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# The Asymmetric Response of Mergers and Acquisitions in the North American Oil and Gas Industry to Oil Price Changes

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**Abstract:** This article examines the effects that oil price changes have on oil and gas industry M&A activities in North America. To investigate this topic thoroughly, unlike early studies we take specific account of the asymmetric effects of oil price changes in our modeling procedure, using the nonlinear autogressive distributed lag (ARDL) model of Shin, Yu and Greenwood-Nimmo. The results provide strong evidence that changes in oil prices have asymmetric effects on oil and gas industry M&A activities in both the short-run and long-run. More importantly, oil and gas industry M&A activities appear to respond more to oil price decreases than to increases.

**Keywords**: Asymmetry; Mergers and acquisitions (M&A); Nonlinear ARDL; North America; Oil prices

**JEL Classifications**: C22, D22, L70, Q41

## 1. Introduction

Many scholars have sought to explore the effect oil price changes have on the number of mergers and acquisitions (M&A) activities in the oil and gas industry (e.g., Weston *et al*. 1999; Ng and Donker, 2013; Monge and Alana, 2016; Hsu *et al*., 2017; Monge *et al*., 2017; Reddy and Xie, 2017). For example, Weston *et al*. (1999) study the factors affecting M&A transactions in the world oil industry, and find that fluctuations in crude oil prices cause increased risks in the petroleum industry and trigger the number of M&As and restructuring. Ng and Donker (2013) report in passing a significant effect of changes in oil prices along with energy reserves on M&A activities. Hsu *et al*. (2017) find that a rise in crude oil prices increases M&A activities via increased the value of exploration and production (E&P) firms and the expected value of their assets, after controlling for other relevant factors such as interest rates, stock prices and production. Monge *et al*. (2017) examine the dynamic effects oil prices have on the petroleum industry M&A in the U.S., and conclude that higher oil prices raise the number of M&A during the mid-1990s and the late-2000s. Unquestionably, the current literature has expanded our understanding of the relationship between changes in crude oil prices and M&A activities in the oil and gas industry.

A crucial shortcoming of empirical studies investigating the oil price-M&A nexus is that fluctuations in oil prices are implicitly assumed to have symmetric effects. It implies that if a 1% rise in oil prices increases in the number of M&A activities by, say, *x*%, then a 1% decline in oil prices should decrease the number of M&A activities by *x*% as well. If not, then oil price changes could have asymmetric effects. In fact, since expectations and responses of M&A market participants in the oil and gas industry to an oil price hike are very likely to differ from their expectations and responses to an oil price drop, oil price changes are more likely to have asymmetric effects in the real world.[1] Studies to date, however, do not allow for the asymmetry effects of oil prices in their modeling process and raise questions about the validity of their conclusions. In examining the oil price-M&A nexus in the North American oil and gas industry, therefore, allowing for the asymmetry effect of oil prices in the autogressive distributed lag (ARDL) framework is the main new contribution of this article. It is worth emphasizing at the onset that, since production of unconventional oil and gas in the U.S. and Canada significantly increased in the late 2000s, the North American oil and gas industry has been playing an important role in the global energy market. Over the decade, however, the industry has experienced the financial boom-and bust cycle with wide fluctuations in oil prices. Given the fact that M&A is considered one of the key business transformation strategies, numerous oil and gas companies in North America have been engaged in M&A transactions. Thus, it is indeed timely to pursue this line of research in the context of the North American oil and gas industry. The remaining sections include methodology, empirical results and concluding remarks with data sources and definitions in the Appendix.

