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Corporate Debt and Stock Returns: Evidence from U.S. Firms During the 2020 Oil Crash

Abstract

This paper explores the effect of oil price fluctuations on the stock returns of U.S. oil firms using a strategy of identification through heteroskedasticity exploiting the 2020 oil crash. Results are twofold. First, we find that a decline in oil prices statistically significantly reduces stock returns of oil firms. On average, a one percent decline in oil prices leads to a 0.44 percent decline in stock prices. Second, results point to the "irrelevance" of debt in mediating the effect of oil prices on stock returns of oil firms. The liquidity backstop provided by the Federal Reserve appears not to have muted the role of debt for oil firms.

JEL-Codes: E440, G120, Q430.

Keywords: oil prices, stock returns, debt.

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I. Introduction

Economists have long explored how debt levels affect stock returns. The literature, dating back at least to Modigliani and Miller (1958), showed that in a frictionless world, the value of a firm is unaffected by how a firm is financed. In the presence of frictions, firms face a trade-off linked to the benefits and costs of debt financing (see Harris and Raviv, 1991).[2] The equity of a levered firm is riskier than the equity of an otherwise identical firm with less leverage. The value of equity falls more when the firm leverage is higher for a given fall in the value of the firm's assets.[3] The shock caused by the Great Recession allowed for the analysis of the role of debt levels in mediating the impact of the Recession on firm performance.[4] In the present paper, we exploit the 2020 oil crash to explore the role of debt in mediating the effect of a fall in the value of the firm's main assets, oil reserves, on stock returns of oil and gas firms in the United States.[5]

Oil firms in the U.S., especially smaller ones, have accumulated a significant amount of debt during the period of relatively high oil prices. Data from Compustat reveal that the simple average debt (including long-term and short-term debt) for all available U.S. oil firms jumps from about 25% of total assets during 2009-2014 to about 40% during 2015-2019. [6] The COVID-19 pandemic and an oil price war sent oil prices to an all-time low in the first half of 2020.[7] Amid the collapse in oil prices, commentators have raised concerns about the sustainability of debt accumulated by oil firms.[8] Commentators argued then that lower price combined with high debt levels could lead to a cascade of bankruptcies.

Moreover, the size of the oil and gas sector has grown rapidly, raising concerns about the potential spillover effect stemming from bankruptcies in the sector to the rest of the economy and financial markets.[9] The findings from existing research contradict the conventional wisdom that lower oil prices

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[2] The trade-off is as follows. On the one hand, higher debt levels effectively increase the equity share of managers in turn reducing agency costs. On the other hand, higher debt levels increase risk-taking of equity holders.

[3] See Merton (1974) and Leland (1994, 1998) for traditional theoretical framework to analyze corporate debt value and optimal capital structure. Absent commitment to leverage policy, important agency frictions determine the firm's choices in terms of leverage. Recent theoretical contributions by Admati et al. (2018) show that without commitment, equity holders will adjust leverage to maximize the current share price rather than total firm value. Demarzo and He (2021) find that bond investors anticipate future leverage increases and require significant credit spreads even when the distance to default is large. The tax benefits of future debt increases are fully dissipated, and equilibrium equity values match those in a model where the firm commits not to issue new debt.

[4] Several papers exploit the great recession to explore the role of debt on firm behavior. Campello et al. (2010) find that financially constrained firms planned deep cuts in employment and spending. Giroud and Muller (2017) find that more highly levered firms experienced significantly larger employment losses in response to decline in local consumer demand.

[5] Thereafter we use the phrase oil firms or oil stocks to mean oil and gas firms and oil stocks.

[6] In 10 of the last 11 years, energy companies were the single largest junk bond borrowers. Since the pandemics, bankruptcies among oil and gas companies in North America have risen (Reuters, 2020b; Haynes and Boone LLP, 2020). Given the concern, the Trump administration even considered giving direct aid to oil firms (Wall Street Journal, 2020).

[7] See Arezki and Fan (2020) for an early account of the oil price war in times of COVID-19.

[8] See Reuters (2020a); Washington Post (2020).

