Oil Price Uncertainty and M&A Activity

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Oil price uncertainty and M&A activity[1]

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Abstract

This study examines the impact of oil price uncertainty on mergers and acquisition (M&A) activity in the oil and gas sector. Analyzing this industry enables us to construct a natural forward-looking measure of oil price uncertainty, namely the implied crude oil volatility. Using a sample of U.S. firms in the oil and gas sector from 1994-2018 containing 4,323 announced transactions, we document that oil price uncertainty is negatively related to future M&A activity. Uncertainty is mainly a driver of horizontal and vertical M&A activity, where upstream firms are more affected by this uncertainty than downstream firms. Our results lend support to a real options explanation of investment under uncertainty where firms choose to defer investments as a response to increased uncertainty.

Keywords: Energy economics, M&A, Corporate investment, Implied crude oil volatility, Oil and gas sector, Oil price uncertainty,

JEL Codes: D81, G34, Q40, Q43, Q49

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Oil price uncertainty and M&A activity

1. Introduction

What is the impact of uncertainty on firms' investment activities, more specifically mergers and acquisitions (M&A)? Recent studies highlight the impact of political (Nguyen and Phan, 2017; Bonaime et al., 2018; Chen et al., 2018; Lee, 2018; Cao et al., 2019), stock market (Bhagwat et al. 2016), regulatory (de Bodt et al. 2020), and cash flow uncertainty (Garfinkel and Hankins, 2011) on the level of M&A activity. In contrast to prior work, we investigate the impact of oil price uncertainty on M&A outcomes using the oil and gas sector as a laboratory. Studying oil price uncertainty in the oil and gas sector is appealing as the market price of inputs and outputs is fully observable and allows for a complete resolution of issues related to cross-industry heterogeneity.[6] The oil and gas sector is economically interesting to observe as the industry provides the foundation for investment decision-making under the conditions of risk and uncertainty (Macmillan, 2000; Kellogg, 2014).[7] Crude oil as a commodity is an output in upstream operations and an input in downstream operations. Consequently, this setting further allows us to examine the impact of both output and input price uncertainty on M&A activity.

The general theories of irreversible investment under uncertainty and real options offer heterogeneous predictions.[8] Incentives of rational agents observed in the irreversible choice theory under uncertainty can lead to a decline in investment activity (Bernanke, 1983; Zeira,

[6] Jin and Jorion (2006) point out that analyzing firms within one industry diminishes the endogeneity problem. Consequently, our attention is not to generalize obtained results on the impact of oil price uncertainty on M&A activity economy-wide, but with a sole focus on the oil and gas sector.
[7] Notable studies examining the impact of oil uncertainty on various investments in the energy sector are Elder and Serletis (2010), Kettunen et al. (2011), Rahman and Serletis (2011), Chronopoulos et al. (2016), Morris et al. (2018). Observing the full set of COMPUSTAT firms, Abdoh and Maghyereh (2020) examine the impact of oil uncertainty on corporate investment.
[8] Jurado et al. (2015) define uncertainty at a general level as the conditional volatility of a disturbance that is unforecastable from the perspective of economic agents.

1989; Dixit and Pindyck, 1994; Bloom, 2009; Lee et al., 2011; Carriero et al., 2018; Drobetz et al., 2018). On the contrary, uncertainty can lead to increasing levels of investment in perfect competition (Hartman, 1972; Abel, 1983; Caballero, 1991) and strategic competition (Kulatilaka and Perotti, 1998), for a class of low-risk, low-growth firms (Sarkar, 2000), and in individual industries (Mohn and Misund, 2009).

In general, uncertainty impacts firm investments and, ultimately, M&A activity via the real options and risk management channels. The real options literature is composed of two strands. The first strand relates to the time value of the option. The value of waiting to exercise the option increases with uncertainty and leads to the deferral of investments until information becomes more complete, e.g., Pindyck (1991) and Dixit et al. (1994). The second strand of the real options literature relates to compound options and opines that conducting investments not only sacrifices the value of waiting options but also results in the acquisition of future investment options. (See, e.g., Kulatilaka and Perotti (1998) and Smit and Trigeorgis (2004)).

The risk management motive emerges from two strands of literature. First, is the operational hedging literature (Hirshleifer, 1988; Penas and Unal, 2004), where firms hedge input price uncertainty by acquiring upstream producers. Second is the transaction cost literature (Williamson, 1971; Carlton, 1979), where firms can solve contracting problems that increase with uncertainty through vertical integration. Building on this, Garfinkel and Hankins (2011) document that increases in cash flow uncertainty induce vertical integration to hedge operational risk. Using M&A as a risk management tool can also explain the presence of diversifying acquisitions. Banal-Estanol and Ottaviani (2006) argue that firms in high uncertainty environments conduct diversifying transactions to share the risk. To conclude, the real options channel does not establish precise predictions. In contrast, the risk management channel postulates a positive relationship between uncertainty and M&A activity regarding vertical and diversifying transactions.

Our main hypothesis is that oil price uncertainty impacts M&A activity. However, this link is theoretically ambiguous; the real options framework provides both negative and positive predictions of the relationship. The risk management framework predicts a positive relationship between uncertainty and M&A activity for vertical and diversifying transactions, but not for horizontal. Hence, to establish the link between oil price uncertainty and M&A activity, we need to study the issue empirically. We employ the implied volatility on West Texas Intermediate (WTI) crude oil options as our oil price uncertainty measure. The advantage of using implied volatility is that it is a forward-looking measure of uncertainty (Alquist et al. 2013). Furthermore, we assume that oil price uncertainty is exogenous with respect to M&A activity in the oil and gas sector. Initially, we test the oil price uncertainty and M&A relationship using aggregated oil and gas industry data. Further, to confirm our findings, we utilize firm-level data to rule out the unobserved sector and market-wide drivers of M&A activity.

We test several additional hypotheses. First, we build a hypothesis on the asymmetric reaction to uncertainty between upstream and downstream participants. They differ primarily in one dimension; their sensitivity to crude oil prices (Kumar and Rabinovitch, 2013). Upstream producers engage in exploration and production, whereas downstream refiners focus on refining and marketing. Upstream producers sell their output on the physical market; thereby, their cash flows are highly correlated to the underlying commodity price. In contrast, downstream refiners see different dynamics since they can take advantage of the crack spread, which is the difference between the prices of refined products and the cost of crude oil as an input (Suenaga and Smith, 2011). This built-in margin allows downstream firms to transfer part of the price variation to their customers. Therefore, the economic impact of crude oil price uncertainty on M&A activity should differ between upstream and downstream firms. We repeat our analysis on a sample divided into upstream producers and downstream refiners to test for these differences. To further elaborate on the viability of the risk management motive, we partition our sample into horizontal, vertical, and diversifying transactions. In line with the risk management motive for M&A activity, we expect uncertainty to be positively related to the number of vertical and diversifying transactions but not for horizontal transactions.

Our analysis complements a relatively non-developed strand of financial literature on how uncertainty in the product market affects M&A activity. The product market and M&A literature are connected through an empirical study by Hoberg and Phillips (2010), building based on the theoretical model of Rhodes-Kropf and Robinson (2008), which states product market competition creates incentives to merge, especially when the target is producing complementary products.