## 2. Methodology

In order to examine the oil price-M&A nexus properly, we extend an empirical framework by Monge *et al*. (2017) to encompass more relevant variables (i.e., rig count and oil price volatility). This model takes the form:

$$M\,\&\,A_t = \beta_0 + \beta_1 OP_t + \beta_2 IR_t + \beta_3 RC_t + \beta_4 V_t + u_t \qquad (1)$$

where $M\&A_t$ is the natural log of the number of M&A activities in the gas and oil industry in North America; $OP_t$ is the natural log of crude oil prices; $IR_t$ is the natural log of interest rates; $RC_t$ is the natural log of rig count; $V_t$ is the natural log of oil price volatility, and $u_t$ is the error term. If rising oil prices tend to trigger an increase in M&A deals in the North American gas and oil industry, then $\beta_1 > 0$. If an increase in interest rate negatively affects M&A activities through an increase in the cost of borrowing, then $\beta_2 < 0$. Since the oil and gas rig count is an important measure of demand for products used in drilling and completing wells, it is commonly considered a leading indicator of

[1] Although the spike in crude oil prices would likely lead to less activity on M&A, the opposite is also tr ue. For example, when high oil prices are expected to be maintained, companies tend to increase capi tal investments on exploration and production (E&P) and find new reserves, thereby resulting in expa nding market share via increased production and enhancing the growth potential in the sector. Conse quently, companies may not pursue active M&A as the price of oil rises. With fall of oil prices, on the other hand, companies generally experience a decline in revenues and cash flows, thereby being forc ed into a financial restructuring. Therefore, a fall in oil price is likely to be incentive for undertaking M &A. Accordingly, asymmetric price responses would make some sense on M&A in oil and gas market.

oil industry activity and is likely to have a significant influence on M&A activities. By incorporating $RC_t$ explicitly in the model, therefore, we are able to control for its effect on $M\&A_t$. If an increase in rig count results in more M&A activities, then $\beta_3 > 0$. In addition, since the oil and gas market is a highly speculative market, oil price volatility is a well-known and critical factor that highly affects M&A activities and is included in the estimation. If an increase in oil price volatility causes M&A activities to increase, then $\beta_4 > 0$.[2]

As noted in the introduction, the key assumption in Eq. (1) is that oil price changes have a symmetric effect on the number of M&A activities. In the empirical model used here, therefore, we extend Eq. (1) to incorporate asymmetric effects of oil price changes as is done in Umekwe and Baek (2017). To achieve this goal, we first need to decompose changes in crude oil prices into two new variables using the so-called partial sum concept; that is, one variable involves only oil price increases, which is denoted by $UP_t$; and the other variable involves only oil price decreases, which is denoted by $DOWN_t$:

$$UP_t = \sum_{j=1}^{t} \Delta \ln OP_j^{+} = \sum_{j=1}^{t} \max(\Delta \ln OP_j, 0) \qquad (2)$$

$$DOWN_t = \sum_{j=1}^{t} \Delta \ln OP_j^{-} = \sum_{j=1}^{t} \min(\Delta \ln OP_j, 0) \qquad (3)$$

In order to allow for asymmetric effects of oil price changes we then need to modify Eq. (1) by replacing $OP_t$ by $UP_t$ and $DOWN_t$. Finally, the ARDL modeling reformulates the modified Eq. (1) into an error-correction model by incorporating the short-run dynamics among the variables:

$$\begin{aligned}\Delta M\&A_t &= \beta_0 + \sum_{k=1}^{p} \beta_{k1} \Delta M\&A_{t-k} + \sum_{k=0}^{p} \beta_{k2} \Delta UP_{t-k} + \sum_{k=0}^{p} \beta_{k3} \Delta DOWN_{t-k} + \\ &+ \sum_{k=0}^{p} \beta_{k4} \Delta IR_{t-k} + \sum_{k=0}^{p} \beta_{k5} \Delta RC_{t-k} + \sum_{k=0}^{p} \beta_{k6} \Delta V_{t-k} + \theta_0 M\&A_{t-1} + \theta_1 UP_{t-1} \qquad (4) \\ &+ \theta_2 DOWN_{t-1} + \theta_3 IR_{t-1} + \theta_4 RC_{t-1} + \theta_5 V_{t-1} + \xi_t\end{aligned}$$

Since the incorporation of $UP_t$ and $DOWN_t$ introduces nonlinearity into the modeling process, Eq. (4) is labeled as the nonlinear ARDL model (Shin *et al.*, 2014) as opposed to the conventional linear ARDL model (Pesaran *et al.*, 2001). The coefficients of the first differences represented by $\beta_{k1}$ - $\beta_{k6}$ enable us to identify the short-run dynamics in the relationship among the variables. The coefficients of $\theta_1 - \theta_5$ by normalizing the coefficient of $\theta_0$ describe the long-run M&A relationship.[3]

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[2] The authors sincerely thank an anonymous referee for suggesting the model specification discussed here.

