

**Oil Price Effects on Exchange Rate and Price Level:
The Case of South Korea**

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Abstract

In this paper, we estimated the causality from crude oil price to exchange rate and consumer price index (CPI) and the causality relationship between exchange rate and CPI for the case of South Korea. We applied an exponential generalised autoregressive conditional heteroskedasticity (EGARCH) model and a cross-correlation function to logarithmic differences of seasonally adjusted monthly data for the period of August 1989 to December 2017. The results of this estimation indicated causality in both mean and variance from crude oil price to CPI, a unidirectional causality in mean from exchange rate to CPI and causality in variance from CPI to exchange rate.

Key words: Crude oil price, South Korea, exchange rate, price level

1. Introduction

South Korea has an advanced economy, well integrated with the world economy. Hence, changes in the economic performance of its major trade partners and international financial and commodity markets affect its macroeconomic fundamentals. South Korea is one of the largest importers and consumers of crude oil. In 2016, the average daily consumption of oil was 2763 thousand barrels, making it the fourth largest in the Asia Pacific and the eighth largest in the world.¹ Therefore, oil price plays an important role in determining crude oil imports (Kim and Baek, 2013) and consumption in South Korea, and sharp changes in international oil supply and oil price are of significant concern (Shin and Savage, 2011). Recent studies have found the dominance of oil price volatility on real stock returns (Masih, Peters and De Mello,

¹ BP Statistical Review of World Energy.

2011), nominal exchange rates (Thenmozhi and Srinivasan, 2016), aggregate output (Hsing, 2016; Kim, 2012) and inflation and interest rates (Kim, 2012).

In this paper, we estimated the causality from crude oil (Brent) price to the exchange rate and CPI, and the causality relationship between the exchange rate and CPI for the case of South Korea. In the next section, we specify the methodology. We describe the data in the third section and explain the empirical findings in the fourth section. In the last section, we summarise the paper.

2. Methodology

We used the seasonally adjusted monthly average CPI, price of crude oil (Brent) and nominal exchange rate of the South Korean won (KRW) per US dollar to calculate monthly logarithmic differences. The Wald test was conducted to test for the presence of structural breaks. For the breaks, we incorporated dummy variables in the equations of the models.

We used Nelson's (1991) EGARCH model, which is based on Engle's (1982) linear autoregressive conditional heteroskedasticity (ARCH) model and Bollerslev's (1986) generalised ARCH (GARCH) model, to compute the conditional mean and conditional variance of each variable. In the conditional mean equation, the monthly logarithmic differences are the function of a constant (c) and the lagged values of the dependent variable and other external variables (in this paper, the dummy variables for the structural breaks):

$$y_t = c + \sum_{j=1}^k \delta_j X_{t-j} + \varepsilon_t \quad (1)$$

The prediction error ε_t (innovations or given information at time t) is defined as $\varepsilon_t = \sigma_t z_t$, where $z_t \sim i.i.d.$ with $E(z_t) = 0$ and $Var(z_t) = 1$. Here, σ_t is the standard deviation and z_t the standardised residuals.

The model's conditional variance equation is

$$\ln(\sigma_t^2) = \omega + \sum_{j=1}^p (\gamma_j \varepsilon_{t-j} / \sigma_{t-j} + \alpha_j (|\varepsilon_{t-j} / \sigma_{t-j}| - (2/\pi)^{1/2})) + \sum_{j=1}^q \beta_j \ln(\sigma_{t-j}^2) \quad (2)$$

Here, σ_t^2 is the conditional variance and ω is a constant. The γ_j parameter measures the asymmetric effect of past information, while the α_j parameter measures the symmetric effect of past information. The β_j parameter measures the effect of the past periods' volatility.

Following Cheung and Ng (1996), we used the standardised residuals and squared standardised residuals from the above model in a cross-correlation function to test the causality from crude oil price to exchange rate and price level, and the causality relationship between the exchange rate and price level.

The sample cross-correlation coefficient at lag i for the standardised residuals was estimated as

$$\hat{r}_{uv}(i) = c_{uv}(i)(c_{uu}(0)c_{vv}(0))^{1/2} \quad (3)$$

Here, $c_{uv}(i)$ is the i th lag's sample cross-covariance and $c_{uu}(0)$ and $c_{vv}(0)$ are the sample variances of u and v , the standardised residuals derived from the EGARCH model.

3. Data

Our estimations used the logarithmic differences of the seasonally adjusted monthly data for the period of August 1989 to December 2017. Crude oil price data were obtained from Thomson Reuters statistics, available via Independent Statistics and

Table 1. Descriptive statistics for logarithm differences of the seasonally adjusted monthly data

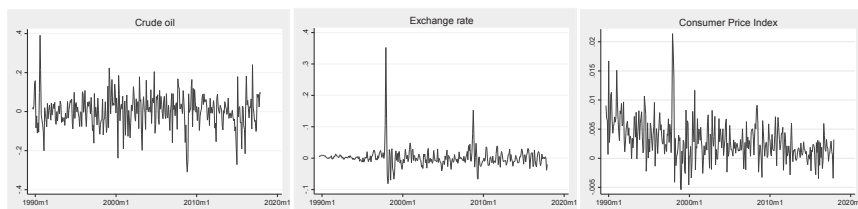
	Brent	Exchange Rate	CPI
Mean	0.0043	0.0014	0.0030
Std. Dev.	0.0841	0.0296	0.0035
Skewness	-0.1151	5.4535	1.1435
Kurtosis	5.2424	62.926	6.8322
Jarque-Bera	71.99***	5300***	282.2***
ADF	-4.696***	-4.494***	-3.613***
ARCH	37.699***	14.803***	63.577***
Observations	340	340	340

Note: The maximum number of lags for the ADF test selected by the Schwarz information criterion was 16. For CPI the base period is January 2010.