The prior literature explores several sources of uncertainty on M&A activity yet neglects oil price uncertainty. Garfinkel and Hankins (2011) document that increases in cash flow uncertainty induce vertical integration and the start of merger waves. Duchin and Schmidt (2013) state that merger waves coincide with elevated uncertainty using expected stock return volatility as an uncertainty measure. Bhagwat et al. (2016) show that an increase in the market volatility index, The Chicago Board Options Exchange Volatility Index (VIX), decreases the deal activity and prolongs the time to deal completion. Nguyen and Phan (2017), Bonaime et al. (2018), Cao et al. (2019), and de Bodt et al. (2020), argue that either political or regulatory uncertainty decreases M&A activity.

Although to the best of our knowledge, there is no prior study examining the impact of crude oil price uncertainty on M&A activity, Henriques and Sadorsky (2011), Aye et al. (2014), Hsu et al. (2017), Phan et al. (2019) and Maghyereh and Abdoh (2020), come close. Henriques and Sadorsky (2011) examine the effect of crude oil price volatility on strategic investment decisions of U.S. firms. They report a U-shaped relationship between crude oil price volatility and the level of firms' investments. Kellogg (2014), who studies upstream producers, finds a negative relation between implied oil price volatility and investments. Aye et al. (2014) finds that oil price uncertainty negatively impacts manufacturing output. Hsu et al. (2017) report that crude oil prices and production levels in the oil and gas sector are the most critical factors determining M&A activity. Phan et al. (2019) report that uncertainty, measured as the standard deviation of daily returns of oil prices, negatively impacts corporate investment, defined as CAPEX scaled by lagged assets. Maghyereh and Abdoh (2020) show that uncertainty also negatively impacts corporate investments, although the impact is asymmetric and more significant after the prior positive price changes. Our study extends the above literature, examining not only how the uncertainty impacts the overall investment/M&A activity but also introduces a novel forward-looking measure of uncertainty to the literature, namely the implied volatility of crude oil options contracts.

Using a sample of firms in the U.S. oil and gas sector between 1994 and 2018, we report a negative relationship between oil price uncertainty and M&A activity. The economic effect is substantial; a one standard deviation decrease in the implied crude oil price volatility increases the sectors' quarterly deal count by 136%. Our results hold up after including other widely-used uncertainty measures, both at the industry and firm-level. This negative relationship between uncertainty and M&A activity rules out the risk management motive as the trigger for M&A transactions. Instead, our results are consistent with the view that uncertainty increases the value of the real option to wait (e.g., Pindyck, 1991; Dixit et al., 1994). In line with our expectations, upstream M&A activity is somewhat more sensitive to oil price uncertainty relative to downstream. The results are consistent with findings in Kellogg (2014) of a negative relation between implied oil price volatility and investments for upstream producers. We further report that our results are mainly driven by firms conducting horizontal and vertical M&A. Hence, even though we do not report a positive relationship between risk management motives and M&A activity, we find that diversifying M&A transactions are less sensitive to changes in oil price uncertainty.

After the above introduction, the rest of the paper has the following structure: part two discusses data sources used to construct our M&A sample and uncertainty measures; part three describes empirical approaches; part four elaborates on results, and part five presents the conclusion.

2. Data

This section describes our data selection processes, including M&A data, uncertainty measures, macro-level control variables, and firm-level data.

2.1. Oil and gas sector M&A data

We begin our data collection by considering all U.S. mergers and acquisitions (both private and public) in the Thomson Financial Securities Data Company (SDC) database beginning 1/1/1994 and ending 12/31/2018[9]. Following the data selection process used in the prior literature (Bonaime et al., 2018), we include acquisitions for which the acquirer owns less than 50% of the target's shares before the announcement and obtains 100% of the shares after the deal with minimum deal values above $1 million (in 2018 dollars). After applying our initial filtering, we end up with 70,089 potential transactions with an average deal value of $129.1 million.

- Insert Table 1-

Since our analysis is focused on examining acquisitions in the oil and gas sector, we include transactions with SIC codes given in Table 1[10]. After excluding all transactions where the acquirer does not meet our criteria, we arrive at 4,323 transactions with an average deal

[9] We begin our sample period in 1994 due to availability of the implied volatility measure.
[10] We begin our sample in 1994 due to the availability of data on traded options for our implied volatility calculations. Likewise, SDC data before 1992 lacks detailed coverage (Netter et al., 2011).

value of $170.6 million. Hence, oil and gas sector acquisitions are approximately 50% smaller than the average U.S. acquisition of $335 million, as reported in Bonaime et al. (2018).

In the first partition of the sample, we split the acquirers based on their position in the oil and gas sector into upstream or downstream transactions (our partitioning criteria is given in Panel A in Appendix Table A1). Out of the 4,323 transactions, 68.14% are conducted by upstream, and downstream acquirers conduct 31.86%. Furthermore, we divide the transactions into horizontal, vertical, and diversifying acquisitions. We classify a takeover as horizontal if both the acquirer and target are at the same partitioning level, both being an upstream or downstream firm. Vertical transactions are acquisitions where an upstream (downstream) firm acquirers a downstream (upstream) target. Diversifying transactions consist of acquisitions conducted outside the oil and gas sector. The majority of our sample contains horizontal acquisitions (54.6%), whereas vertical and diversifying acquisitions comprise 27.7% and 17.6%, respectively.

We calculate the number of acquisitions every quarter to avoid significant outliers due to the small proportion of transactions (4,323 out of 70,089) of the oil and gas sector acquisitions in relation to the total amount of acquisitions. Our calculation differs from related studies such as Bonaime et al. (2018) and Bhagwat et al. (2016), which aggregate the number of acquisitions on a monthly basis. To graphically illustrate the relationship of M&A activity and our uncertainty measure, and the division of the M&A sample we construct two figures reported in Appendix B. Figure 1, in Appendix B suggests that crude oil implied volatility and the total deal volume in the oil and gas sector is negatively correlated. The pattern is strongest in the period preceding the financial crisis. Figure 2 in Appendix B shows that upstream and downstream acquirers' acquisition patterns deviate over the sample period. The difference in the number of deals between upstream and downstream firms is especially noticeable in the earlier part of the sample.

2.2 Uncertainty Measures

We include three factors that control for various aspects of uncertainty. Our primary uncertainty measure is the implied volatility for West Texas Intermediate (WTI) crude oil contracts calculated based on *at the money second nearby options,* which is provided by the Commodity Research Group.[11] Bakanova (2010) documents how implied volatility as a measure of uncertainty outperforms historical volatility as a predictor of future realized volatility and properly aggregates all information contained in historical data. Kellogg (2014) report that implied volatility is a better predictor of greenfield investments in the upstream oil sector relative to historical volatility and volatility measures using GARCH models. The implied volatility measure is calculated using the Black and Scholes (1973) option pricing model modified for commodities. Once the front-month option expires, the options are rolled over into the second month. Implied volatility of the WTI crude oil contract is collected from the beginning of the calendar year 1994 and concluding with the end of the calendar year 2017.[12] We calculate the quarterly percentage change in implied volatility for our main regression specifications by using closing prices on the last day of the quarter.

Our second uncertainty measure controls for the overall market variation. We follow Bhagwat et al. (2016) and utilize the VIX. We use the closing price of the VIX on the last day of the quarter to calculate the percentage change during the quarter. The VIX data is retrieved from Wharton Research Data Services (WRDS).