[9] Data from US Energy Information Administration website show that US crude oil output has more than doubled from about 5 million barrels per day (mb/d) in 2008 to over 12 mb/d in 2019.

have traditionally been good for the U.S. economy.[10] This paper specifically tests whether oil price fluctuations have a differentiated effect on levered oil firms. Because of the theoretical predictions mentioned above, we expect stock prices to fall more for levered oil firms in response to the 2020 oil crash.

To test whether debt levels mediate the effect of oil price fluctuations on stock returns, we use daily data on oil prices and stock prices of U.S. oil firms from January to June of 2020—a period of great upheaval for the oil market. Taking the issue of endogeneity seriously, we establish a causal relationship between changes in oil prices and changes in stock prices of oil firms by following Rigobon (2003). Specifically, we instrument for changes in oil prices with plausibly exogenous news that might exclusively affect current or future oil supplies, coined "oil-specific news."[11] We note that current oil demand by investors may increase if oil-specific news makes them worry about the availability of future oil supplies. We call days with oil-specific news "event days" and days without oil-specific news "non-event days."

The results are twofold. First, we find that a decline in oil prices statistically significantly reduces oil stock returns. Quantitatively, a one percent decline in oil prices leads on average to a 0.44 percent decline in stock prices. Furthermore, we find that the elasticity becomes smaller with lower oil prices. Second, our empirical results point to the "irrelevance" of level of debt in mediating the effect of oil prices on oil stock returns. The role of total debt becomes smaller and statistically insignificant after standard firm characteristics are progressively controlled for. The liquidity backstop provided by the Federal Reserve appears not to have muted the role of debt for oil firms.

This paper contributes to the rapidly growing strand of the finance literature exploring the effect of COVID-19 on firm performance. Notably, Ding et al. (2021) evaluate the connection between corporate characteristics and the reaction of stock returns to COVID-19 cases for firms across over 60 economies. The authors find that the pandemic-induced drop in stock returns was milder among firms with stronger pre-2020 finances and less exposure to COVID-19 through global supply chains. Fahlenbrach et al. (2020) document that firms with high financial flexibility within an industry experience a stock price drop of 26 percent, or 9.7 percentage points, lower than those with low financial flexibility. This differential return persists as stock prices rebound. The authors also argue that their findings cannot only be explained by the leverage effect. On the more normative front, Brunnermeier and Krishnamurthy (2020) develop a corporate finance framework to guide interventions in credit markets to avoid scarring. The authors emphasize that policies reducing funding costs are only socially desirable if the pandemic is expected to be short-lived and if bankruptcy costs are high. Our paper contributes to this strand of literature by documenting the absence of the role of corporate debt in mediating the effect of the COVID-19 induced oil price crash on stock returns for oil firms. We also explore the role of the Federal Reserve liquidity provision in explaining our results on the muted role of debt.

Our paper also contributes to the strand of literature on the nexus between corporate debt and oil firms. Donders et al. (2018) document that between the period from 2003 to 2015, a 10 percent change in oil price leads to a 0.15 percent change in the bond yields of oil firms. Also, Gilje et al. (2020) show that highly indebted oil firms are forced to make distorted investment decisions.[12] They complete projects early to enhance collateral value at the expense of long-run project return. Our findings suggest that the

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[10] See for instance Nguyen et al. (2020) and Bjørnland and Zhulanova (2019).

[11] See for example, Rigobon and Sack (2004), Anderson et al. (2007), Ehrmann et al. (2011), Chaboud et al. (2014), Hébert and Schreger (2017), Nguyen et al. (2020).

[12] Domanski et al. (2015) highlight the high debt burden of the oil sector during the collapse of oil price in 2014.

role of debt in the transmission of oil price fluctuations to stock prices of oil firms experiencing a fall in the value of their main assets is not robust to controlling for other firm characteristics.

The remainder of the paper is organized as follows. Section II presents the data and the empirical framework. Section III presents our main results. Section IV discusses robustness checks and extensions. Section V concludes.

II. Data and Empirical Framework

This section describes the data and sources used in the empirical analysis. The section also presents the empirical framework used to explore the effect of the COVID-19 oil price crash on the stock returns of U.S. oil firms.

