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THE EFFECT OF OIL PRICE CHANGES ON CORPORATE INVESTMENT IN THE US: THE ROLE OF ASYMMETRIES

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Abstract:
This paper investigates the influence of oil price changes on corporate investment in the US using a large sample of 15,411 companies from 1984 to 2017. It adds to the literature by showing an asymmetric response of capital investments to oil price changes for non-oil companies. Particularly, positive oil price changes have a larger adverse impact on investments than the positive impact created by negative oil price changes. These results are important in assessing the impact of energy price fluctuations on the long-term investment decisions of US companies.

Keywords: Oil price; Corporate investment; U.S. firm; Asymmetry

JEL classification: G3, G32, Q4, Q41

1. Introduction

Oil-related products (e.g. gasoline) represent an important input that firms use for their operation. In fact, the profitability of oil-producing companies is more influenced by oil price changes than to oil-consuming company, since the latter is impacted by a range of other factors including oil price changes (Phan et al., 2015). Therefore, changes in oil prices may disrupt the critical decisions made by the company including the investment decisions because most investment expenditures are at least partly irreversible, that is, there is a cost of reducing capital if there is an unfavorable change in oil price. As a result, oil price changes carry serious implications on capital profitability and thus on investment decisions.[1] In addition, capital investment determines the growth prospects of the aggregate economy through capital accumulation. In the US market, which constitutes the sample of our study, the gross private domestic investment, including investment in plants, machinery, and equipment, accounted for around 18.1% of GDP in 2018 (Economic Report of the President, 2019, Table B-4).

[1] Changes in oil price can affect the demand for company output. For example, the household disposable income decreases with higher cost for energy consumption. This in turn may reduce the sales and thus the profitability of the company. Edelstein and Kilian, 2007; Hamilton, 2009 and Kilian, 2009 noted that energy price shocks are associated with lower consumer spending.

Oil price fluctuations may not only affect investments directly through their effect on company profitability but also may introduce uncertainty regarding future oil prices, causing firms to postpone growth plans and expansion decisions (Bernanke, 1983; Pindyck, 1991; Pindyck and Rotemberg, 1983). Other studies conclude that the influence on investment is negative and investment is less responsive to sales growth when oil price uncertainty is high (Elder and Serletis, 2010; Henriques and Sadorsky, 2011; Mohn and Misund, 2009; Ratti et al., 2011; Sadath and Acharya, 2015; Sadorsky, 2011; Uri, 1980; Wang et al., 2017; Yoon and Ratti, 2011).

Kellogg (2014) finds that drilling activity slows down during periods of high oil price volatility. Empirical proof of the positive influence of uncertainty is also provided by Henriques and Sadorsky (2011), who find a U-shaped relationship between oil company investments and oil price uncertainty. Recently, Phan et al. (2019) and Maghyereh and Abdoh (2020) show that crude oil price uncertainty negatively influences corporate investment. Sadath and Acharya (2015) document a negative relationship between energy prices and corporate investment in the Indian manufacturing sector, while Wang et al. (2017) find that oil price uncertainty has a negative impact on corporate investment expenditure in China, especially for non-state-owned listed companies. Loria (2017) finds that, while a small oil price increase leads to a decline in U.S. nonresidential fixed investment, the effect of a large oil price increase is ambiguous. However, Çakır Melek et al. (2017), Çakır Melek (2018), and Bjørnland and Zhulanova (2019) show that the response of U.S. investment to oil price shocks has changed following the shale boom in mid-2016. Specifically, they find that U.S. investment has become more responsive to demand shocks and less responsive to oil supply shocks. They argue that higher oil prices make oil businesses more profitable, which allows them to increase both production and investment. Similarly, Gilje et al. (2016), Feyrer et al. (2017), and Allcott and Keniston (2018) examine the local implications of the shale boom and find strong positive spillovers for employment and wages.

In all these studies, the influence of oil on investment is assumed to be symmetric and corporate capital expenditure sensitivity does not differentiate between the impact of positive and negative oil price changes. However, this distinction is important, as the differentiation allows for more accurate predictions and modeling of the reaction of corporate investment to oil price changes and uncertainty. In the literature, the analysis of asymmetry focuses on aggregate macroeconomic and stock markets, with no evidence on whether company investments respond differently to oil price increases and decreases. For example, Mork (1989) identifies asymmetry in the response of output to oil price shocks. An increase in oil price influences economic growth by a higher degree than a decrease in the oil price. Similar findings have been reported by Cologni and Manera (2009), Hamilton (2003), Lardic and Mignon (2008), Zhang (2008), and Awartani et al. (2020). The reaction of stock returns to oil prices is also found to be symmetric by Maghyereh and Al-Kandari (2006), Bachmeier (2008), Nandha and Faff (2008), and Maghyereh and Awartani (2016). Therefore, the main contribution of this paper lies in identifying the potential asymmetry in the response of the investments of US corporations to oil price changes. To the best of our knowledge, this analysis has not been yet conducted in the related empirical literature.