As a final uncertainty measure, we control for political uncertainty by including the Baker et al. (2016) index. The data is retrieved from http://www.policyuncertainty.com/. In

[11] The data are kindly provided by James Colburn at Commodity Research Group http://www.commodityresearchgroup.com/

[12] As we use lagged independent variables, we only need to observe our volatility measure until the end of the calendar year 2017, one year shorter than M&A data.

short, the economic policy uncertainty index is constructed based on newspaper coverage of the most important media outlets in the U.S.[13]

2.3 Macro Level Controls

To conform to prior studies, we use identical macro-level controls as in Bhagwat et al. (2016) and similar to Bonaime et al. (2018). Our macro controls capture factors related to acquisitions not coming from oil price uncertainty. We include the cyclically-adjusted Price-Earnings Ratio (CAPE) retrieved from Robert Shiller's web page: www.econ.yale.edu/~shiller/data.htm, to control for the overall stock market price levels. The CAPE is defined as the current inflation-adjusted price level of the S&P500, scaled by the simple average of the inflated earnings on S&P500. To further capture changes in the overall stock market, we include the market return using the value-weighted (CRSP) index from the Center for Research in Security Prices. In order to capture the effect of industry-wide cash holdings on acquisitions, we include the percentage change in aggregated cash holdings held by firms in the oil and gas sector scaled by aggregated total assets based on quarterly reports in COMPUSTAT. We use the spread between AAA corporate bonds and the Federal funds rate to control for changes in capital availability. The spread is downloaded from the Federal Reserve Economic Data (FRED) at St. Louis. We use changes in the spread as a control variable in our analysis. Finally, to better capture the dynamics of the oil and gas sector's M&A activity, we include the return on the WTI as a control variable.

- Insert Table 1 -

We present our macro-level sample in Table 1. The average percentage change in quarterly acquisitions is 4.4%, which is slightly higher than the monthly charge of 1.1%, as

[13] In general, the index is used to estimate uncertainty about the three decision making aspects in the U.S. economy. The first aspect of the index is to assess overall uncertainty in the U.S economy. The second aspect is to assess what economic policy measures could be undertaken to respond to this uncertainty. The third aspect gauges the timing of economic policy actions. The index is updated frequently and is available over the entire study period.

reported in Bhagwat et al. (2016), with all other variables being close in magnitude. We further test for the stationarity of the times-series in all variables using an Augmented Dickey-Fuller (1979; 1981) test. The Dickey-Fuller test rejects the null hypothesis of a unit root in all variables. Panel B reports the correlations between the main independent variables. The implied oil volatility positively correlates with VIX (0.4239) and Political uncertainty (0.2105).

2.4 Firm-level data

In our second set of tests, we study the quarterly effect of crude oil price uncertainty at the firm-level. We include the full set of COMPUSTAT firms with the SIC codes defined in Appendix Table A1. We follow Bonaime et al. (2018) and use a binary variable taking the value of one if the firm has conducted an acquisition during the given quarter. All our independent variables are lagged by one quarter. In addition to the macro-level variables defined above, we include a set of independent firm-level variables. Market to book (M/B) represents the market value of equity minus book value of equity plus total assets scaled by total assets. We use earnings before interest, taxes, depreciation, and amortization (EBITDA) scaled by total assets as the profitability measure. Leverage is defined as long-term plus short-term debt scaled by total assets. Size is calculated as the natural logarithm of sales. We measure asset tangibility with the net value of property, plant, and equipment (PPE) scaled by total assets. We control for firm cash holdings by scaling cash holdings by total assets. We include a dividend-paying indicator variable taking the value one if the firm pays any cash dividends during the given quarter. We further control for lagged investments by scaling research and development (R&D) plus capital expenditure (CAPEX) by total assets. For R&D, we follow, e.g., Alti (2006), and replace missing values with zero. All our firm-level control variables are retrieved from COMPUSTAT. After excluding all firms with missing data, we end with a total of 1,675 firms and 46,176 firm-quarters, as reported in Table 2.

- Insert Table 2 -

Table 2 also provides firm-level descriptive statistics of variables at the quarterly level. All Acquisitions is an indicator variable taking the value of one if the firm conducts an acquisition during the observed quarter. Furthermore, we present basic statistics for other relevant firm characteristics: dividends payment, the degree of leverage, the level of cash-holdings, size in relation to sales, ROA (EBITDA/TA), investment (R&D + CAPEX)/TA, and PPE (PPE/TA). We report that the average quarterly acquisition likelihood is 1.5%, which is a comparatively lower level of acquisition activity than the 16.1% on an annual basis reported in Bonaime et al. (2018). The acquisition likelihood for the three types of acquisitions (horizontal, vertical, and diversifying) is 1.1%, 0.4%, and 0.3%, respectively.[14]

We compare high to low uncertainty quarters and the subsequent effect on M&A activity. Appendix Table A2 reports univariate tests on the relationship between implied volatility and M&A activity, where we sort the data into four quartiles, with the first quartile having the lowest uncertainty. Our sortings show that the acquisition volume is evenly distributed between the three quartiles with the lowest uncertainty. However, acquisition volume is significantly lower in the quartile consisting of the highest uncertainty. The economic difference is large, with approximately 30% more acquisitions being initiated during the lowest uncertainty quartile relative to the highest. Our univariate findings confirm our graphical evidence presented in Appendix B Figure 2. The results among upstream firms follow a similar pattern as in the full sample. Acquisition activity in the highest implied volatility quartile of upstream firms is significantly lower than for the other three quartiles. When studying downstream firms, we do not find any significant difference between the highest and the lowest uncertainty quartiles. We further report evidence that firms conduct more vertical transactions in the bottom uncertainty quartile. The univariate sortings confirm the results of Bhagwat et al.

[14] The reason the sum of the different acquisition types does not add up to 1.5%, is due to that a firm can conduct acquisitions of all three types during a given quarter. Meanwhile, a firm that conducts two horizontal acquisitions during a given quarter will still be coded as a one.

(2016), market-wide uncertainty study, which finds that the results are driven by the top quartile of uncertainty quarters.

3. Empirical design

To assess whether oil price uncertainty impacts corporate investment through changes in M&A volume, we perform two tests. The first test is conducted on an aggregated industry-level, and the second test is implemented on a firm-level.

In our first set of tests, we investigate the impact of crude oil price uncertainty on aggregate industry acquisitions. Our model aims to explain the percentage change in the number of acquisitions on a quarterly basis. To achieve this, all our independent variables have one quarterly lag relative to the dependent variable, as in Bhagwat et al. (2016). Our baseline Equation (1) is stated as below:

$$\%\,\Delta\, Acquisitions_t = \alpha + \beta_1 * \%\,\Delta\, Implied\ volatility_{t-1} + \boldsymbol{X}\delta + \varepsilon_t \tag{1}$$

Where *t,* the time index, is on a quarterly basis, and **X** is a matrix of macro-level control variables measured with one lag relative to the dependent variable. In our first specification, we test the univariate relation between implied crude oil volatility and the percentage change in the number of acquisitions. In the second specification, we include the macro-level controls. In the third specification, we further include year fixed-effects and clustering on quarter and year. We redo our tests for both different acquirer types (upstream and downstream) and three different acquisition types (horizontal, vertical, and diversifying).