II.1 Data

The daily data for oil and stock prices used in the analysis covers January 2, 2020, to June 30, 2020, for 43 U.S. oil firms. Daily crude oil prices are obtained from the U.S. Energy Information Administration. We use oil prices for the Western Texas Intermediate (WTI) benchmark. Indeed, WTI is the main benchmark for oil consumed in the U.S.[13] Daily data on stock prices for U.S. oil firms are obtained from Compustat. The list of U.S. firms used in the empirical analysis is shown in Appendix Table A1.

Data for debt and other firm's characteristics are from 2019, meaning they are *pre-determined* before the period of analyses. Debt data are obtained from the Compustat database. The debt variables used in the analysis include long-term debt/assets, short-term debt/assets, cash/assets, and net debt/assets. Debt variables are measured in the last quarter of 2019—before COVID19 was discovered. Short-term debt/assets is the ratio of debt in current liabilities to total assets (DLC/AT). Current liabilities are those that mature within a year. Long-term debt/assets is the ratio of total long-term debt to total assets (DLTT/AT). Long-term debt is the liabilities with maturities longer than one year. Finally, net debt/assets is the ratio of total debt, including short-term and long-term debt, net of cash, to total assets ((DLC+DLTT-CHE)/AT). Note that all the debt variables are *pre-determined* before the period of analyses.

Other firm characteristics used as controls include the logarithm of the firm's assets, beta, market-to-book ratio, momentum, and profitability. The logarithm of the firm's assets, market-to-book ratio, and profitability are from the Compustat database, measured in the last quarter of 2019. The Market-to-Book ratio is the ratio of the market value of equity at year-end 2019 to book value of equity (CEQ). The latter equals the last observation of daily close price (PRCCD) at year-end 2019 multiplied by the number of shares outstanding (CSHOC). Profitability is the ratio of gross profit to total assets (GP/AT). Beta is captured by the slope parameter of the regression of excess daily returns on the daily market logarithm of excess returns from January 1, 2019, to December 31, 2019. Finally, momentum is the exponent of the sum of the daily logarithm of excess returns from January 1, 2019, to the last observation of the daily logarithm of excess returns at year-end 2019.

Table 1 provides basic summary statistics. Between January 2, 2020 and June 30, 2020, the average change in daily oil price is -0.12 percent, and the average change in stock prices is 0.37 percent. Note that, April 20 and 21 are dropped from our analyses because of extreme values of log change in oil prices (WTI oil price was negative on April 20). At the year-end of 2019, total debt is on average about 27 percent of assets. The standard deviation of net debt across oil firms is about 18.5 percent of assets.

[13] The WTI benchmark refers to the prices of oil extracted from wells in the US and sent via pipelines to Cushing, Oklahoma.

Most oil firms' debt is long-term. On average, short-term debt is 0.9% of total assets; and long-term debt is 26.3% of total assets.

Table 1. Summary Statistics.

This table presents summary statistics for key variables used in our analyses. N designates the number of non-missing observations for the variable. The mean and standard deviation are determined across these observations for the variables. Our analyses include 43 oil and gas firms (see Appendix Table A1 for the list). Note: Data are from Jan 2, 2020 to June 30, 2020. U.S. holidays are not included because the financial market was closed (Jan 20; Feb 17; April 10; May 25). In addition, April 20 and 21 are dropped because of extreme values in $\Delta\ log$ *(oil) (WTI oil price was negative on April 20).*

Variable	N	Mean	Standard Deviation	Min	Max	Number of firms
$\Delta\ log$ (oil)	122	-0.0012	0.0888	-0.2814	0.3747	
$\Delta\ log$ (stock)	5,332	-0.0037	0.1072	-1.1418	2.4761	43
ST Debt/Assets	43	0.009	0.018	0.000	0.098	43
LT Debt/Assets	43	0.261	0.188	0.000	0.721	43
Total Debt/Assets	43	0.270	0.185	0.000	0.724	43
Cash/Assets	43	0.076	0.155	0.000	0.742	43
Beta	43	1.028	0.520	-0.645	2.088	43
Market-to-Book	42	0.992	1.113	-1.685	5.375	42
Log(Assets in USD million)	43	7.050	2.595	1.850	11.602	43
Profitability	43	0.014	0.070	-0.275	0.091	43
Momentum	43	0.856	0.271	0.301	1.396	43

II.2 Empirical Framework

An important challenge in our empirical analysis is identifying the *causal* effects of oil prices on the stock prices of U.S. oil firms. Indeed, other macroeconomic factors such as shifts in aggregate demand or interest rate changes could simultaneously affect oil and stock prices. These omitted variables driving both oil and stock prices may bias our estimates if we were not to address the issue of endogeneity. In this section, we discuss our identification in more details.