The nature of the influence of oil price changes on investment differs across firms in different industries. Oil-producing firms are expected to benefit from oil price hikes and therefore invest more following the increase in oil prices. The investment decisions of oil companies under oil price uncertainty has been modeled and studied by many researchers. Hurn and Wright (1994); Favero et al. (1994) note that expected oil prices and their uncertainty are important determinants along with geological factors of the development decision of oil corporations.[2] Berntsen et al. (2018) indicate that the price of oil can only influence the investment and development of oil wells in Norway. Baqaee and Farhi (2017) and Çakır Melek (2018) find that negative oil shocks can have larger effects on the fixed investments of oil and gas companies than those of non-oil and gas companies. As the influence of oil price changes is different for oil companies, we use a sample of only oil and gas companies and another sample for all other companies.

Our empirical results show significant asymmetry in the investment reaction of non-oil and gas companies to oil price changes. Particularly, the decrease in investments following oil price increase is higher than the increase in investments following oil price decrease. This indicates that positive changes in oil prices have a more determinantal impact on investments. This asymmetric investment response to oil price changes provides a further explanation for the asymmetry in the response of output to oil price shocks documented by Mork (1989) and others.[3] On the other hand, oil and gas companies' investments respond symmetrically to oil price changes where capital spending has the same sensitivity to positive and negative oil price shocks. Perhaps, the long-term nature, persistency, and irreversibility of these companies' investments make them less sensitive to the annual changes in oil prices.

The rest of the paper is organized as follows. In section 2, we describe the dataset and the model. The analysis of the empirical results is presented in Section 3. Finally, Section 4 draws concluding remarks.

2. Data and Methodology

The sample includes all companies listed on three US exchanges: the NYSE, AMEX, and NASDAQ. The annual financial data of all companies are collected o from 1984 to 2017 from the Compustat database. From the original dataset, we excluded finance, insurance, real estate, not-for-profit organizations, and governmental companies due to the specific nature of their activity.[4] All firms with missing data, with less than five years of data, or that belong to an industry not classified are also excluded from the sample. To alleviate the impact of outliers, we winsorized all firm-level variables at the 1st and 99th percentiles. The final sample consists of 15,411 firms, which sum up to 135,353 firm-year observations.

The daily West Texas Intermediate (WTI) closing crude oil price is used and retrieved from the US Energy Information Agency. Finally, annual real GDP growth data of the US is obtained from the Federal Reserve Bank of St. Louis.

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[2] Investment in oil companies includes three stages: exploration, development, and extraction. There is always the option not to develop and postpone investment. Note that development investments are irreversible and are carried over a period that may extend to 10 years.

[3] In the literature, the asymmetry in the response of output is explained by reallocation, uncertainty and unemployment uncertainty, and monetary policy effects. See Hamilton (1988), Bernanke (1983), and Bernanke et al. (1997) for more in-depth analyses.

[4] The SIC codes for finance and real estate companies are 6000 and 6999 and those for not-for-profit and governmental ones are 9100 and 9727, respectively.

Corporate investments are computed as the proportion of capital expenditure to total assets in the previous year and denoted as INV_t. The percentage change in real oil price is computed and used as the main independent variable. Following the literature on the determinants of corporate investment, we control for leverage, cash flow, Tobin's Q, profitability, and size.[5] US economic growth is the main determinant of corporate investment and is controlled for by including real GDP growth. To accommodate for any possible structural changes in the variables during the US financial crisis, a dummy that equals 1 in 2007, 2008, and 2009 is added to the model. Table 1 lists the variables and their definitions and sources.