In the second set of tests, we analyze the firm-level data and are mainly interested in the within-firm variation. Using panel data allows us to study the effect of oil price uncertainty levels on acquisition activity. By studying the within-firm variation, we observe the firm over time and control for time-invariant unobservable factors driving the acquisition likelihood. This is analogous to studying the firm-level time-series effect of the level of the crude oil price uncertainty on the acquisition likelihood (Pastor et al., 2017). Due to a large number of fixed effects included in our analysis, we estimate our models with a linear probability model (LPM) instead of Probit or Logit regression models (Angrist and Pischke, 2008).[15] Since we use quarterly data in our analysis, we cannot include year fixed-effects in our regressions. The year fixed-effects completely absorb the variation in the crude oil implied volatility measure. Hence, we estimate the following model on firm-level data:

$$Acquisition\ likelihood_t = \alpha_i + \beta_1 * Implied\ volatility_{t-1} + \boldsymbol{X}\delta + \boldsymbol{Z}\gamma + \varepsilon_t \qquad (2)$$

Where the time index, *t,* is quarterly, and *Acquisition likelihood* is a binary variable taking the value of one if the firm conducts at least one acquisition of the corresponding type during the given quarter. We use four different types of acquisition measures: All acquisitions, Horizontal Acquisitions, Vertical Acquisitions, and Diversifying Acquisitions. The macro controls matrix (**X**) includes the same set of macro variables used in Equation (1) plus the levels of Implied oil price volatility (VIX) and a measure of Political uncertainty following (Bhagwat, 2016). **Z** is a matrix of firm-level controls, as presented in the section 2.4 above.

4. Results

This study explores the link between oil price uncertainty and M&A activity. This section presents our empirical findings.

-Insert Table 3-

Table 3 reports the results obtained from the set of regressions based on Equation (1). Our main objective is to establish how changes in implied crude oil volatility (%Δ Oil Implied Volatility) affect the percentage change in the number of acquisitions (%Δ Acquisitions).

[15] Angrist and Pischke (2008) show that Logit and standard linear OLS or LPM provide similar estimates.

Column 1 in Table 3 reports baseline estimates of a univariate regression for the entire sample and shows a negative and statistically significant relationship between the change in implied crude oil price volatility and the change in the number of acquisitions (β= -0.2145, t= -2.146). As our independent and dependent variables are reported in percent changes, their coefficients can be interpreted as an elasticity. The reported economic magnitude is substantial: the elasticity between the crude oil price implied volatility and the change in the number of acquisitions is -0.2145. Our results are robust for the inclusion of control variables in column (2). We report similar results for upstream acquisitions in isolation (β= -0.2623, t= -2.892) in column (3) and (β= -0.3149, t= -3.420) in column (4) where the full set of control variables is included. The relationship between the percentage change in implied oil price volatility and the percentage change in downstream acquisitions is weaker. In the univariate setting in column (5) the relationship does not reach statistical significance (β= -0.1806, t= -1.036). When adding macro and industry controls in column (6), the impact of oil price uncertainty on acquisitions again becomes statistically significant (β=0.4915, t= -3.171). In columns (7) and (8), we study the impact of oil price uncertainty on horizontal acquisitions. Again the univariate relation does not reach statistical significance (β=-0.1861, t= -1.645). After the inclusion of the controls in column (8), we observe a negative effect of oil price uncertainty on horizontal acquisitions (β=-0.3173, t= -2.348). In columns (9) and (10) we study the oil price uncertainty impact on diversifying acquisitions and do not find and relation. Finally, the results in columns (11) and (12) show a negative relationship between changes in oil price uncertainty and vertical acquisitions. Among the controls, only lagged market return (+) and the change in the oil and gas sector's cash holdings (-) impact the change of acquisition volume in the time series.

- Insert Table 4 -

In Table 4, we study the implied volatility relationship on firm-level data by estimating Equation (2) using quarterly data. In columns (1) to (4), we examine the effect of the implied oil price volatility levels on acquisition likelihood. In columns (1) and (2), our firm-level evidence supports the results from the time-series analysis above, documenting that firms are less likely to conduct acquisitions during years of high crude oil price uncertainty. In columns (3) and (4), we add an interaction term between the implied oil price volatility and upstream firms.[16] The non-statistically significant interaction term suggests no substantial difference between upstream and downstream firms when observed on the firm level. In columns (5) to (6), we repeat our initial analysis and examine the impact of oil price uncertainty levels on the frequency of horizontal acquisitions. Our results suggest a weakly negative relationship between oil price uncertainty and the firm's likelihood of conducting at least one horizontal acquisition during the given quarter. We repeat the analysis on the subsample of vertical acquisitions and report results in columns (7) and (8). Finally, diversifying acquisitions' subsample results are presented in columns (9) and (10). Our findings suggest a negative impact of implied oil price volatility on both vertical and diversifying acquisitions in the multivariate cases (columns 8 and 10).

The reported results confirm our main hypothesis. An increase in oil price uncertainty decreases overall M&A activity in the oil and gas sector. The real options literature offers dual predictions on the role of uncertainty on M&A. Waiting time models predict a negative sign since the option value to defer investment increases with uncertainty (e.g., Pindyck, 1991; Dixit et al., 1994). Although, in some industry-specific cases, the investment offers additional strategic options embedded whose value increases with uncertainty. (See, e.g., Kulatilaka and Perotti, 1998; Smit and Trigeorgis, 2004). Focusing solely on the oil and gas sector reduces potential omitted variable bias problems. In addition, Mohn and Misund (2009) argue that both real option types are potentially present and important in the oil and gas sector, providing a

[16] Since we use firm level fixed effects the main effect of upstream becomes fully absorbed by the firm fixed effects.

good setting to empirically test the real options framework. We conclude that oil price uncertainty in the oil and gas sector reduces M&A activity through the real options channel. Our results support the view that real options value increases with uncertainty and consequently defers investments. In addition, oil price uncertainty has stronger explanatory power on overall M&A activity compared to political uncertainty (Bonaime et al., 2018) and the VIX (Bhagwat et al., 2016). Our main findings are robust, both in an aggregate industry and at a firm-level setting.

Concerning our additional hypotheses, we find that our results are principally driven by horizontal and vertical M&A. Meanwhile, diversifying M&As are less sensitive to changes in oil price uncertainty. Our findings reject the risk management hypothesis as a driver of vertical and diversifying M&A activity under uncertain times (Banal-Estanol and Ottaviani, 2006; Garfinkel and Hankins, 2011) in the oil and gas sector. However, diversifying acquisitions are less sensitive to changes in oil price uncertainty in the time-series. We further test for differences among upstream/downstream M&A sensitivity to oil price uncertainty and find mixed evidence. Our industry-level results are in line with our expectations, upstream firms are more sensitive to changes in uncertainty. In the firm level case we do not find any difference between upstream and downstream firms when including an interaction term between upstream and implied oil price volatility levels. When studying the effect of uncertainty on different types of acquisitions on the firm level we report mixed evidence. Horizontal acquisitions are affected by the level of oil price uncertainty in both specifications. Meanwhile, results for vertical and diversifying acquisitions differ in statistical power. We report a strong link between uncertainty and M&A activity when adding macro and firm-level controls for both vertical and diversifying acquisitions. One explanation for our findings is the presence of firm-level heterogeneity in financial constraints. We find that variables controlling for internal and external capital availability such as: ROA, dividend payer and the capital availability proxy (AAA-Fed funds spread) impact the vertical acquisition outcomes. We document similar impact by dividend payer and the AAA-Fed funds spread on diversifying acquisitions. Reported results are in line with findings in the prior literature that links investment sensitivity to financial constraints (e.g., Almeida et al., 2004, Fazzari et al., 1988; Harford, 1999; Harford, 2005); suggesting that diversifying and vertical acquisitions are more affected by financial constraints. Meanwhile, horizontal acquisitions are less sensitive to credit market conditions. Hence, our firm-level evidence is likely to be affected by capital supply that constrains firms from conducting all net present value positive M&A opportunities. Another interesting finding is that vertical and diversifying acquisitions are more affected by overall market uncertainty (VIX). Where a higher level of overall market uncertainty impacts firms propensity to conduct vertical and diversifying transactions to manage risk.