Identification through Heteroscedasticity

To address the issue of identification, we use the heteroscedasticity-based identification strategy following Rigobon (2003) and Rigobon and Sack (2004).

Let us consider the following system of equations:

$$\Delta p_t = \gamma \Delta s_t + \beta z_t + \varepsilon_t \qquad (1)$$

$$\Delta s_t = \alpha \Delta p_t + \delta z_t + \mu_t \qquad (2)$$

where Δp_t is the change in oil prices, Δs_t is the change in a firm's stock price, and z_t is a set of common aggregate demand factors that could affect oil prices and the firm's stock price (such as interest rates, news about global growth, or other aggregate demand news). ε_t represents oil shocks that only affect oil prices. ε_t captures events that affect current or future oil supply, such as an agreement for production cuts by the Organization of the Petroleum Exporting Countries (OPEC) and its allies. Similarly, μ_t

represents the idiosyncratic shocks that only affect stock prices. Our goal is to estimate the value of α: the causal impacts of changes in oil prices on changes in stock prices.[14]

We divide the days in our sample into two types: event (*E*) and non-event (*N*) days. Event days are days with important announcements and developments about the current or future oil supply (see Appendix Table A2 for our selected event days between January and June of 2020). A useful feature of the approach is that it does not require the complete absence of common aggregate demand or shocks on the global economy during event days. This strategy instead relies on the identifying assumption that the variances of the common aggregate demand shocks z_t and financial shocks μ_t are the same on non-event days and event days, whereas the variance of oil-specific shocks ε_t is higher on event days than on non-event days:

$$\sigma_{z,E}^2 = \sigma_{z,N}^2 \qquad (3)$$

$$\sigma_{\mu,E}^2 = \sigma_{\mu,N}^2 \qquad (4)$$

$$\sigma_{\varepsilon,E}^2 > \sigma_{\varepsilon,N}^2 \qquad (5)$$

These assumptions imply the "importance" of oil-specific announcements increases on event days (*E*). Again, news on aggregate demand can occur on event days—so long as the influence of aggregate demand factors is similar to that on non-event days. Rigobon and Sack (2004) argue that these assumptions are much weaker than those required in traditional event-study analyses.

Under such assumptions, we can identify parameter α by comparing the covariance matrices of stock price and oil price changes on event days and non-event days. In particular, for each of the two types of days $j \in \{E, N\}$, we can estimate the covariance matrix of $[\Delta s_t, \Delta p_t]$, denoted Ω_j:

$$\Omega_{j=}[var(\Delta s_t)\ cov(\Delta s_t, \Delta p_t)\quad cov(\Delta s_t, \Delta p_t)\ var(\Delta p_t)\ ] \qquad (6)$$

Rigobon and Sack (2004) show that the difference in the covariance matrices on the event and non-event days as $\Delta\Omega$=$\Omega_E - \Omega_N$:

$$\Delta\Omega = \frac{\sigma_{\varepsilon,E}^2 - \sigma_{\varepsilon,N}^2}{(1-\alpha\gamma)^2}\ [\alpha^2\ \alpha\ \alpha\ 1\ ] \qquad (7)$$

From (7), α can be estimated as

$$\hat{\alpha} = \frac{\Delta\Omega_{1,2}}{\Delta\Omega_{2,2}} \qquad (8)$$

which from (6), (8) can be written as:

$$\hat{\alpha} = \frac{cov_E(\Delta s, \Delta p) - cov_N(\Delta s, \Delta p)}{var_E(\Delta p) - var_N(\Delta p)} \qquad (9)$$

The numerator captures the difference between the covariance of oil prices and stock prices for event days and non-event days. If the covariance for event days is the same as that for non-event days, the relationship between oil prices and stock prices is driven only by common aggregate demand shocks, z_t. Hence, the causal impact of oil price on stock price, $\hat{\alpha}$, would be zero.