Table 1: Variable definitions and sources

Variable	Definition	Source
INV_t	Corporate investment; calculated as capital expenditure scaled by total assets in the previous year	Compustat
ΔO_t	Percentage change in real oil prices.	US Energy Information Agency
$\dot{o}_{t-1}^{+}$	Positive real crude oil price change	Authors' calculations
$\dot{o}_{t-1}^{-}$	Negative real crude oil price change	Authors' calculations
Lev_t	Firm leverage ratio; calculated as total debt (including loans, securities and other current liabilities) scaled by total assets	Compustat
CF_t	Cash flow; calculated as earnings before interest and taxes minus taxes and interest expense plus depreciation and amortization, scaled by total assets	Compustat
$Tobin\ Q_t$	Tobin's Q; calculated as the ratio of market value of equity plus preferred stock plus total debt to total assets	Compustat
$Prof_t$	Profitability; calculated as the ratio of earnings before interest, taxes, depreciation and amortizations (EBITDA) to total assets	Compustat
$Size_t$	Firm size; calculated as the natural logarithm of total assets	Compustat
GDP_t	Real GDP growth	Federal Reserve Bank of St. Louis
$Crisis_t$	Crisis dummy; equals 1 if the year is in the global financial crisis (2007–2009), and 0 otherwise	

Note: This table describes the variables used in the paper.

Empirical literature typically studies corporate investment behavior using a dynamic panel model (see, e.g., Blundell et al., 1999; Bond and Meghir, 1994; Gulen and Ion, 2015). Therefore, we estimate the following baseline dynamic panel model:

[5] See, for instance, Henriques and Sadorsky (2011), Andreou et al. (2017), Phan et al. (2019), Maghyereh and Abdoh (2020), among others.

$$INV_{i,t} = \beta_0 + \beta_1 INV_{i,t-1} + \beta_{oil}\Delta O_{t-1} + \sum_{k=1}^{k} \beta_k X_{i,t-1}^{k} + \beta_g GGDP_{t-1} + \beta_c Crisis_t + \tau_i + \delta_t + \varepsilon_{it}, \quad (1)$$

where i and t stand for the firm and the year, respectively. $INV_{i,t}$ is the dependent variable, representing investment expenditures as a percentage of the total assets of firm i at time t. The lagged value of corporate investment is added as an explanatory variable to control for persistence and possible autocorrelation in company investment spending.

The main independent variable is denoted as ΔO_{t-1}, representing the percentage change in real oil price. $X_{i.t}^{k}$ is the vector of firm-level control variables—leverage, cash flows, profitability, Tobin's Q, and firm size. $GGDP_{t-1}$ is the US real GDP growth rate, which is used to control the general economic conditions that influence capital spending in all firms. All control variables are lagged by one year to avoid potential endogeneity and simultaneity bias in the estimates. $Crisis_t$ is a crisis dummy variable that takes 1 in crisis years, and 0 otherwise. The firm-specific effects that control for firm heterogeneity are captured by τ_i, which is a firm variant but time-invariant. Time heterogeneity is captured by δ_t, which does not change across companies and only changes from year to year. ε_{it} is the error term, assumed to be normally distributed, $\varepsilon_{it} \sim iid\ N(0, \sigma^2)$.

As Equation (1) is linear in real oil returns, it is unable to capture any potential asymmetry in the response of corporate investment to oil price changes. Hence, we adjust it by decomposing the oil price changes into positive ($\dot{o}_t^+$) and negative components:[6]

$$\dot{o}_t^+ = max\{\dot{o}_t^+, 0\} \Rightarrow \dot{o}_t^+ = \begin{cases} \dot{o}_t & if\ \Delta o_t > 0 \\ 0 & otherwise \end{cases},$$

$$\dot{o}_t^- = min\{\dot{o}_t^-, 0\} \Rightarrow o_t^- = \begin{cases} \dot{o}_t & if\ \Delta o_t \leq 0 \\ 0 & otherwise \end{cases}.\mathrm{e}$$

The extended version of Equation (1) to include asymmetries can be written as:

$$INV_{i,t} = \beta_0 + \beta_1 INV_{i,t-1} + \beta_{oil}\dot{o}_{t-1}^+ + \beta_{oil}\dot{o}_{t-1}^- + \sum_{k=1}^{k} \beta_k X_{i,t-1}^{k} + \beta_g GGDP_{t-1} + \beta_c Crisis_t + \tau_i + \delta_t + \varepsilon_{it}. \quad (2)$$

In this specification, asymmetry in the influence of oil price changes is captured by parameters β_{oil}^+ and β_{oil}^-. If β_{oil}^+ and β_{oil}^- are statistically equivalent, the conjecture of asymmetry is not statistically supported. Hence, we test the hypothesis of symmetry for the response of investment to oil price movements by using a Wald test of the null hypothesis ($\beta_{oil}^+ = \beta_{oil}^-$) against the alternative ($\beta_{oil}^+ \neq \beta_{oil}^-$).

