Economics Bulletin

Volume 31, Issue 3

Relationship between Crude Oil Prices and Stock Prices of Alternative Energy Companies with Recent Evidence

Alex YiHou Huang
College of Management, Yuan Ze University

Chiao-Ming Cheng
College of Management, Yuan Ze University

Wen-Cheng Hu
College of Management, Yuan Ze University

Chih-Chun Chen
Department of Management, Fo Guang University

Abstract

This paper examines the recent interactive relationships between crude oil prices and stock performances of alternative energy companies. Oil prices and stock index of alternative energy sector are found independent from each other before late 2006. Contrary to existing studies, however, we find significant interdependence between oil prices and stock index of alternative energy industry in the recent years. Since late 2006, oil prices become significantly responsible for the stock performances of alternative energy companies. This finding suggests that the stock market investors of alternative energy sector incorporate oil price shocks into their trading decisions only recently.

The paper benefited from the comments of participants in the 50th Southwestern Financial Association annual meeting. This research is supported in part by the National Science Council of Taiwan (NSC99-2410-H-155-012).
Citation: Alex YiHou Huang and Chiao-Ming Cheng and Wen-Cheng Hu and Chih-Chun Chen, (2011) "Relationship between Crude Oil Prices and Stock Prices of Alternative Energy Companies with Recent Evidence", *Economics Bulletin*, Vol. 31 no.3 pp. 2434-2443.
Submitted: May 12 2011. **Published:** August 29, 2011.

1. Introduction

Oil is the primary energy source in modern economies, and crude oil price dynamics have been documented as a major influence on economic activities.[1] Park and Ratti (2008) argue that oil price volatility is a key factor in stock market operation. Oil prices have been dramatically volatile over the past few years. Chiou and Lee (2009) find significant structural change in recent oil prices and show that the impacts from oil to stock prices are dynamical and asymmetrical.

Bleischwitz and Fuhrmann (2006) and McDowall and Eames (2006) show that the recent popularity of alternative energy sources is mainly motivated by two factors: environmental protection and the political instability of oil-exporting countries. Consequently, the relationship between oil prices and the alternative energy industry bears further examination. In this paper, we address the narrower question of how oil prices interact with the performance of alternative energy firms and the stock returns of oil companies in recent years.

Henriques and Sadorsky (2008) find that oil prices and the stock prices of alternative energy companies do not interact with each other. However, they also find that the trend of an alternative energy stock index is significantly linked with that of technology stock prices. The present paper extends this line of research, focusing on the interaction between oil prices and the financial performance of alternative energy companies in a more recent sample. The returns of oil industry stocks are also considered, since prior studies have suggested that they are significantly related to the alternative energy industry (e.g. Sadorsky, 2001).

Most of the major oil exporters are Middle East sovereigns, and the conflicts in this region often generate large impacts on oil prices.[2] For the first time in the literature, we will show that oil prices behaved differently before and after two recent Middle East wars. In contrast with the result of Henriques and Sadorsky (2008), we document a significant interdependence between oil prices and the stock index of alternative energy firms, but only after the Lebanon War of 2006.[3] The next section presents the data and methodology of the study in detail. It is followed by a discussion of empirical outcomes and concluding remarks.

[1] See Hamilton (1983), Sadorsky (1999), and Nandha and Faff (2008) for examples.
[2] The Middle East holds 60% of global oil reserves and accounts for 32% of current oil production (data source: Energy Information Administration). The oil price of West Texas Intermediate (WTI) jumped by 86%, from $16.10 to approximately $30, immediately after the occupation of Kuwait by Iraq in 1990.
[3] The sample period of Henriques and Sadorsky (2008) spans January 2001 to May 2007.

2. Data and Methodology

Three oil price series are used in this study: the spot prices of West Texas Intermediate (WTI), the spot prices of Brent (Brent), and NYMEX Crude Futures (Futures). Following Henriques and Sadorsky (2008), we adopt the WilderHill Clean Energy Index (ECO) as a proxy for the stock performance of alternative energy companies. All the components of this index are required to have at least one business concentration that produces or develops environmentally friendly energy.[4] The crude oil stock index of the American Stock Exchange, comprising 12 global oil companies, is used to track the financial performance of the oil industry.