Empirically, the approach can be implemented through an instrumental variable estimation technique. As such, we define vectors Δs_E and Δp_E with size $T_E \times 1$ to contain the changes in the logarithm of asset prices and oil prices on the event days, and vectors Δs_N and Δp_N with size $T_N \times 1$ to contain the logarithm changes in asset prices and oil prices on the non-event days. We then combine the

[14] Note that in this framework, the effects of oil price increases and decreases are symmetric.

two subsamples into two $(T_E + T_N) \times 1$ vectors that contain the changes in the logarithm of asset prices and oil prices in our sample, $\Delta s = [\Delta s_E' \quad \Delta s_N']'$ and $\Delta p = [\Delta p_E' \quad \Delta p_N']'$.

Consider the following instrument:

$$w = \left[\frac{\Delta p_E'}{T_E - L} \qquad -\frac{\Delta p_N'}{T_N - L}\right]' \tag{10}$$

where L is the number of explanatory variables. α can be estimated by regressing log change in asset prices Δs on log change in oil prices over the sample period using the standard instrumental variable approach, with the instrument w:

$$\hat{\alpha} = (w'\Delta p)^{-1}(w'\Delta s) \tag{11}$$

Simple algebra shows that the estimated value of α is *asymptotically* identical to (9). To assess the effect of oil prices on U.S. oil firms' stock prices, we set up the regression framework as follows:

$$\Delta \boldsymbol{y}_{i,t} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1}\Delta \boldsymbol{y}_{i,t-1} + \boldsymbol{\beta_2}\widehat{\Delta \boldsymbol{p}_t} + \boldsymbol{\beta_3}\widehat{\Delta \boldsymbol{p}_{t-1}} + \boldsymbol{fe}_i + \boldsymbol{\epsilon_t} \quad \textbf{(12)}$$

where $\Delta y_{i,t}$ is logarithm change in the stock price of firm *i* at day *t;* and $\Delta y_{i,t}$ is logarithm change in firm i's stock prices at day t-1; $\widehat{\Delta p_t}$ is logarithm change in WTI oil price at day t, instrumented by *w*; Δp_{t-1} is logarithm change in WTI oil price at day t-1; fe_i captures firm fixed effects. Standard errors are clustered at the firm level.

To assess the role of debt, we set up the regression framework as follows:

$$\Delta \boldsymbol{y}_{i,t} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1}\Delta \boldsymbol{y}_{i,t-1} + \boldsymbol{\beta_2}\widehat{\Delta \boldsymbol{p}_t} + \boldsymbol{\beta_3}\widehat{\Delta \boldsymbol{p}_{t-1}} + \boldsymbol{\beta_4}\Delta \boldsymbol{p}_t \widehat{\times \boldsymbol{Debt}_\iota} + \boldsymbol{fe}_i + \boldsymbol{\epsilon_t} \quad \textbf{(13)}$$

where $\Delta p_t \widehat{\times Debt_\iota}$ is the interaction between logarithm change in WTI and firm i's debt at the end of 2019, instrumented by $w \widehat{\times Debt_\iota}$.

Identifying Oil Specific Events

Identifying oil-specific events or news (as opposed to aggregate demand news) is challenging. We define oil-specific news to be news exclusively affecting the current or potential future oil supplies. An example of news on future oil supplies is OPEC agreeing to production change, which could cause market participations to update their demand for oil on their expectation that oil supply will change in the future.

There is no fixed calendar for oil-specific events. Hence, we screened these event days from financial news. Since multiple events could happen on any one day, we employ several rounds of screening to identify oil-specific events. In the first round, we used the "Seeking Alpha" news portal. Seeking Alpha is a community-based platform for investment research, with broad coverage of stocks, asset classes, ETFs, and investment strategy.[15] "Seeking Alpha" records all surprising events and announcements that arguably affect current or future oil supply. From 1/1/2020 to 6/30/2020, we identified 36 events. We restrict our attention to the six-month window to focus on the period when the oil market crashed. The window for our event study is one day. We examine the change in financial markets on the following trading day for announcements after trading hours. The relevant dates are shown in Appendix Table A2, with links to in-depth financial news discussing the events.