To estimate models (1) and (2), we use a system GMM estimator as in Arellano and Bover (1995) and Blundell and Bond (1998). This estimator has two steps and yields asymptotically efficient and consistent parameters. It also controls for unobserved individual heterogeneity and potential endogeneity problems. The GMM estimates are

[6] Mork (1989) has implemented a similar adjustment to study asymmetry in the response of output to oil price changes.

generated using two to four lags of the explanatory variables as instruments and then the standard errors of these estimates are corrected using the procedure advocated by Windmeijer (2005).

3. Empirical results

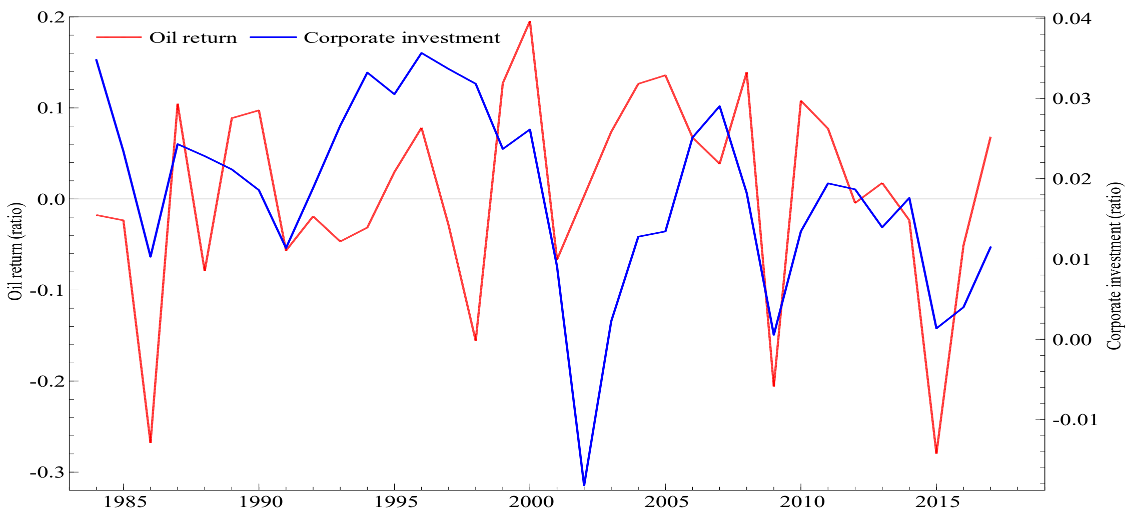
Table 2 shows descriptive statistics of corporate investment, oil price changes, and the rest of control variables in the model. The median company invests annually an average of 3.8% of its total assets over the sample period. The minimum capital spending is zero, which indicates some companies do not even compensate for depreciated capital over the year. The average highest capital spending is around 78% of total assets. The oil prices increase just under 1% annually over the sample period, with the biggest drawdown in 1986, when the oil prices dropped by more than 28%. The biggest increase in oil prices took place in 2000 (19.5%). Figure 1 displays the time series of annual oil price returns and corporate investments as a proportion of total assets over the sample period. Most of the time, company investments and oil returns move in the same direction, particularly during the periods when the US economy faced recession, such as in 1986, 2002, and 2008.

Table 2: Descriptive statistics of the variables for 1984–2017

Variable	Mean	Std. dev.	Min	25th percentile	Median	75th percentile	Max
INV_t	0.066	0.091	0.000	0.013	0.038	0.081	0.778
ΔO_{t-1}	0.009	0.109	-0.280	-0.047	0.018	0.089	0.195
$\dot{o}_{t-1}^{+}$	0.047	0.057	0.000	0.000	0.018	0.089	0.195
$\dot{o}_{t-1}^{-}$	-0.039	0.071	-0.280	-0.047	0.000	0.000	0.000
Lev_t	0.216	0.199	0.000	0.034	0.176	0.347	0.818
CF_t	0.004	0.226	-2.015	0.004	0.057	0.109	0.393
$Tobin\ Q_t$	1.898	1.813	0.383	1.015	1.287	2.025	30.872
$Prof_t$	0.045	0.214	-1.409	0.017	0.088	0.152	0.461
$Size_t$	5.609	2.400	-0.098	3.848	5.531	7.256	12.820
GDP_t	0.029	0.016	-0.025	0.019	0.029	0.040	0.072

Note: All variables are as defined in Table 1. The sample consists of 135,353 firm-year observations representing 15,411 firms over 1984–2017.

