and related statistics are presented in Table 1. Except for the coefficient of the expected inflation rate, the coefficients of other variables are significant at the 1% or 10% level. Real GDP in Korea is positively associated with M2 money supply, real deficit spending, and the real stock price and negatively influenced by the real oil price and real depreciation of the won.

A number of comments are worth noting. The relatively small elasticity of real GDP with respect to the real oil price suggests that a 10% rise in the real oil price would cause real GDP to decrease by 0.42%. During 2005-2006, the real oil price per barrel rose from US$47.042 to US$54.899 or 16.70%. Based on the elasticity estimate, this increase in the real oil price would reduce real GDP in Korea by 0.70%. The Korean authorities may need to reduce its dependence on oil imports, diversify the sources of energy, and take conservation measures in order to reduce the adverse effect of rising oil prices on real output. Although the impact of more government deficit spending is positive and significant, deficit-financed government spending may have a neutral effect in the long run (Barro, 1989). Hence, fiscal discipline would need to be pursued. The positive significant relationship between real GDP and the real stock price implies that a healthy stock market would be conducive to output growth partly due to the wealth effect and the balance-sheet effect. The negative significant relationship between real GDP and the real exchange rate suggests that the negative impact of real depreciation is greater than the positive effect. Hence, exchange rate movements in recent years from 1,401.44 wons per U.S. dollar in 1998 to 954.79 in 2006 are favorable to economic growth and consistent with the empirical findings in this study.

Attempts were made to consider different measurements for some variables to see if any improvements over the above results may be found. If M1 money supply is chosen in lieu of M2 money supply, its coefficient is significant at the 1% level. However, the use of M1 money supply changes the coefficients of the real oil price and the real exchange rate from the negative to positive sign. In comparison, M2 money supply would be a better measure because the broader measure includes the money market account and other deposits which can be converted into liquid assets and are closely related to overall economic activities. When the ratio of government deficit spending to GDP is used to replace real government deficit spending, its coefficient is positive and significant at the 1% level. Other results are similar. Hence, expansionary fiscal policy may be considered when the economy needs to be stimulated. If the average inflation rate of past four quarters is chosen to replace the lagged inflation rate, its coefficient is negative and insignificant at the 10% level. However, the use of this expected inflation rate causes the coefficient of the real oil price to become marginally significant at the 10% level. To consider a possible capital mobility effect or the cost of borrowing effect in the money demand function, attempts were made to include a world interest rate represented by the U.S. 3-month Treasury bill rate or the U.S. 10-year bond
yield. The coefficient of each of these variables is insignificant at the 10% level. To save space, these results are not reported here and will be available upon request.

4. Summary and Conclusions

This paper has studied output response to rising oil prices and changing macroeconomic conditions for Korea. A simultaneous-equation model is specified to include the equilibrium in the goods market, the equilibrium in the money market, and an augmented aggregate supply function. The estimated elasticity of -0.042 suggests that when the real oil price rises 1%, real GDP would decline by 0.042%. The Korean government may need to monitor the consequences of a large percent increase in the real oil price because it would be harmful to the growth of real GDP. In addition, more money supply, more real deficit spending, a higher real stock price, and real appreciation of the won would increase real output. Although more deficit spending would raise output in the short run, deficit-financed government spending may have a neutral effect in the long run due to the Ricardian equivalence theory. A large foreign debt to finance deficit spending might cause a possible default or delay of debt repayment and lead to a currency and financial crisis that Korea had experienced in the Asian financial crisis. Recent exchange rate movements from 1,145.32 to 954.79 won per U.S. dollar during 2004-2006 suggest that the exchange rate policy pursued by the Korean authorities is consistent with the finding of this study that real exchange rate depreciation would not help increase real output for Korea.

Several areas may be considered for further research. The money market equilibrium may be replaced by the monetary policy function (Romer, 2000; Taylor, 1993, 1999, 2001) to describe the monetary policy that the Bank of Korea has pursued in determining the short-term interest rate based on the inflation target, the GDP gap, and other related variables. If the data are available, the real effective exchange rate may be considered because it is a trade-weighted index with a broader coverage of major exchange rates. If there are complete time series data, the ratio of government debt to nominal GDP may be considered as another proxy for fiscal policy.

Endnote

* Dr. Wen-jen Hsieh, Professor of Economics, Department of Economics, National Cheng Kung University, No.1, University Road, Tainan City 701, Taiwan (R.O.C.). E-Mail: whsieh@mail.ncku.edu.tw.

References


Table 1. Estimated Regression of Real GDP for South Korea

Dependent Variable: LOG(Y)
Included observations: 116 after adjustments
White Heteroskedasticity-Consistent Standard Errors & Covariance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>8.044559</td>
<td>0.635179</td>
<td>12.66502</td>
<td>0.0000</td>
</tr>
<tr>
<td>LOG(O)</td>
<td>-0.042303</td>
<td>0.024237</td>
<td>-1.745382</td>
<td>0.0837</td>
</tr>
<tr>
<td>LOG(M)</td>
<td>0.402081</td>
<td>0.009060</td>
<td>44.37940</td>
<td>0.0000</td>
</tr>
<tr>
<td>G-T</td>
<td>4.18E-06</td>
<td>1.68E-06</td>
<td>2.485434</td>
<td>0.0145</td>
</tr>
<tr>
<td>LOG(W)</td>
<td>0.080445</td>
<td>0.026993</td>
<td>2.980263</td>
<td>0.0036</td>
</tr>
<tr>
<td>LOG(E)</td>
<td>-0.215244</td>
<td>0.079905</td>
<td>-2.693736</td>
<td>0.0082</td>
</tr>
<tr>
<td>$\pi^*$</td>
<td>0.001744</td>
<td>0.006117</td>
<td>0.285045</td>
<td>0.7762</td>
</tr>
</tbody>
</table>

R-squared       0.978188  Akaike information criterion  -1.976566
Adjusted R-squared 0.976988  Schwarz criterion  -1.810401
Durbin-Watson Statistic 2.207718  F-statistic  814.7256