[3] This leads to the following relationship among the variables:

$$\theta_0 M\&A_{t-1} + \theta_1 UP_{t-1} + \theta_2 DOWN_{t-1} + \theta_3 IR_{t-1} + \theta_4 RC_{t-1} + \theta_5 V_{t-1} = 0 \qquad (5)$$

Now, by solving Eq. (5) for $M\&A_{t-1}$ the resulting model takes the form:

The asymmetry effects of oil price changes in the short- and long-run are detected when $\sum \beta_{k2} \neq \sum \beta_{k3}$ and $\theta_1 / \theta_0 \neq \theta_2 / \theta_0$, respectively. For this purpose, we carry out the Wald test.

## 3. Empirical Results

To estimate Eq. (4), we first impose a maximum lag length of four quarters on each of the first-differenced variables and then utilize the Akaike Information Criterion (AIC) to determine the ARDL (1, 4, 0, 3, 4, 3) as the optimal model specification.[4] Table 1 summarizes the short-and long-run results.

Our primary interest is in what happens to the coefficients on $UP_t$ and $DOWN_t$. In the short-run, the estimated elasticities of oil price increases with respect to M&A give mixed results. For example, $\Delta UP_t$ has a positive coefficient, while $\Delta UP_{t-1}$, $\Delta UP_{t-2}$ and $\Delta UP_{t-3}$ have negative coefficients. All coefficients except for $\Delta UP_t$ have statistically significant *t* statistics.

For example, the estimated coefficient of $\Delta UP_{t-1}$ is -1.561, indicating the 1.561% decrease in M&A deals after one quarter given a 1% increase in oil prices. On the other hand, the estimated elasticity of oil price decreases with respect to M&A is 1.272, suggesting the immediate 1.272% decrease in M&A deals given a 1% decrease in oil prices (Panel A). This is highly significant with $t$ = 5.373. Given different signs and magnitudes of the coefficients in oil price increases and decreases, therefore, our findings seem to support short-run asymmetric effects of oil price changes. In fact, this short-run asymmetric effect is endorsed by the Wald test. The Wald test statistic is 6.229, and this is the outcome of a $\chi_1^2$ random variable (Panel C). The *p*-value is 0.013. This rejects the null hypothesis of no short-run asymmetry at the 5% level, providing evidence of short-run asymmetry effects. Do short-run effects last into the long-run? Given the results reported in Panel B, the answer seems to be in the affirmative. For example, the estimated elasticity of oil price increases with respect to M&A is 1.148 (1.602), indicating that a 1% increase (decrease) in oil prices would lead to an estimated 1.148% (1.602%) increase (decrease) in M&A deals in the long-run. The Wald test produces $\chi_1^2$ = 13.409, and the associated *p*-value is 0.000 (Panel C). This rejects the null of no long-run asymmetry, thereby providing strong evidence of the long-run asymmetry effects.

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$$M\&A_{t-1} = -\frac{\theta_1}{\theta_0}UP_{t-1} - \frac{\theta_2}{\theta_0}DOWN_{t-1} - \frac{\theta_3}{\theta_0}IR_{t-1} - \frac{\theta_4}{\theta_0}RC_{t-1} - \frac{\theta_5}{\theta_0}V_{t-1} \quad (6)$$

Following Pesaran *et al*. (2001), Eq.(6) is used to form an error-correction term as follows:

$$ec_{t-1} = M\&A_{t-1} + \frac{\theta_1}{\theta_0}UP_{t-1} + \frac{\theta_2}{\theta_0}DOWN_{t-1} + \frac{\theta_3}{\theta_0}IR_{t-1} + \frac{\theta_4}{\theta_0}RC_{t-1} + \frac{\theta_5}{\theta_0}V_{t-1} \quad (7)$$

Finally, we then replace Eq. (7) with the lagged level variables in Eq. (4).