Figure 1: Oil price returns and corporate investment, 1984–2017



The median leverage is low and around 18% and the operating cash flows are around 5.7% of total assets. Higher profitability and low leverage can enhance the firm position in taking corporate investments. The median value of Tobin's Q, which reflects the ratio of market value to replacement costs of the firm's assets, is around 1.3, indicating growing prospects potential for the average firm in the market. On average, the sample companies are profitable and the median company generates profits around 8.8% of total assets. Given the median firm size of 252 million dollars, the median amount of profits is around 22.176 million dollars. Finally, the real GDP of the US economy increased by 2.9%, on average, during the sample period.

Table 3 presents the correlation matrix coefficients of our main variables. Column 1 shows the correlation of corporate investment with each of our explanatory variables. There is a negative correlation between corporate investments and oil indicating a negative sensitivity of investments to oil price changes. Investments are more correlated with company profitability, cash flow, and economic growth than with variables such as size, leverage, or Tobin's Q.

Table 3: Pearson correlation coefficients

	INV_t	ΔO_{t-1}	$\dot{o}^{+}_{t-1}$	$\dot{o}^{-}_{t-1}$	Lev_t	CF_t	$Tobin\ Q_t$	$Prof_t$	$Size_t$	GDP_t
INV_t	1.000									
ΔO_{t-1}	-0.011	1.000								
$\dot{o}^{+}_{t-1}$	-0.024	0.816	1.000							
$\dot{o}^{-}_{t-1}$	0.002	0.886	0.455	1.000						
Lev_t	-0.092	-0.026	-0.017	-0.027	1.000					
CF_t	0.132	0.010	-0.004	0.018	0.057	1.000				
$Tobin\ Q_t$	0.067	0.025	0.025	0.019	-0.217	-0.202	1.000			
$Prof_t$	0.139	0.006	-0.009	0.016	0.112	0.918	-0.200	1.000		
$Size_t$	-0.046	0.040	0.058	0.015	0.196	0.325	-0.213	0.339	1.000	
GDP_t	0.134	0.143	0.102	0.138	0.032	0.026	0.042	0.021	-0.171	1.000

Note: All variables are as defined in Table 1.

Table 4 presents estimates of six versions of Equation (2) we use to describe the response of US corporate investment to oil price changes in columns 1–6.[7] Columns 1, 3, and 5 do not differentiate between positive and negative oil price returns shocks. Oil returns have a positive influence on the investments of oil and gas firms and a negative influence on the capital spending of the other companies. This is not unexpected, as the revenues of oil and gas companies benefit from higher oil prices, unlike the revenues of non-oil ones.

The model estimates in columns 1, 3, and 5 are linear. In these models, the influence of oil price increases and decreases are described by the same parameter and, hence, they symmetric, which is not suitable for our purpose. Therefore, we decompose oil returns into positive and negative ones and re-estimate the model for the three samples. The

[7] The full sample includes oil and non-oil companies and is used to estimate models (1) and (2). The estimates are shown in columns 1 and 2. The parameters in columns 3 and 4 are generated from the sample excluding oil and gas companies. Finally, columns 5 and 6 show the estimates only for oil and gas companies. For each sample, we decompose the positive and negative oil price shocks and re-estimate the models. These estimates are shown in columns 2, 4, and 6, respectively.

parameter estimates of oil price increases are now different from those of oil price decreases and are shown in columns 2, 4, and 6.

Table 4: The asymmetric impact of oil prices on corporate investment (SYS GMM regressions)