Prior literature on the oil and gas sector mainly focus on greenfield investments where new capacity is built, while we focus on M&A where existing capacity change ownership. Our study complements the work of Kellogg (2014) who reports a negative relation between oil price uncertainty and M&A activity.

4.1. Robustness tests and validity discussion

This study examines how oil price uncertainty affects M&A activity in the oil and gas sector. In our reduced-form estimations, we assume that implied oil price volatility is exogenous with respect to M&A activity. This is a strong assumption to make. Therefore, we take several steps to address this concern. Since endogeneity mainly arises from either reverse causality or confounding factors, we focus on the two. We first argue that reverse causality is a lesser problem since oil price uncertainty is not likely to be driven by M&A activity.[17] We have also

[17] It not likely that M&A activity affects oil price uncertainty. Outside of the scoop of this paper, several studies examine the drivers of oil price volatility (see, e.g., Barsky and Kilian, 2001; Barsky and Kilian, 2004; Pierru et al., 2018) and M&A is not considered to be a primary driver.

used lagged explanatory variables to have a more negligible impact on potential simultaneity and reverse causality. A greater concern relates to omitted variables in our main specifications. We try to address this problem in three ways. First, we have included a wide range of controls used in prior studies (e.g., Bhagwat et al., 2016) and added WTI return and political uncertainty in our estimations. Second, we test the robustness of our main findings on firm-level data. Using firm-level data allows the use of firm-level fixed effects that efficiently control for constant unobservable firm characteristics. Hence, only time-varying unobservable factors could potentially bias our findings following the inclusion of firm-level fixed effects. Third, even though we do not use excluded instruments in our analysis, we test for the severity of the potential omitted variable bias using the Oster (2019) methodology of coefficient stability.[18] We have conducted the Oster test in our main specifications (Column 2 of Table 3 and Column 2 of Table 4). Our results indicate that the beta coefficient estimates stay within negative bounds after using the Oster (2019) proposed R^2_{max} of 1.3*R^2 as the key input to the formula. The calculated estimations suggest that the observables are at least as informative as the non-observables in our models. Even though we include firm level fixed effects, add several control variables and examine the stability of the coefficients, it is plausible that oil price uncertainty is correlated with macro uncertainty not captured in our model.

In further robustness tests, we explore whether the results differ if we instead use raw changes in the number of acquisitions and implied oil volatility as an alternative to percentage changes. Our proposed mechanism is agnostic to how we measure M&A activity and implied oil volatility. To ensure the reader that our results are robust to different measures, we re-estimate our tests using raw differences and present them in Appendix Table A3. Our results

[18] The Oster (2019) test is widely used as a test of the coefficient stability in the economics literature (Acharya et al., 2019; Heimer et al., 2019; Ruhm, 2019)

remain unchanged in spite of how we measure changes in M&A activity and implied oil price volatility.

5. Conclusion

Extending the growing literature on the impact of uncertainty on M&A activity, this paper builds on the risk management and real options theories. It examines the impact of uncertainty in the product market. We concentrate our analysis to establish the impact of crude oil price uncertainty as measured by implied crude oil price volatility on the level of M&A activity in the oil and gas sector. Using a sample of U.S. firms in the oil and gas sector from 1994-2018 consisting of 4,323 announced transactions, we document that oil price uncertainty is negatively related to future M&A activity. Uncertainty is mainly a driver of horizontal and vertical M&A. Furthermore, we show that the output price uncertainty of upstream firms is somewhat a more important driver of M&A activity than the input price uncertainty of downstream firms. Our findings complement Kellogg's (2014) study, which reports that upstream producers exhibit a negative relation between implied oil price volatility and investments. In general, our results support the view that uncertainty increases the option value to wait and thereby deferring investments.

Stating the implications of our results, we are aware that the reported impact is not economy-wide (Edelstein and Kilian 2007; Kilian and Vigfusson, 2011; Baumeister and Kilian, 2016). Consequently, our findings are primarily addressing the relationship between uncertainty and M&A activity in the oil and gas sector. In addition, our measure of oil price uncertainty is averaged over one month; meanwhile, investments, in general, may have longer horizons. In that respect, our measure for capturing the relationship may not be perfect. However, as Alquist et al. (2013) point out, implied volatility is a better measure of oil price uncertainty relative to backward-looking measures such as GARCH and historical volatility. As final caveats, we treat the oil and gas sector as one market, although they may have their distinct characteristics and accordingly could be observed separately. Furthermore, regarding the underlying exogeneity assumptions of our estimations, it remains to be seen how much the apparent effect of the oil price uncertainty may reflect domestic or global macroeconomic uncertainty.

In sum, our findings regarding investment decisions under uncertainty in the oil and gas sector add to the general M&A literature (Bonaime et al., 2018; Bhagwat et al., 2016) and further provide guidance to the practitioners in the field.

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Table 1: Time-series averages

Panel A, reports averages of the time-series variables on quarterly level. % Δ in All Acquisitions is defined as the quarterly percentage change in the number of acquisitions. % Δ in Upstream and % Δ in Downstream is the quarterly percentage change in the number of upstream and downstream acquisitions. Upstream and downstream are defined as in Appendix Table A1. % Δ in Diversifying Acquisitions measures the percentage change in diversifying acquisitions (with a non-oil and gas sector SIC code). Vertical is defined as if a downstream (upstream) firm acquirers an upstream (downstream) firm. % Δ in Vertical Acquisitions measures the quarterly percentage change in vertical acquisitions. The main explanatory variable: (% Δ Oil Implied Volatility) is defined as the percentage change in implied WTI crude oil price volatility. Our covariates are defined as: quarterly percentage change in VIX: (% Δ VIX); quarterly percentage change in Baker et al.'s (2015) political uncertainty (% Δ Political Uncertainty); quarterly change in AAA-fed funds spread (Δ AAA-Fed Funds Spread); quarterly change in aggregated cash holdings (Δ Cash Holdings); quarterly change Robert Shiller's PE ratio (Δ Shiller P/E); quarterly return on the CRSP index (CRSP Return); quarterly WTI oil price return (Oil Price Return). Panel B reports the correlations between the independent variables used in the time-series estimations. The table further shows augmented Dickey-Fuller (1979) tests of stationarity, where the critical values for Dickey-Fuller test are the following: -3.518 (1%), -2.895 (5%) and -2.582 (10% significance).