[4] Both monthly and quarterly data are available for the analysis. Since monthly data set yields some missing observations for the variables of interest (i.e., M&A activities and rig counts), however, quarterly data set is assembled for the period 2001:Q1 to 2016:Q4. 2001:Q1 is chosen because M&A activities in the gas and oil industry in North America is only traced back to the date. 2016:Q4 is the last date for which complete data are available.

**Table 1**. Results of nonlinear ARDL model

**Panel A: Short-Run Coefficient Estimates**

| **Independent variables** | Dependent variable: $M\&A_t$ | | | |
|---|---|---|---|---|
| | Lag order | | | |
| | 0 | 1 | 2 | 3 |
| $\Delta(UP_t)$ | 0.041<br>(0.119) | -1.561<br>(-4.085)** | -0.919<br>(-2.423)** | -0.667<br>(-1.826)* |
| $\Delta(DOWN_t)$ | 1.272<br>(5.373)** | | | |
| $\Delta(IR_t)$ | -0.030<br>(-0.266) | -0.055<br>(-0.464) | -0.293<br>(-2.639)** | |
| $\Delta(RC_t)$ | -0.508<br>(-3.334)** | 0.338<br>(2.097)** | -0.308<br>(-2.061)** | 0.293<br>(1.833)* |
| $\Delta(V_t)$ | 0.003<br>(0.296) | -0.039<br>(-3.718)** | -0.018<br>(-1.889)* | |

**Panel B: Long-Run Coefficient Estimates**

| $UP_t$ | $DOWN_t$ | $IR_t$ | $RC_t$ | $V_t$ |
|---|---|---|---|---|
| 1.148<br>(4.554)** | 1.602<br>(4.359)** | -0.036<br>(-0.633) | -1.065<br>(-2.853)** | 0.062<br>(2.179)** |

**Panel C: Diagnostic Statistics**

| $ec_{t-1}$ | LM | RESET | Wald-S | Wald-L |
|---|---|---|---|---|
| -0.794<br>(-7.831)** | 2.448<br>[0.654] | 0.755<br>[0.385] | 6.229<br>[0.013]** | 13.409<br>[0.000]** |

**Notes:** Numbers inside the parentheses and brackets are *t*-statistics and *p*-values, respectively. ** and * demarcate significance at the 5% and 10% levels, respectively. $ec_{t-1}$ denotes an error-correction term. LM and RESET represent the Lagrange multiplier test of serial correlation and Ramsey's regression specification error test, respectively. Wald-S and Wald-L are the Wald tests for short-run asymmetry and long-run asymmetry, respectively.

With regard to interest rates, only $\Delta IR_{t-2}$ for the short-run has a statistically significant *t* statistic (two-sided *p*-value = 0.031), that is -0.293, suggesting that a higher interest rates decrease M&A activities in the short-run (Panel A). The estimated coefficient for the long-run is also negative (0.036), with $t = -0.633$. This is not significant and indicates that interest rates have little effect on M&A deals in the long-run. Although the estimated elasticities of rig count with respect to M&A for the short-run give mixed results, the magnitudes of negative coefficients ($\Delta RC_t$ and $\Delta RC_{t-2}$) dominate those of positive coefficients ($\Delta RC_{t-1}$ and $\Delta RC_{t-3}$). They are all statistically significant. The coefficient for the long-run is also significantly negative with $t = -1.065$. This finding suggests that an increase in rig count generally results in a decrease in M&A activities. This appears counterintuitive. One plausible possibility is that, since rig counts generally rise as a result of an internal growth such as increased exploration and productivity (E&P) activity rather than an external growth or M&A activities, increasing rig counts are likely to result in pushing M&A deals down. Finally, the estimated elasticities of oil price volatility with respect to M&A for the short-run also give mixed results. $\Delta V_t$ has a positive coefficient, while $\Delta V_{t-1}$ and $\Delta V_{t-2}$ have negative coefficients. However, $\Delta V_{t-1}$ and $\Delta V_{t-2}$ have statistically significant $t$ statistics, implying that price volatility has a detrimental effect on M&A. The estimated coefficient for the long-run, on the other hand, becomes positive (0.062) and the effect is statistically significant with a $t$ statistic of -2.853. Therefore, oil price volatility increases M&A activities in the long-run.