Our sample spans the period from January 3, 2001 to May 31, 2010. All time series are weekly and extracted from the Thomson Reuters Datastream database. Since oil prices are strongly affected by instability in the Middle East, we divide the sample into three time segments around the dates of two Middle East wars: the Iraq War in March 2003 and the Lebanon War in July 2006. Table 1 provides summary statistics of the series for the entire sample period and the three sub-periods.[5] As the table shows, the time series of spot prices and futures prices for crude oil have very similar properties. When the three sub-periods are compared, however, we find that their volatility and skewness measures are significantly different. Using WTI as an example, the standard deviations are 4.01, 13.54, and 23.41 for Periods I, II, and III respectively, while the skewness measures are 0.15, 0.28, and 0.30. Generally, oil prices are most stable in Period I (when the coefficients of variation are lowest), grow gradually in Period II (the distributions become skewed to the right), and fluctuate most strongly in Period III (when ranges and coefficients of variation are highest).

All three trends are clearly illustrated in Figure 1, which graphs the oil price of WTI during the sample period. Before the 2003 Iraq War (first grey band), the oil price was generally stable between $20 and $40. After the Iraq War the oil price trends significantly upward, reaching nearly $80. After the Lebanon War of 2006 (second grey band), a small drop in the oil price was followed by a dramatic jump to more than $140 over two years. The price then crashed below $40 in late 2008.

This study uses the vector autoregressive (VAR) model and vector error correction model (VECM) to examine the interdependencies of the variables. VAR and VECM are

[4] The ECO index is a weighted stock index with worldwide green energy companies as components. Please see detail description of the index at http://www.wildershares.com/index.php.
[5] In order to avoid extremely volatile movements of oil prices, we exclude a four-month period around each war from the sample.

maximum likelihood estimation models requiring only a single regression. VECM can be seen as a first-difference version of VAR; the former is applied when each variable of regression is integrated with order 1. Prior to the application of VAR/VECM, we conduct unit root and Johansen cointegration tests to check for stationarity and long-term relationships respectively. The Granger Causality test is also applied to evaluate the interdependence between variables.[6]

3. Empirical Results

The Augmented Dickey-Fuller and Phillips-Perron statistics fail to reject the null hypotheses of a unit root process for all series. These results hold during the entire sample period and during the sub-periods. Both tests also confirm stationarity for the first differences of the sample series. The Johansen statistics fail to reject the null hypothesis of no cointegrated vector between oil prices and the ECO index, regardless of which sample period is being examined. However, significant trace statistics imply that oil prices and the Oil index are cointegrated during time periods II and III.

Table 2 presents the VAR/VECM and Granger Causality test results. VAR is applied to the first differences of oil prices and the ECO index when the I(1) series are not cointegrated. VECM is only applied to the cointegrated series (oil prices and the Oil index in Periods II and III). The optimal lag is one, based on the Schwartz Bayesian Criterion (SBC). The first and second columns of the table are the left-hand and right-hand variables.

Panel A describes results for the entire sample period. The first two rows show VAR outcomes between the WTI price and the ECO index. The coefficient estimates are 0.1310 and 0.0482 for the two directions of causality, but only causality from oil prices to the ECO index (coefficient 0.0482) is statistically significant. The finding that the ECO index has no effect on the WTI price is confirmed by the Granger Causality test, which yields χ^2 equal to 1.16 (insignificant). Similar results (not shown) are obtained when the ECO index is modeled with the other two oil prices. Between oil prices and the oil stock index, interdependence is generally significant and two-way. There is a significant negative impact from the Oil index to the oil price, and a significant positive impact from oil prices to the Oil index.[7]

[6] Please see Enders (2004) for detailed descriptions of VAR/VECM and the time series tests.
[7] Please note that the negative relation shows that lag oil index inversely lead oil price and does not suggest contemporaneous relation. Such lag negative correlation is often observed from mean-reverting time-series.

Panel B presents the results for Period I, the pre-Iraq War period. All estimated coefficients for the oil prices-ECO index vector are statistically insignificant. This finding implies that the two series did not interact with each other prior to 2003. There is also no significant relationship between oil prices and the Oil index.

Panel C provides the outcomes for Period II, the time between the two wars. Between oil prices and the ECO index, all estimated coefficients are statistically insignificant. However, there is one-way causality from oil prices to the Oil index. The estimated significance levels for this relationship are 0.0097, 0.0077, and 0.0081 for WTI, Brent, and Futures prices respectively. This result is confirmed by the Granger Causality test.