[15] In contrast to other equity research platforms, insights are provided by investors and industry experts rather than sell-side analysts. Seeking Alpha has 4 million registered users, about 500,000 to 1 million unique users per day as of August 2013, over 18.5% of the audience are financial professionals, making it one of the biggest investment-related social media websites in the US. We use Seeking because it is popular among investors and because it is a free, open-source platform which we could draw news about oil price. See Chen et al (2014) for an example of usage of Seeking Alpha to study how social media affects stock values.

There are potential concerns with this approach. First recorded events could reflect ad-hoc ex-post explanations by the analysts. For example, an analyst might see oil prices drop during the day and look for news about current or future oil supply that could explain the event. In other words, oil prices drop because of aggregate demand factors, but the analysts interpret this as oil-specific shocks. We minimize the ad-hoc ex-post problem by *not* considering the days with important aggregate demand announcements recorded by Seeking Alpha analysts. We also do not consider announcements about U.S. oil inventories because oil inventories could reflect both aggregate demand factors and current or future oil supplies.

To ensure that the event days are primarily oil-specific news or events about current and future oil supplies, we also use U.S. news coverage as a check. We use Dow Jones's FACTIVA news database to count how many U.S. newspaper articles with the words "*economy*" or "*economic growth*." The number of articles represents how intensively news about the economy, or "aggregate demand news," is covered. The assumption is that the higher the count for any given day, the more important aggregate demand news is for that day. We collect article counts for all the days since January 2, 2020 to June 30, 2020. Then, we check econometrically if the log of article count for the event days is higher than that for the non-event days and find that the log count for event days is not significantly different from non-event days.

Second, OPEC announcements could reflect worries about global aggregate demand by OPEC. For example, an announcement that OPEC countries will be meeting to cut production could reflect their concerns that aggregate demand is low now or would be low in the future. Should this announcement be treated as an event about a possible current or future oil supply cut or aggregate demand decline? The reaction of oil prices in the market can help us answer this question. An aggregate demand decline shifts the demand curve for oil to the left, reducing its price. A cut in oil production shifts the supply curve for oil to the left, raising its price. We thus verify that oil prices increased following an OPEC announcement to cut production because investors perceive this news as a sign of possible cuts in current or future oil supply.

III. Results

In this section, we present the main results from our estimation of the effect of oil prices on the returns of U.S. oil stocks. We present results of our tests of whether the relationship between oil prices and oil stock returns is mediated by debt levels.

III.1 On the Average Effect of Oil Prices on U.S. Oil Stocks

Our estimation results of oil price declines on oil firms' stock prices cover January 2020 to the end of June 2020. During this period, the oil price varied between 60 and -37 dollars per barrel (WTI oil price went to a negative value on April 20, 2020). Table 2 presents both Ordinary Least Square (OLS) and Instrumental Variable (IV) results using the heteroscedasticity-based identification strategy approach.[16]

A decline in oil prices statistically significantly reduces oil stock prices during this period. The OLS results (columns [1] and [2]) suggest a 1 percent decline in oil prices is associated with a 0.32 percent decline in oil firm stock prices. The IV results (columns [4] and [5]) suggest that, on average, a 1 percent decline in oil prices *causes* a 0.43 to 0.44 percent decline in oil firms' stock prices. In other words, the average stock price-oil price elasticity is around 0.43.[17] This magnitude is substantially larger than what

[16] Regression analyses control for $\Delta\log(\text{oil})_{t-1}$ and $\Delta\log(\text{stock})_{t-1}$.

[17] Appendix Table A3 shows the elasticity of each US oil firm in our sample.

Boyer and Filion (2007) reported: stock price-oil price elasticity for Canadian oil firms between 1995 and 2002 is 0.26.

Table 2: Changes in Oil Price and Change in Stock Prices of Oil Firms.
This table reports regression results of change in the logarithm of oil firms' stock prices on changes in the logarithm of oil prices, using OLS and IV (heteroscedasticity-based identification) approaches. The dependent variable, Δlog(stock), is the daily return of a firm's stock price. Notes: Standard errors are in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at the firm level.