Before leaving this section, we demonstrate that, since all the series in Eq. (4) are cointegrated, the discussed estimation results do not suffer from the spurious regression problem. For this purpose, we calculate the $F$-statistic to test the null hypothesis that all the five variables have no effect on M&A activities. This is stated as $H_0$: $\theta_0=\theta_1=\theta_2=\theta_3=\theta_4=\theta_5=0$. We would reject the null and support cointegration if the computed value of the $F$-statistic exceeds the upper critical value given by Pesaran *et al*. (2001). In fact, our calculated $F$-statistics is 9.05. The 10% upper critical value is about 3.35, and so we soundly reject the null. Therefore, there is strong evidence of cointegration among the variables. Note that the error correction coefficient is negative (-0.794) and very significant ($t$ = -7.831), providing confirming evidence of cointegration (Banerjee *et al*., 1998). We also test serial correlation in the error term of Eq. (4) in order to detect dynamic misspecification and validate statistical testing (Panel C). Using the usual Lagrange Multiplier (LM) statistic, we obtain $LM$ = 2.448; in a chi-square distribution with four degrees of freedom, this yields a $p$-value = 0.654. Thus, we do not reject the null and there is little evidence of serial correlation in the residuals, so our model specification and statistical testing are well justified. The Ramsey's regression specification error test (RESET) statistic turns out to be 0.755; this is the value of a chi-square distribution with one degree of freedom and the associated $p$-value is 0.385. This is evidence of no functional form misspecification in Eq. (4). Finally, such stability tests as cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) reveal that our model performs very well (Figure 1).