Panel D presents the outcomes for Period III (June 2006 to May 2010; post-Lebanon War). Between oil prices and the ECO index, we now observe the significant one-way dependence detected in Panel A. In the first two rows of Panel D, the estimated coefficients are 0.1050 and 0.1066 but only the second of these is significant, at the 1% level.

Thus, the ECO index is found to depend on oil prices only during Period III, after the Lebanon War in 2006. As shown in Figure 1 and Table 1, this is also the period when oil prices exhibited drastic movements, and furthermore overlaps with the recent financial crisis. The causal link between oil prices and the ECO index implies that investors in alternative energy companies are now paying closer attention to oil price shocks when making their investment decisions. When oil prices are highly volatile, there is a higher demand for green energy and of the companies in the ECO index perform better.[8] During the final period we also found a highly significant interaction between oil prices and the Oil index, with negative impacts from stock prices to oil prices and positive impacts in the reverse direction.

4. Concluding Remarks

This study documents a significant difference in the dynamics of oil prices before and after the Middle East wars of 2003 and 2006. Oil prices are relatively stable prior to the Iraq war of 2003, grow gradually during the period between the two wars, and fluctuate strongly in the most recent period. Only in the period following the two wars do oil prices generate a significant impact on the stock index of green energy companies. This finding implies that investors in alternative energy are now paying closer attention to oil price shocks when

[8] Empirical results are similar when we replace WTI with Brent prices or oil futures, suggesting that the ECO index significantly depends on oil price movements during this period. The outcomes of these models are excluded from the table due to space limitations, but are available from the authors upon request.

making their investment decisions. Another behavior unique to the post-war period is a two-way causality between oil prices and the Oil index. Taken together, these relationships suggest that the crude oil market and the energy sector stock market are interacting more closely in recent years than they did prior to 2006.

Acknowledgements

The paper benefited from the comments of participants in the 50th Southwestern Financial Association annual meeting. This research is supported in part by the National Science Council of Taiwan (NSC99-2410-H-155-012).

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Table 1 Descriptive Statistics

	WTI	Brent	Futures	ECO index	Oil index
Panel A. Entire Period (2001/01/03~2010/05/31)					
Mean	54.49	53.15	54.54	158.98	868.92
Median	52.51	51.09	52.77	160.02	875.37
Maximum	143.74	142.17	143.57	297.05	1625.29
Minimum	18.38	18.46	18.36	63.73	411.09
Std. Dev.	26.22	26.21	26.24	49.01	332.85
C.V.	0.48	0.49	0.48	0.30	0.38
Skewness	0.88	0.82	0.87	0.14	0.30
Kurtosis	3.51	3.33	3.50	2.16	1.88
Panel B. Period I: Pre-Iraq War Period (2001/01/03~2003/02/26)					
Mean	26.60	25.40	26.57	158.17	508.98
Median	26.94	25.77	26.92	163.49	515.12
Maximum	37.96	33.54	37.70	258.71	590.08
Minimum	18.38	18.46	18.36	78.78	411.09
Std. Dev.	4.01	3.46	3.95	47.07	46.69
C.V.	0.15	0.14	0.15	0.30	0.09
Skewness	-0.04	-0.18	-0.06	0.16	-0.36
Kurtosis	3.28	2.64	3.31	2.06	2.12
Panel C. Period II: Post-Iraq and Pre-Lebanon War Period (2003/05/07~2006/06/28)					
Mean	47.82	45.74	47.86	160.04	759.92
Median	47.36	44.09	47.27	156.80	713.44
Maximum	72.26	73.42	72.28	253.02	1165.25
Minimum	26.24	24.18	26.23	97.42	449.23
Std. Dev.	13.54	12.15	13.62	30.61	218.72
C.V.	0.28	0.27	0.28	0.19	0.29
Skewness	0.14	0.21	0.14	0.79	0.23
Kurtosis	1.73	1.73	1.71	3.79	1.67
Panel D. Period III: Post-Lebanon War Period (2006/09/06~2010/05/31)					
Mean	76.54	75.74	76.65	160.39	1175.30
Median	72.23	71.48	72.15	182.54	1143.42
Maximum	143.74	142.17	143.57	297.05	1625.29
Minimum	32.94	35.62	34.62	63.73	802.18
Std. Dev.	23.41	22.38	23.31	61.17	211.76
C.V.	0.30	0.29	0.30	0.38	0.18
Skewness	0.77	0.81	0.79	0.05	0.19
Kurtosis	3.25	3.39	3.27	1.55	1.87

Note: Std. Dev. and C.V. stand for the standard deviation and coefficient of variation respectively.