Panel A

Variable	N	Mean	Std. Dev	Min	Max	ADF-test
% Δ in All Acquisitions	95	0.044	0.32	-0.582	1.4	-14.606***
% Δ in Upstream Acquisitions	95	0.047	0.342	-0.571	1.385	-14.138***
% Δ in Downstream Acquisitions	95	0.163	0.664	-0.773	3	-14.122***
% Δ in Horizontal Acquisitions	95	0.053	0.360	-0.571	1.8	-13.883***
% Δ in Vertical Acquisitions	92	0.119	0.571	-0.737	2.8	-14.138***
% Δ in Diversifying Acquisitions	95	0.34	1.409	-0.857	10	-12.050***
% Δ Oil Implied Volatility	95	0.032	0.284	-0.51	1.325	-10.460***
% Δ VIX	95	0.032	0.315	-0.455	1.6	-12.898***
% Δ Political Uncertainty	95	0.034	0.271	-0.509	1.177	-14.894***
Δ AAA-Fed Funds Spread	95	-0.02	0.517	-1.13	1.65	-6.654***
Δ Cash Holdings	95	0.002	0.37	-1.622	1.092	-30.409***
Δ Shiller P/E	95	0.007	0.073	-0.245	0.23	-8.240***
CRSP Return	95	0.009	0.04	-0.102	0.096	-7.695***
Oil Price Return	95	0.002	0.11	-0.369	0.36	-8.204***

Panel B

	% Δ Oil Implied Volatility	% Δ VIX	% Δ Political Uncertainty	Δ AAA-Fed funds spread	Δ Cash Holdings	Δ Shiller P/E	CRSP Return	Oil Price Return
% Δ Oil Implied Volatility	1							
% Δ VIX	0.4239	1						
% Δ Political Uncertainty	0.2105	0.5055	1					
Δ AAA-Fed Funds Spread	0.0294	-0.0588	-0.0431	1				
Δ Cash Holdings	-0.0118	-0.1156	0.1472	-0.0478	1			
Δ Shiller P/E	-0.2686	-0.5383	-0.4825	-0.1394	0.0409	1		
CRSP return	-0.2055	-0.4283	-0.2164	-0.1050	0.0122	0.3935	1	
Oil Price Return	-0.2637	-0.0648	-0.1776	0.0107	-0.2032	0.2092	0.1765	1

Table 2: Firm-level descriptive statistics

This table reports firm-level descriptive statistics on the quarterly level. ACQ is an indicator variable taking the value of one if the firm conducts an acquisition during the given quarter. Horizontal ACQ is an indicator variable taking the value of one if the firm conducts at least one horizontal acquisition occurred during the given quarter. Vertical ACQ is an indicator variable taking the value of one if the firm conducts at least one vertical acquisition during the given quarter. Diversifying ACQ is an indicator variable taking the value of one if the firm conducts at least one diversifying acquisition during the given quarter. The Dividend Payer indicator is a binary variable taking the value of one if the firm pays a cash dividend during the given quarter. Leverage is defined as long term plus short-term debt scaled by total assets. Cash holdings is cash holdings scaled by total assets. Size is defined as the natural logarithm of sales. ROA is EBITDA scaled by total assets. Investment is (R&D+CAPEX)/TA defined as research and development expenditures plus capital expenditures scaled by total assets. PPE is property plant and equipment scaled by total assets.

Variable	N	Mean	Std. Dev.	Min	Max
All Acquisitions	46,176	0.015	0.123	0.000	1.000
Horizontal Acquisitions	46,176	0.011	0.106	0.000	1.000
Vertical Acquisitions	46,176	0.004	0.063	0.000	1.000
Diversifying Acquisitions	46,176	0.003	0.050	0.000	1.000
Dividend payer	46,176	0.416	0.493	0.000	1.000
Leverage	46,176	0.216	0.206	0.000	1.012
Cash holdings	46,176	0.086	0.149	0.000	0.973
Size	46,176	4.204	3.189	-4.423	11.016
ROA	46,176	0.010	0.466	-6.010	0.841
Investment	46,176	0.100	0.118	0.000	0.630
PPE	46,176	0.664	0.250	0.000	0.978

Table 3: Time-series evidence at the quarterly level

This table reports time-series regressions where the dependent variable is the percentage change in the number of acquisitions at the quarterly level. We use six different classifications of our dependent variable: % Δ in All Acquisitions, % Δ in Upstream Acquisitions, % Δ in Downstream Acquisitions, % Δ in Horizontal Acquisitions, % Δ in Diversifying Acquisitions, and % Δ in Vertical Acquisitions. In each classification, the first column reports univariate regression results where the independent variable is quarterly % Δ Oil Implied Volatility (the quarterly percentage change in implied crude oil volatility). The second column in each classification report regression results, including control variables. All independent variables are lagged by one quarter. The control variables include: quarterly percentage change in VIX: (% Δ VIX); quarterly percentage change in political uncertainty (% Δ Political Uncertainty); quarterly change in AAA-fed funds spread (Δ AAA-Fed Funds Spread); quarterly change in aggregated cash holdings (Δ Cash Holdings); quarterly change in Robert Shiller's P/E ratio (Δ Shiller P/E); quarterly return on the CRSP index (CRSP Return); quarterly WTI oil price return (Oil Price Return). We use Newey West (1987) standard errors with 4 lags based on the rule of thumb T^(1/4) (Wooldridge, 2012). The Newey-West t-stats are reported in brackets. ***, **, * denotes 1%, 5%, 10% significance, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	%Δ All Acquisitions		%Δ Upstream		%Δ Downstream		%Δ Horizontal		%Δ Diversifying		%Δ Vertical	
%Δ Oil Implied Volatility	-0.2145**	-0.3400***	-0.2623***	-0.3149***	-0.1806	-0.4915***	-0.1861	-0.3173**	-0.3610	-0.3900	-0.3777**	-0.4692***
	(-2.146)	(-3.954)	(-2.892)	(-3.420)	(-1.036)	(-3.171)	(-1.645)	(-2.348)	(-0.792)	(-1.051)	(-2.003)	(-2.639)
%Δ VIX		0.2308		-0.0117		0.7741***		0.2090		0.1289		0.3146
		(1.630)		(-0.068)		(3.474)		(1.091)		(0.247)		(1.198)
%Δ Political Uncertainty		-0.0783		0.0709		-0.3970		-0.0799		-0.5758		-0.1601
		(-0.429)		(0.381)		(-1.631)		(-0.412)		(-0.990)		(-0.544)
Δ AAA-Fed Funds Spread		0.0319		-0.0294		0.2490		0.0131		-0.0641		0.0480
		(0.686)		(-0.521)		(1.527)		(0.259)		(-0.293)		(0.455)
Δ Cash Holdings		-0.1376**		-0.1755*		-0.1524		-0.1360*		-0.4062		-0.1133
		(-2.399)		(-1.929)		(-1.093)		(-1.696)		(-1.217)		(-0.745)
Δ Shiller P/E		-1.0321**		-1.0370***		-0.6437		-1.3610**		-0.5133		-0.1800
		(-2.494)		(-2.650)		(-0.662)		(-2.541)		(-0.261)		(-0.197)
Lagged CRSP Return		2.6774**		2.0940*		3.7110**		2.4068*		4.2487**		3.4905***
		(2.492)		(1.855)		(2.317)		(1.694)		(2.180)		(2.815)
Lagged Oil Price Return		-0.3553		-0.3336		-0.7181		-0.2282		-1.7212		-0.5902
		(-1.554)		(-1.295)		(-1.476)		(-0.916)		(-1.308)		(-1.221)
Constant	0.0476***	0.0316	0.0535***	0.0415**	0.1620***	0.1391***	0.0551***	0.0441*	0.3540***	0.3375***	0.1310***	0.1017***
	(2.640)	(1.647)	(2.663)	(2.040)	(4.211)	(2.795)	(2.631)	(1.961)	(2.798)	(2.663)	(3.610)	(2.662)
Observations	94	94	94	94	94	94	94	94	94	94	94	94
Newey West	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags