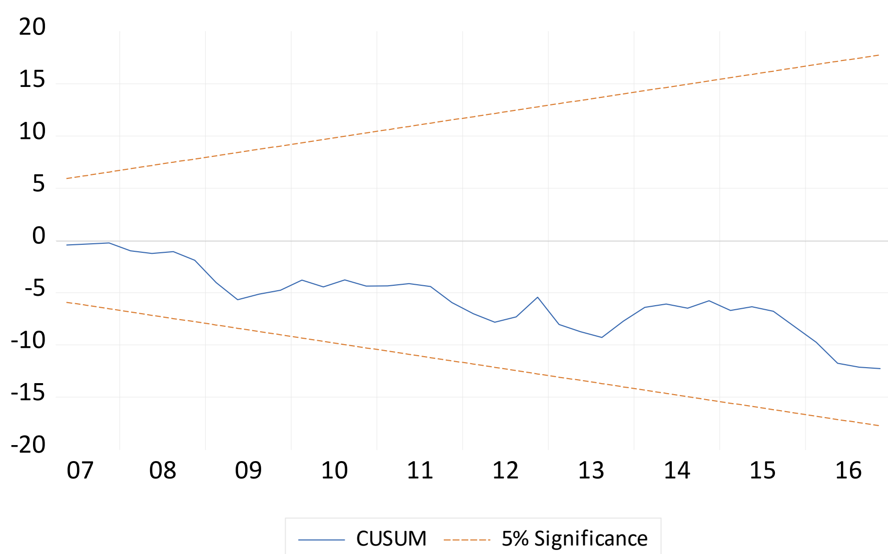


**Figure 1**. Plots of CUSUM and CUSUMSQ

(a) CUSUM

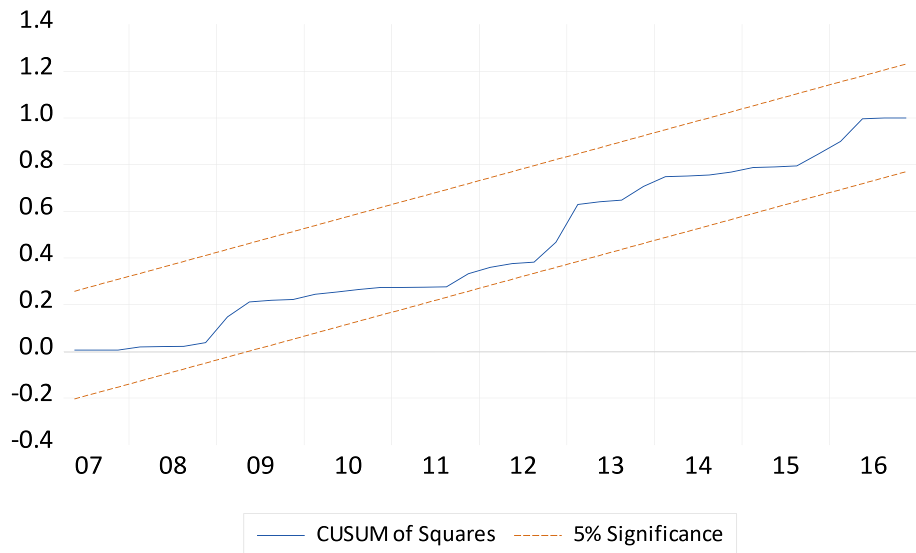


**Figure 1**. Plots of CUSUM and CUSUMSQ

(b) CUSUMSQ

## 4. Concluding Remarks

The focus of this article is to estimate the effect of oil price changes on oil and gas industry M&A activities in North America. The contribution of this article is to address the asymmetric M&A response to oil prices changes in our modeling process, using the nonlinear ARDL model. We find that changes in oil prices indeed have an asymmetric impact on oil and gas industry M&A activities in both the short- and long-run. That is, oil and gas industry M&A activities respond more to oil price declines than to hikes. When examining the oil price-M&A nexus, therefore, analysts need to incorporate the asymmetric effects of oil price changes; otherwise, the empirical models could give rise to biased estimation.

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## **Appendix:** Data sources, definition of variables, and descriptive statistics

**I. Sources:**

Quarterly data during the period 2001:Q1--2016:Q4 are collected from the following four sources:

a. Thomson One Banker Bloomberg.
b. U.S. Energy Information Administration (EIA).
c. Federal Reserve Bank of St. Louis.
d. Baker Hughes

**II. Definition of variables:**

$M\&A_t$ = M&A transactions proxied by the total deal count of upstream oil and gas M&A transactions in the U.S. and Canada. The data includes completed transactions by such the Standard Industrial Classification (SIC) codes as 1131 (crude petroleum and natural gas), 1321 (natural gas liquids), 1381 (drilling oil and gas wells) and 1382 (oil and gas field exploration services) (source a).

$OP_t$ = Crude oil prices proxied by the Western Texas Intermediate (WTI) (source b).

$IR_t$ = Interest rates proxied by the 3 month U.S. dollar (USD) LIBOR interest rate (source c).

$RC_t$ = Rig count (source d).

$V_t$ = Oil price volatility. It is measured as the standard deviation of the three monthly oil prices within each quarter.

**III. Descriptive statistics of the variables:**

| Variables \ Statistics | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|
| $M\&A_t$ | 73.20 | 22.97 | 30 | 128 |
| $OP_t$ | 64.53 | 27.58 | 20.50 | 123.78 |
| $IR_t$ | 1.80 | 1.78 | 0.23 | 5.44 |
| $RC_t$ | 1739.00 | 524.86 | 469.50 | 2573.70 |
| $V_t$ | 4.726 | 5.074 | 0.127 | 24.869 |