Table 2 VAR/VECM and Granger Causality

Left-hand side	Right-hand side	VAR/VECM		Causality	
		Coefficient	*p*-value	χ^2	*p*-value
Panel A. Entire Period (2001/01/03~2010/05/31)					
WTI	ECO index	0.1310	0.2825	1.16	0.2820
ECO index	WTI	0.0482	0.0061***	7.60	0.0059***
WTI	Oil index	-0.3649	0.0058***	7.66	0.0056***
Oil index	WTI	0.0037	0.0002***	14.42	0.0001***
Panel B. Period I (2001/01/03~2003/02/26)					
WTI	ECO index	0.6271	0.3987	0.72	0.3968
ECO index	WTI	0.0088	0.4864	0.49	0.4849
WTI	Oil index	-0.0026	0.9984	0.01	0.9984
Oil index	WTI	0.0068	0.3981	0.72	0.3962
Panel C. Period II (2003/05/07~2006/06/28)					
WTI	ECO index	-0.0093	0.9705	0.01	0.9704
ECO index	WTI	-0.0186	0.4724	0.52	0.4713
WTI	Oil index	0.4024	0.5162	0.42	0.5153
Oil index	WTI	0.0097	0.0046***	8.28	0.0040***
Panel D. Period III (2006/09/06~2010/05/31)					
WTI	ECO index	0.1050	0.4857	0.49	0.4849
ECO index	WTI	0.1066	0.0037***	8.63	0.0033***
WTI	Oil index	-0.4380	0.0261**	5.03	0.0250**
Oil index	WTI	0.0057	0.0061***	7.68	0.0056***

Note: *,**, and *** indicate significance at the 10%, 5% and 1% levels respectively.

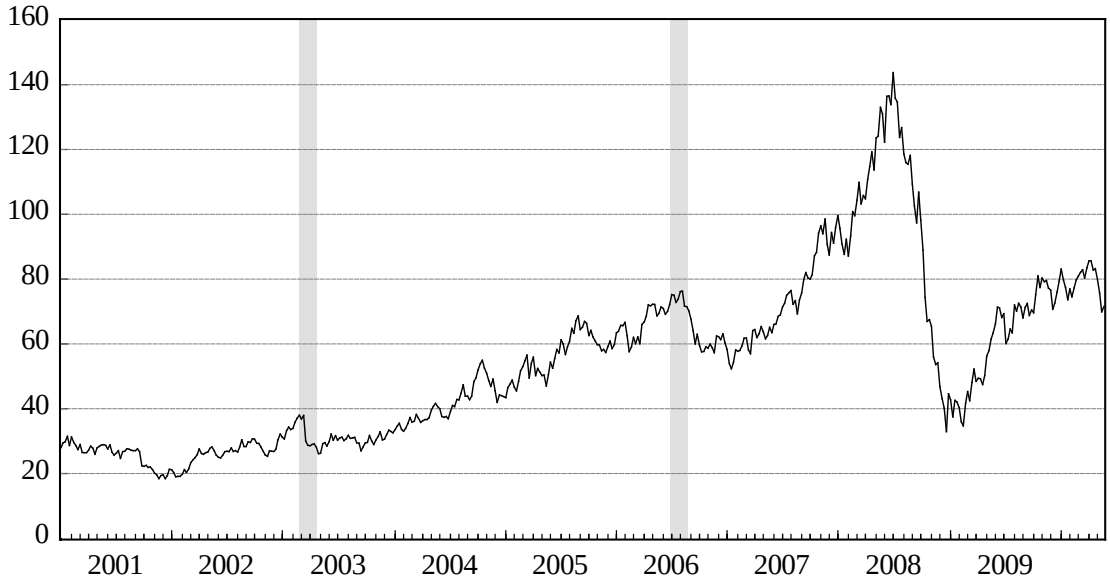

Figure 1 Crude Oil Price of WTI