Δlog(stock)	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Δlog(oil)	0.318***	0.319***	-1.994***	0.428***	0.443***	-2.559***
	(0.0380)	(0.0381)	(0.203)	(0.0678)	(0.0768)	(0.456)
$\Delta log(\text{oil})_{t-1}$		0.0398**	0.0340**		0.0962**	0.0471
		(0.0157)	(0.0156)		(0.0409)	(0.0403)
$\Delta log(\text{stock})_{t-1}$		-0.0482	-0.0462		-0.0603	-0.0472
		(0.0594)	(0.0586)		(0.0594)	(0.0592)
$\Delta log(\text{oil})*\log(\text{oil})_{t-1}$			0.749***			0.954***
			(0.0765)			(0.166)
$\log(\text{oil})_{t-1}$			-0.0173***			-0.0160***
			(0.00317)			(0.00361)
Constant	yes	yes	yes	yes	yes	yes
Number of observations	5,246	5,203	5,203	5,246	5,203	5,203
R-squared	0.069	0.072	0.124			
Firm fixed effects	yes	yes	yes	yes	yes	Yes

The elasticity is smaller for lower levels of oil prices. Both the OLS and IV results (columns [3] and [6]) point to such nonlinearity. The interaction terms between $\Delta log(\text{oil})*\log(\text{oil})_{t-1}$ in both columns are significantly positive. In column [6], the coefficient for the interaction term is 0.95. This coefficient implies that every 10 percent lower oil price level reduces the elasticity by 0.095.

The finding that the elasticity is smaller for a lower level of oil prices is surprising. Our prior is that at low levels of oil prices, the response of stock prices to the same percentage decline in the oil price should be larger because the likelihood of bankruptcy is larger. However, the empirical results are opposite to our priors. Investors were more likely to hold on to their shares when oil prices became lower. Possible explanations are that investors might have expected a quick rebound of oil prices from these "unsustainable" low levels or that investors expected policy responses such as firm bailouts.

III.2 On the Role of Debt

This section asks whether the effect of lower oil prices on oil firms' stock prices is larger for oil firms with a higher level of debt. In the baseline results, we consider the pre-existing debt position during the last quarter of the calendar year 2019.[18] In other words, we take the debt position and the firm's capital structure as given. We consider two measures of debt levels. First is total debt over assets. Total debt equals the sum of long-term and short-term debt. In addition, cash is also included. Second, we unpack total debt into long-term debt and short-term debt. Table 3 presents both the OLS and IV

[18] In the robustness section, we consider debt levels and other financial variables immediately for the previous quarter.

results about the role of total debt and cash, while Table 4 presents the OLS and IV results for separate debt categories.

Does debt mediate the effects of lower oil prices on the stock prices of U.S. oil firms? The short answer is yes, but the results are not robust. Since the OLS and IV results give qualitatively similar results, we focus on the IV results (columns [7] to [12] in Table 3). Special attention is given to the interaction between Δlog(oil)*TotalDebt/Assets.

When only total debt and cash are included, the interaction between total debt and logarithm changes in oil prices is significant and positive (column [7] of Table 3). This result implies that oil firms with higher debt at the end of 2019 see a larger elasticity between January and June 2020. The coefficient of 1.331 implies that when total debt over asset increases by 0.19 (or 19%, or one standard deviation), the oil price-stock price elasticity increases by 0.19*1.331=0.25. In other words, a 1 percent decrease in oil price causes a 0.25 percent large decrease in stock price when the total debt-asset ratio is one standard deviation higher, given the same level of cash-asset ratio.

However, the role of total debt is not robust. Both the magnitude and the significance of the interaction term Δlog(oil)*TotalDebt/Assets drop quickly after standard firm characteristics are progressively controlled for (see columns [8] to [12]). We consider the following firm characteristics: market to book ratio, assets, profitability (in Q4-2019), beta and momentum (calculated with 2019 data). They are standard firms' financial characteristics[19]. Beta and log of assets remain highly significant with stable magnitude when all firm characteristics are included (column [12]).

Why does the effect of net debt become less robust? One reason is the correlation between total debt, beta, and the logarithm of assets. In our sample, total debt over assets is strongly correlated with the logarithm of assets (the correlation is 0.62). In other words, in Q4-2019, larger U.S. oil firms also tended to have higher total debt over assets[20]. In addition, total debt over assets is also strongly correlated with beta (the correlation is 0.52).