Table 4: Firm-level evidence at the quarterly level

This table reports regressions using the acquisition likelihood on quarterly level as dependent variable. The estimations use four different acquisition likelihood measures as dependent variables. Columns (1 to 4) use the likelihood of any acquisition to take place during the given quarter (All Acquisitions). Horizontal (columns 5-6), Vertical (columns 7-8) and Diversifying (columns 9-10) represents horizontal, vertical and diversifying acquisition likelihood. All models include firm level fixed effects. Columns (1, 5, and 9) only include the level of Oil implied volatility as the independent variable. Column (3) includes further includes an interaction term between upstream and oil implied volatility (the main effect of upstream is absorbed by the fixed effects). Upstream is an indicator taking the value of one if the firm is classified as upstream according to the definition in Appendix Table A1. Columns (2, 4, 6, 8 and 10) further include macro and firm level controls (CRSP return, level of Shiller P/E, Oil Price Return, level of Political Uncertainty, level of VIX, AAA-Fed Funds Spread, Dividend Payer, Leverage, Cash Holdings, Size, ROA, Investment). All models cluster standard errors at the firm and quarterly level. Cluster robust t-stats are reported in brackets. ***, **, * denotes 1%, 5%, 10% significance, respectively.

	(1) All Acquisitions	(2) All Acquisitions	(3) All Acquisitions	(4) All Acquisitions	(5) Horizontal Acquisitions	(6) Horizontal Acquisitions	(7) Vertical Acquisitions	(8) Vertical Acquisitions	(9) Diversifying Acquisitions	(10) Diversifying Acquisitions
Oil Implied Volatility	-0.0001**	-0.0002***	-0.0000	-0.0001	-0.0001*	-0.0001*	-0.0000	-0.0001**	-0.0000	-0.0001***
	(-2.313)	(-2.819)	(-0.611)	(-1.434)	(-1.990)	(-1.862)	(-0.524)	(-2.201)	(-1.294)	(-3.078)
Upstream x Oil Implied Volatility			-0.0001	-0.0001						
			(-0.823)	(-0.894)						
CRSP Return		-0.0027		-0.0026		-0.0027		0.0001		-0.0019
		(-0.591)		(-0.578)		(-0.694)		(0.023)		(-0.984)
P/E Shiller		0.0000		0.0000		-0.0000		0.0000		0.0000
		(0.170)		(0.175)		(-0.113)		(0.435)		(0.520)
Oil Price Return		0.0008		0.0008		0.0013		-0.0004		0.0002
		(0.487)		(0.476)		(0.841)		(-0.499)		(0.271)
Political Uncertainty		-0.0000**		-0.0000**		-0.0001***		0.0000		0.0000
		(-2.142)		(-2.132)		(-3.260)		(1.293)		(0.909)
VIX		0.0003**		0.0003**		0.0001		0.0002***		0.0002***
		(2.366)		(2.363)		(0.709)		(3.033)		(2.855)
AAA-Fed Funds Spread		-0.0005		-0.0005		0.0002		-0.0007***		-0.0006***
		(-1.116)		(-1.117)		(0.459)		(-3.162)		(-3.023)
Dividend Payer		-0.0016		-0.0016		-0.0038*		0.0022**		0.0018**
		(-0.757)		(-0.765)		(-1.888)		(2.365)		(2.383)
Leverage		0.0032		0.0032		0.0053		-0.0021		-0.0016
		(0.670)		(0.660)		(1.255)		(-0.989)		(-0.946)
Cash Holdings		0.0010		0.0010		-0.0008		0.0018		0.0023

		(0.162)		(0.157)		(-0.155)		(0.470)		(0.689)
Size		-0.0005		-0.0005		-0.0000		-0.0004		-0.0004
		(-0.700)		(-0.698)		(-0.079)		(-1.239)		(-1.568)
ROA		0.0003		0.0003		-0.0001		0.0004*		0.0003
		(0.226)		(0.211)		(-0.073)		(1.699)		(1.558)
Investment		0.0218***		0.0219***		0.0196***		0.0022		0.0007
		(3.428)		(3.442)		(3.323)		(0.923)		(0.369)
PPE		-0.0099*		-0.0100*		-0.0042		-0.0057		-0.0028
		(-1.782)		(-1.788)		(-1.118)		(-1.426)		(-1.222)
Constant	0.0189***	0.0291***	0.0189***	0.0291***	0.0144***	0.0214***	0.0045***	0.0076*	0.0033***	0.0058*
	(12.389)	(3.945)	(12.398)	(3.945)	(7.657)	(3.526)	(4.826)	(1.750)	(5.385)	(1.656)
Observations	46,093	46,093	46,093	46,093	46,093	46,093	46,093	46,093	46,093	46,093
R-squared	0.072	0.073	0.072	0.073	0.067	0.068	0.052	0.053	0.049	0.049
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Appendix A Table A1: Industry classification and sample selection

This table shows the industry classification and the deal type distribution. Panel A reports the classification between upstream and downstream firms based on their subsector SIC codes. Panel B reports the distribution of deal types in our sample. Horizontal transactions are defined when an upstream (downstream) firm acquires an upstream (downstream) firm. Vertical transactions are defined when an upstream (downstream) firm acquires a downstream (upstream) firm and vice versa. Diversifying deals are defined as transactions outside the oil and gas sector.

Panel A

Industry	SIC Codes
Upstream	
Crude petroleum and natural gas	1311
Natural gas liquids	1321
Drilling oil and gas wells	1381
Oil and gas exploration services	1382
Oil and gas field services, nec	1389
Downstream	
Petroleum refining	2911
Misc. products of petroleum and coal	2990
Lubricating oils and greases	2992
Oil and gas field machinery	3533
Crude petroleum pipelines	4612
Refined petroleum pipelines	4613
Pipelines, nec	4619
Natural gas transmission	4922
Gas transmission and distribution	4923
Natural gas distribution	4924
Gas production and/or distribution	4925
Petroleum bulk stations and terminals	5171
Petroleum products, nec	5172
Gasoline service stations	5541
Fuel oil dealers	5983
Oil royalty traders	6792

Panel B

Type	All	Upstream	Downstream
Horizontal	2,660	2,401	259
Vertical	900	176	724
Diversifying	763	369	394
Total	4,323	2,946	1,377

Appendix A Table A2: Implied volatility and M&A

This table reports the sorting of the quarterly number of acquisitions divided into implied crude oil volatility quartiles where the low (high) implied volatility contains the lowest (highest) implied volatility quarters. The table contains five different deal types: total, upstream, downstream, diversifying, and vertical number of acquisitions. ***, **,* denotes 1%, 5%, 10% significance, respectively.