	All firms		Exclude crude oil and gas firms		Crude oil and gas firms	
	(1)	(2)	(3)	(4)	(5)	(6)
INV_{t-1}	0.0829***	0.0833***	0.0863***	0.0867***	-0.0508***	-0.0513***
	(13.650)	(13.730)	(13.380)	(13.450)	(-4.300)	(-4.350)
ΔO_{t-1}	-0.0041***		-0.0053***		0.0702***	
	(-3.170)		(-4.090)		(6.900)	
$\dot{o}^{+}_{t-1}$		-0.0162***		-0.0173***		0.0562**
		(-6.530)		(-7.090)		(2.320)
$\dot{o}^{-}_{t-1}$		0.0030		0.0018		0.0780***
		(1.490)		(0.910)		(4.880)
Lev_{t-1}	-0.0971***	-0.0967***	-0.0939***	-0.0934***	-0.3780***	-0.3769***
	(-24.740)	(-24.620)	(-25.000)	(-24.860)	(-20.540)	(-20.360)
CF_{t-1}	0.0180***	0.0179***	0.0190***	0.0190***	0.0268	0.0273
	(6.830)	(6.800)	(7.390)	(7.360)	(1.310)	(1.340)
$Tobin\ Q_{t-1}$	0.0024***	0.0024***	0.0026***	0.0026***	0.0171***	0.0173***
	(7.000)	(7.030)	(7.580)	(7.600)	(5.150)	(5.270)
$Prof_{t-1}$	0.0149***	0.0148***	0.0089**	0.0088**	0.0928***	0.0926***
	(3.870)	(3.830)	(2.340)	(2.300)	(4.420)	(4.410)
$Size_{t-1}$	-0.0022**	-0.0021**	-0.0043***	-0.0041***	0.0265***	0.0267***
	(-2.190)	(-2.020)	(-4.150)	(-3.980)	(8.640)	(8.740)
GDP_{t-1}	0.1620***	0.1673***	0.1642***	0.1693***	0.5997***	0.5916***
	(14.110)	(14.510)	(14.380)	(14.770)	(6.600)	(6.560)
$Crisis_t$	-0.0003**	-0.0007***	0.0000***	-0.0004***	-0.0136**	-0.0141**
	(-2.690)	(-3.460)	(-2.100)	(-2.890)	(2.560)	(-2.650)
$Constant$	0.0694***	0.0691***	0.0790	0.0786***	0.0948***	0.0943***
	(11.790)	(11.740)	(13.020)	(12.960)	(5.230)	(5.200)
Sargan test	135.66	133.87	142.097	141.039	26.883	26.071
(p-value)	(0.3403)	(0.3512)	(0.398)	(0.390)	(0.766)	(0.750)
AR (2)	0.130	0.1298	0.241	0.229	0.082	0.089
(p-value)	(0.896)	(0.896)	(0.809)	(0.818)	(0.934)	(0.928)
W_β		26.73***		27.37***		0.40
(p-value)		(0.0000)		(0.0000)		(0.5275)
No. of firms	15,411	15,411	14,870	14,870	541	541
Observations	135,353	135,353	131,129	131,129	4,224	4,224

*Note: This table reports the regression results of the impact of oil prices on corporate investment. The dependent variable is corporate investment 〖(INV〗 _t), defined as the ratio of gross capital expenditures to book value of total assets in the previous year. Detailed definitions of all variables are provided in Table 1. All regressions are estimated using the two-step system-GMM estimator of Arellano and Bover (1995) and Blundell and Bond (1998). We adopt the procedure of Windmeijer (2005) to correct the standard errors of the two-step GMM estimates. The t – 2 to t – 4 lags of the variables are used as instruments in the difference equation and the same lags of differenced variables are used. The regressions include industry-year dummy variables and standard errors are clustered at industry level. Sargan is a test statistic for the validity of the instruments used, where rejection implies that the instruments are not valid. AR(2) is test statistics for second order autocorrelations. W_β represents the Wald test for the null hypothesis (β_oil^+=β_oil^-) against the alternative (β_oil^+≠β_oil^-). In all regressions, the industry effects based on four -digit SIC codes. Numbers in parentheses indicate the robust t statistics. ***, **, * indicate significance at 1%, 5%, and 10% levels, respectively.*

Column 4 shows that the investment of non-oil and gas companies is more significantly affected by oil price increases than by price decrease. The estimated parameters indicate that, for every 1% increase in oil prices, corporates reduce capital spending by 1.73% of total assets. However, when oil prices fall by 1%, capital spending increases by only 0.18% of total assets. These asymmetries highlight the importance of the impact of oil price increase on US corporate investment. They also highlight the high probability that corporations will not be able to recover lost investments for a subsequent fall in oil prices. The antepenultimate row shows the Wald test statistics of the null that corporate investment responds equally to increases and decreases in oil price. The null of an equal response is rejected and, therefore, we conclude that the influence of oil on US corporate investments is asymmetric.

Column 6 reports the results for oil and gas companies. The parameters indicate that oil companies increase the proportion of capital spending by 8% and 6% following a 1% negative and positive change in the annual oil prices, respectively. It is clear that with an increase in oil prices, oil-producing company's profitability will increase, thereby encouraging more capital investments. The same effect is observed with a decrease in oil prices. As oil prices drop, revenues of crude oil and natural gas companies decline as well—and in order to maintain their profit against low break-even prices, it is reasonable to expect that these companies will increase capital expenditures especially in new technology and innovation in order to enhance efficiency and operational flexibility which in turn reduce the operating cost.