Analysis of the US Energy Information Administration. The exchange rates and CPI are calculated using the data reported by the Bank of Korea and the national statistics of South Korea, available via the Korean Statistical Information Service.

The mean values of the logarithmic differences are positive (Table 1), showing an increasing trend in the variables. The standard deviation values show that the crude oil price and exchange rate are more volatile than the CPI. The skewness and kurtosis values show that the logarithmic differences are not distributed normally. The Jarque-Bera test confirms that the sample data have skewness and kurtosis not matching a normal distribution. The Lagrange multiplier test for an ARCH effect shows that the series exhibit conditional heteroskedasticity. This means the logarithmic differences fluctuate around a constant level, but exhibit volatility clustering. The augmented Dickey-Fuller (ADF) test for unit root returned values smaller than the critical values at the 1% significance level, thus strongly rejecting the presence of unit root.

Figure 1. Logarithmic differences of the seasonally adjusted monthly data



The Wald test for the presence of structural breaks led us to reject the null hypothesis of no structural break at the 1% significance level. The estimated break date was January 1998 for the exchange rate and March 1998 for CPI. The logarithmic differences are depicted in Figure 1.

4. Empirical findings

The estimations of the EGARCH model (Table 2) show a significant impact (at the 1% significance level) of previous month's values and dummy variables for structural breaks. For crude oil, past negative information has a stronger effect on conditional

variance than past positive information. However, this asymmetric effect is smaller than the symmetric effect of past information. The symmetric effect of past information and the impact of past volatility on the variance of all three variables is positive and statistically significant at a 1% to 5% significance level. The portmanteau (Q) test statistic for white noise indicates that the standardised residuals and their squared values do not contain autocorrelation up to order 5.

Table 2. Results of the EGARCH model

Variable	Crude oil	KRW	CPI
Model	G(1, 1, 1)	G(1, 1, 1)	G(2, 1, 1)
δ_1	0.1680*** (0.0596)	0.3837*** (0.0550)	0.2169*** (0.0615)
δ_2			-0.0259 (0.0555)
D		-0.0037*** (0.0012)	-0.0022*** (0.0004)
c	0.0036 (0.0042)	0.0021*** (0.0006)	0.0037*** (0.0005)
γ_1	-0.2200*** (0.0741)	0.1146 (0.0741)	0.0916 (0.0949)
α_1	0.6168*** (0.1131)	0.6147*** (0.1156)	0.3682** (0.1659)
β_1	0.3347** (0.1354)	0.9262*** (0.0227)	0.7795*** (0.1998)
ω	-3.3904*** (0.71315)	-0.5723*** (0.1987)	-2.5603 (2.3236)
$Q_{(5)}$	2.2493 (0.8137)	4.2804 (0.5098)	2.6788 (0.7494)
$Q^2_{(5)}$	2.3520 (0.7986)	1.2692 (0.9381)	0.5345 (0.9908)

Note: The numbers in parentheses are standard errors.

Table 3 shows that crude oil price Granger-causes CPI in mean within two months (as the coefficient of the previous month is significant) and in variance within six months (as the coefficients of the previous five months become significant). That means the previous month's price of crude oil helps predict the current month's CPI. The volatility of the crude oil price over the previous five months helps predict the volatility of CPI in the current month.

Exchange rate Granger-causes CPI in mean within two months (as the coefficient of

Table 3. Causality relationship

Period	Causality-in-mean				Causality-in-variance			
	Crude oil to KRW	Crude oil to CPI	KRW to CPI	CPI to KRW	Crude oil to KRW	Crude oil to CPI	KRW to CPI	CPI to KRW
Previous month	0.3657	9.2589	10.6118	1.0085	-0.5311	-0.0055	-0.7071	78.7950
Previous 2 months	-0.1871	6.0471	7.0328	0.2454	-0.8734	-0.5025	-0.9672	55.2166
Previous 3 months	-0.0117	4.5394	5.8523	-0.0305	-0.2966	-0.7478	-1.1923	44.6871
Previous 4 months	-0.0257	3.6445	4.7272	-0.3433	-0.4830	-0.9293	-1.3100	38.6547
Previous 5 months	-0.1686	3.3078	4.0912	-0.6096	-0.4471	3.7117	-1.4730	34.3369
Previous 6 months	1.1733	2.7402	4.1988	0.4000	-0.6782	3.1001	-1.5651	31.1417
Previous 7 months	0.8230	2.5797	3.9206	0.1397	-0.2544	2.6785	-1.6860	28.6958

Note: Generalised chi-square test statistics suggested by Hong (2001) are presented. Asymptotic critical values are 1.645 at the 5% level and 2.326 at the 1% level.

the previous month is significant). That means the previous month's exchange rate helps to predict the current month's CPI. CPI Granger-causes exchange rate in variance within two months (as the coefficient of the previous month is significant). That means the volatility of CPI in the previous month helps predict the volatility of the exchange rate in the current month.

5. Concluding remarks

We estimated the impact of the crude oil price on exchange rate and CPI and the relationship between the exchange rate and CPI for the case of South Korea. Our estimations, which are based on seasonally adjusted monthly logarithmic differences, showed that the exchange rate and CPI Granger-cause each other. The crude oil price Granger-causes CPI but not the exchange rate. Nevertheless, considering the relationship between crude oil and other important economic variables, as described in the introduction, the crude oil price could affect the exchange rate via price level and other economic variables.

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