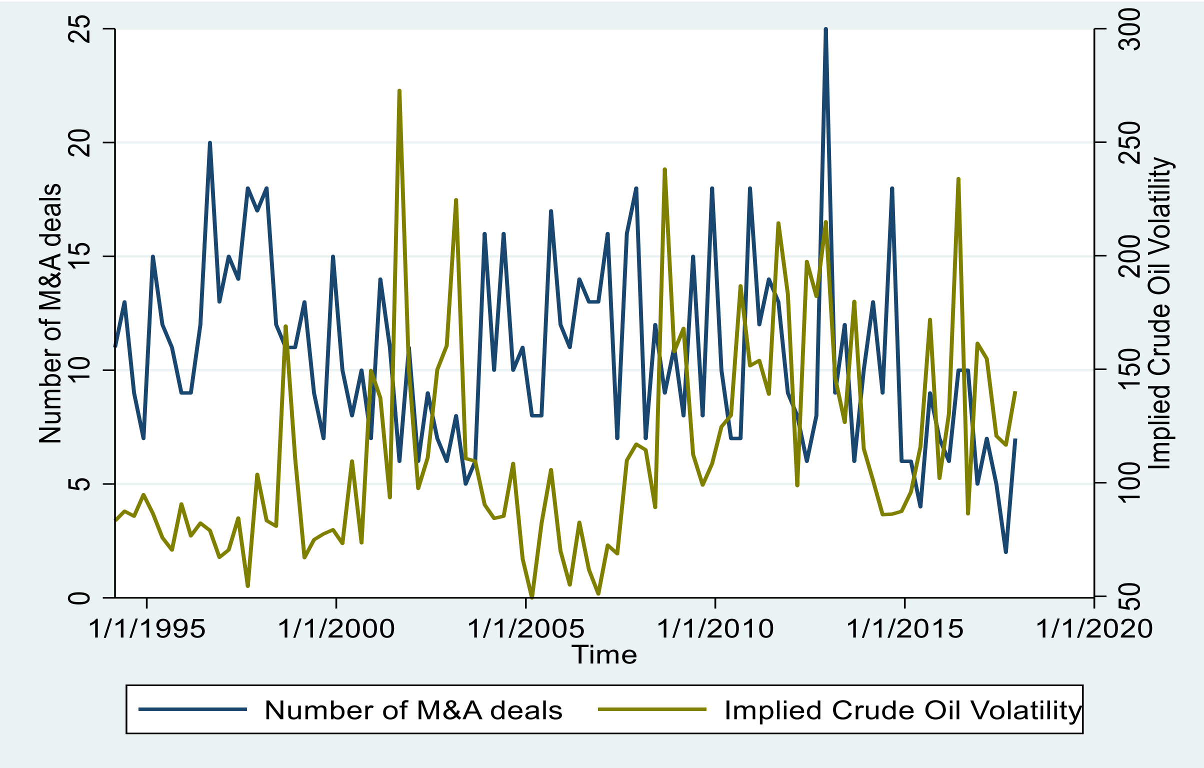
	Total All Acquisitions	Upstream	Downstream	Diversifying	Vertical
Low implied volatility	36.43	25.78	10.65	6.04	9.48
2	35.46	23.79	11.67	6.92	10.29
3	35.67	25.08	10.58	6.54	9.29
High implied volatility	28.08	18.13	9.96	5.08	7.67
Difference (low-high)	8.35***	7.66***	0.69	0.96	1.81*

Appendix A Table A3: Time-series regressions using first differences

This table reports time-series regressions where the dependent variable is the percentage change in the number of acquisitions at the quarterly level. We use six different classifications of our dependent variable: Δ in All Acquisitions, Δ in Upstream Acquisitions, Δ in Downstream Acquisitions, Δ in Horizontal Acquisitions, Δ in Diversifying Acquisitions, and % Δ in Vertical Acquisitions. In each classification, the first column reports univariate regression results where the independent variable is quarterly Δ Oil Implied Volatility (the quarterly change in implied crude oil volatility). The second column in each classification report regression results, including control variables. All independent variables are lagged by one quarter. The control variables include: quarterly change in VIX: (Δ VIX); quarterly change in political uncertainty (Δ Political Uncertainty); quarterly change in AAA-fed funds spread (Δ AAA-Fed Funds Spread); quarterly change in aggregated cash holdings (Δ Cash Holdings); quarterly change in Robert Shiller's P/E ratio (Δ Shiller P/E); quarterly return on the CRSP index (CRSP Return); quarterly WTI oil price return (Oil Price Return). We use Newey West (1987) standard errors with 4 lags based on the rule of thumb T^(1/4) (Wooldridge, 2012). The Newey-West t-stats are reported in brackets. ***, **, * denotes 1%, 5%, 10% significance, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Δ All Acquisitions		Δ Upstream		Δ Downstream		Δ Horizontal		Δ Diversifying		Δ Vertical	
Δ Oil Implied Volatility	-0.2145**	-0.3400***	-0.2623***	-0.3149***	-0.1806	-0.4915***	-0.1861	-0.3173**	-0.3610	-0.3900	-0.3777**	-0.4692***
	(-2.146)	(-3.954)	(-2.892)	(-3.420)	(-1.036)	(-3.171)	(-1.645)	(-2.348)	(-0.792)	(-1.051)	(-2.003)	(-2.639)
Δ VIX		0.2308		-0.0117		0.7741***		0.2090		0.1289		0.3146
		(1.630)		(-0.068)		(3.474)		(1.091)		(0.247)		(1.198)
Δ Political Uncertainty		-0.0783		0.0709		-0.3970		-0.0799		-0.5758		-0.1601
		(-0.429)		(0.381)		(-1.631)		(-0.412)		(-0.990)		(-0.544)
Δ AAA-Fed Funds Spread		0.0319		-0.0294		0.2490		0.0131		-0.0641		0.0480
		(0.686)		(-0.521)		(1.527)		(0.259)		(-0.293)		(0.455)
Δ Cash Holdings		-0.1376**		-0.1755*		-0.1524		-0.1360*		-0.4062		-0.1133
		(-2.399)		(-1.929)		(-1.093)		(-1.696)		(-1.217)		(-0.745)
Δ Shiller P/E		-1.0321**		-1.0370***		-0.6437		-1.3610**		-0.5133		-0.1800
		(-2.494)		(-2.650)		(-0.662)		(-2.541)		(-0.261)		(-0.197)
Lagged CRSP Return		2.6774**		2.0940*		3.7110**		2.4068*		4.2487**		3.4905***
		(2.492)		(1.855)		(2.317)		(1.694)		(2.180)		(2.815)
Lagged Oil Price Return		-0.3553		-0.3336		-0.7181		-0.2282		-1.7212		-0.5902
		(-1.554)		(-1.295)		(-1.476)		(-0.916)		(-1.308)		(-1.221)
Constant	0.0476***	0.0316	0.0535***	0.0415**	0.1620***	0.1391***	0.0551***	0.0441*	0.3540***	0.3375***	0.1310***	0.1017***
	(2.640)	(1.647)	(2.663)	(2.040)	(4.211)	(2.795)	(2.631)	(1.961)	(2.798)	(2.663)	(3.610)	(2.662)
Observations	94	94	94	94	94	94	94	94	94	94	94	94
Newey West	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags	4 lags

Appendix B : Figure 1: Total number of deals and implied crude oil volatility



Appendix B Figure 2: Number of upstream and downstream deals