Table 5: Robustness checks: Alternative corporate investment measures (SYS GMM regressions)

	All firms	Exclude crude oil and gas firms	Crude oil and gas firms
	(1)	(2)	(3)
INV_{t-1}	0.1822***	0.1835***	0.1239***
	(14.720)	(14.550)	(13.210)
$\dot{o}^{+}_{t-1}$	-0.0543***	-0.0554***	0.0621**
	(-4.560)	(-4.580)	(2.060)
$\dot{o}^{-}_{t-1}$	0.0490*	0.0539*	0.0904*
	(1.390)	(1.720)	(1.830)
Lev_{t-1}	-0.1200***	-0.1228***	-0.1919***
	(-5.160)	(-5.230)	(-3.000)
CF_{t-1}	0.0343***	0.0332***	0.0260***
	(3.790)	(3.760)	(6.870)
$Tobin\ Q_{t-1}$	0.0783***	0.0948**	0.0169***
	(3.360)	(2.430)	(3.040)
$Prof_{t-1}$	0.0573***	0.0575***	0.0705***
	(3.940)	(3.940)	(2.740)
$Size_{t-1}$	0.1717***	0.1732***	0.1900***
	(11.430)	(11.250)	(6.160)
GDP_{t-1}	0.0573***	0.0547***	0.1717***
	(3.170)	(3.950)	(3.170)
$Crisis_{t}$	-0.0037***	-0.0027***	-0.0350***
	(-3.400)	-(2.980)	(2.520)
$Constant$	-0.0902***	-0.0811***	-0.0116***
	(-6.530)	-(7.350)	(-5.410)
Sargan test	50.811	48.311	20.500
(p-value)	(0.139)	(0.144)	(0.924)
AR (2)	0.0516	-0.0086	0.9131
(p-value)	(0.958)	(0.993)	(0.361)
W_{β}	25.10***	26.93***	1.15
(p-value)	(0.0000)	(0.0000)	(0.3165)
No. of firms	15,411	14,870	541
Observations	135,353	131,129	4,224

Note: In this table, we undertake robustness checks. The dependent variable is corporate investment 〖(INV〗_t), defined as the ratio change in net fixed assets plus depreciation to total assets in the previous year. The detailed definitions of all variables are provided in Table 1. All regressions are estimated using the two-step system-GMM estimator of Arellano and Bover (1995) and Blundell and Bond (1998). We adopt the procedure of Windmeijer (2005) to correct the standard errors of the two-step GMM estimates. The t – 2 to t – 4 lags of the variables used as instruments in the difference equation and the same lags of differenced variables are used.

*The regressions include industry-year dummy variables and standard errors are clustered at the industry level. Sargan is a test statistic for the validity of the instruments used, where rejection implies that the instruments are not valid. AR(2) is test statistics for second order autocorrelations. W_β represents the Wald test for the null hypothesis (β_oil^+=β_oil^-) against the alternative (β_oil^+≠β_oil^-). In all regressions, the industry effects are based on four -digit SIC codes. The numbers in parentheses indicate the robust t statistics. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.*

The null of symmetry in the influence of oil price increases and decreases is not rejected by the Wald test statistics and, therefore, we may conclude oil companies respond similarly to positive and negative oil price changes. The lack of asymmetry can be explained by the long-term nature of oil company investments. The irreversibility of these investments implies a lower sensitivity to the oil price, meaning companies may respond similarly to positive and negative oil changes.

Table 6: Robustness checks: Alternative estimation method (fixed effect regressions)

	All Firms	Exclude crude oil and gas firms	Crude oil and gas firms
	(1)	(2)	(3)
INV_{t-1}	0.0088***	0.0033	0.2212***
	(2.610)	(0.960)	(7.180)
$\dot{o}^{+}_{t-1}$	-0.0299***	-0.0311***	0.0895**
	(-4.090)	(-4.140)	(2.220)
$\dot{o}^{-}_{t-1}$	0.0188*	0.0189*	0.0322
	(1.840)	(1.800)	(0.600)
Lev_{t-1}	0.0360***	0.0362***	0.1092***
	(8.150)	(8.000)	(2.840)
CF_{t-1}	0.0151***	0.0145***	0.1502***
	(3.030)	(2.850)	(2.880)
$Tobin\ Q_{t-1}$	0.0030***	0.0030***	0.0236***
	(8.260)	(8.040)	(5.420)
$Prof_{t-1}$	0.0468***	0.0463***	0.0074***
	(7.540)	(7.310)	(3.140)
$Size_{t-1}$	0.0061***	0.0059***	0.0098**
	(9.150)	(8.630)	(2.160)
GDP_{t-1}	0.4632***	0.4615***	0.3660**
	(11.370)	(11.060)	(2.190)
$Crisis_t$	-0.0075***	-0.0075***	-0.0010**
	(-2.920)	(-2.880)	(0.050)
$Constant$	0.0715***	0.0705***	0.0477*
	(16.890)	(16.260)	(1.490)
W_β	22.54***	23.43	1.24
(p-value)	(0.0000)	(0.0000)	(0.2671)
No of firms	15,411	14,870	541
Observations	135,353	131,129	4,224

*Note: In this table, we undertake a robustness checks using the fixed effects method. The dependent variable is corporate investment 〖(INV〗_t), defined as the ratio change in net fixed assets plus depreciation to total assets in the previous year. The detailed definitions of all variables are provided in Table 1. The regressions consider only time dummies and standard errors are clustered at the industry level. W_β represents the Wald test for the null hypothesis (β_oil^+=β_oil^-) against the alternative (β_oil^+≠β_oil^-). In all regressions, the industry effects are based on four -digit SIC codes. The numbers in parentheses indicate the robust t statistics. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively..*

The influence of the rest of the control variables on corporate investments in the US is as expected. For instance, companies tend to invest more when economic growth increases. US oil and non-oil corporates invest more following increases in cash flow and profitability. Moreover, Tobin's Q is positively correlated with company investment and, hence, corporates may expand their asset bases if the market valuation of their assets has increased relative to the assets' replacement costs. Size is found to negatively influence corporate investments.

To further validate the findings, we undertake two robustness checks in Tables 5 and 6. Particularly, we use an alternative measure of investment in Table 5, which is defined as the change in net fixed assets plus depreciation scaled by total assets in the previous year. Table 6 reports the results of Equation (2) using the fixed-effect method. We then re-estimate Equation (2) and find the results are quantitatively similar to the primary investment measure and use the fixed-effect method. In column 1, the coefficient on the positive oil price return is negative and its value is greater (in absolute term) than the coefficient on the negative oil price return. We re-run the regression models as above using Equation (2) on the samples sorted by industry classification (i.e., US oil and non-oil corporates). Again, the results reported in columns 2 and 3 of Tables 5 and 6 are quantitatively similar to those previously obtained.

4. Conclusion and Policy Implications

The costs and revenues of current and potential company investments are influenced by oil prices. Hence, company expansion, growth, and investment may be affected by oil price changes and fluctuations. Corporations are generally expected to invest less when oil prices are high and uncertain, while oil and gas firms are expected to expand and invest more. In the literature, the relationship between oil and corporate investments has been extensively explored.[8] In these studies, the response of investment to oil prices is linear and the different investment sensitivities to oil prices is not addressed. Therefore, we investigate whether corporate investment responds differently to oil price increases and decreases. This issue of asymmetric sensitivity to oil price is important, as it enables analysts to measure more accurately the responses of corporate investment to potential oil price changes. This is important for company growth prospects, whose value depends on assumptions regarding its capital spending. The issue is also important for modeling the investment decision of corporates and their dependence on the oil price.

Consistent with the literature, we find corporate investments are influenced by the oil price. More importantly, capital expenditure and spending respond differently to oil price increases and decreases. Specifically, an increase hurts assets expansion more than a decrease benefits corporate investments. These asymmetries indicate that the lost investment following an increase in oil price may not be recovered even when oil prices decline. For oil and gas companies, the response of investment is linear and symmetric.

These results highlight the importance of non-linear modeling for the influence of oil price changes on corporate investments. In particular, accounting for asymmetry when predicting the response of investment to oil price change becomes more accurate. Moreover, our results can potentially increase the shareholder value if firms manage the change of oil price (the increase or decrease in price) that exerts the largest effect on corporate investments.

[8] See, for instance, Edelstein and Kilian (2007), Hamilton (2009), Kilian (2009), Uri (1980), Mohn and Misund (2009), Elder and Serletis (2010), Yoon and Ratti (2011), Sadorsky (2011), Henriques and Sadorsky (2011), Sadath and Acharya (2015), Ratti et al. (2011), Wang et al. (2017), and Maghyereh and Abdoh (2020).

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