Similar findings are obtained when net debt is divided into long-term debt, short-term debt, and cash. Results in Table 4 show that long-term debt seems to matter, but its effect is not robust. The findings are robust for both OLS and IV regressions. Let us focus on the IV results (columns [7] to [12] of Table 4). When only short-term debt and long-term debt are considered (column [7]), the interaction between change in the log of oil prices and long-term debt is positive and highly significant, indicating an important role of long-term debt. However, when more firm characteristics are controlled for, the significance and magnitude of the interaction drop. The coefficient becomes statistically insignificant with a much smaller magnitude (column [12]). Beta and logarithm of assets remain statistically significant with stable magnitude.

The finding casts doubt on the conventional wisdom that debt plays a big role in oil firms' viability when the oil price drops. Instead, factors such as assets and risk in 2019 (proxied by beta) are empirically shown to be more important by investors. Thus, it is possible that more risk-taking oil firms in 2019, which had a higher beta in 2019, suffered disproportionately more in 2020 when oil prices declined sharply. Accumulating large debt is just one component of these firms' risk-taking.

[19] See a discussion of firm's characteristics and firm stock prices in Fahlenbrach et al. (2020)

[20] Note that this does not contradict to Figure 1, since Figure 1 shows gross debt (total short-term and long-term debt).

IV. Robustness Checks and Extensions

This section explores the robustness of our main results and possible explanations.

IV.1 Controlling for Firm Characteristics in the Previous Quarters

In this robustness check, firm characteristics are controlled using the immediate previous quarter in the regressions instead of the end of the calendar year 2019 as in the baseline. Thus, for example, for a day in May 2020, firm characteristics will be at the end of calendar quarter I, 2020. This approach responds to the possibility that U.S. oil firms drastically changed their operations, such as cutting down (or expanding their debt) to respond to the Covid-19 crisis. If so, investors' assessments of a firm's characteristics, such as risk-taking behavior, could change rapidly. As a result, information in Quarter 4 2019 may be outdated.

The results are unchanged. Even if we use firm characteristics reported in the immediately previous quarter, the role of the firm's debt is not robust. Appendix Tables A4 and A5 report the results (only IV regressions) for total debt over assets (Table A4) and short-term and long-term debt (Table A5). The findings are that once controlling a firm's other characteristics, the firm's debt is found not to play a role in the transmission from lower oil prices to U.S. oil firms' stock prices.

IV.2 On the Role of Federal Reserve's Bond Purchasing Program

This subsection explores whether the Federal Reserve's bond purchase program impacted investors' perception of debt for oil firms. On March 17, 2020, the Fed announced a new facility with the authority to buy corporate paper from issuers who might otherwise have difficulty selling the paper on the market. The program is called Commercial Paper Funding Facility (CPFF).[21] We examine if the program has any impact by splitting our regressions into two periods, before and after March 17, 2020.

Table Appendix A6 shows that the role of debt is not robust both before and after March 17, 2020. This result suggests that the program did not affect the investors' perception of oil firms' debt. Nevertheless, we cannot categorically rule out the possibility that even before March 17, 2020, investors already expected such a program would be enacted. Indeed, the anticipation effect could have possibly driven their actions before the program was announced.

V. Conclusion

This paper examined to what extent debt played a role in the effects of oil price declines on stock prices of U.S. oil firms during the first six months of 2020. To our surprise, and in contrast to the popular belief among media and policy circles, the results do not support a robust role of oil firms' debt. Once standard firm characteristics are controlled for, the magnitude and significance of debt disappear. This phenomenon is robust to different categories of debt and different data timing. Instead, firm risk-taking measures, such as profitability and beta, played a robust and significant role in explaining the effects of oil price declines on U.S. oil firms' stock prices. The liquidity backstop provided by the Fed bond purchasing program appears not to have muted the role of debt for oil firms.

The finding has clear policy implications. If investors do not view debt as a significant factor in assessing a firm's viability when the oil price drops, the policy focus on oil firms' debt (such as buying debt of oil firms) could be misplaced and proved to be costly. If investors view firms' risk-taking behavior (proxied by beta in 2019) as the main driver of falling stocks, firms simply need to reduce risk taking.

[21] See Press Release regarding the CPFF.

Table 3: The Role of Debt.

*This table reports regression results regarding how the relationship between changes in oil prices and oil stock returns is mediated by total debt levels, with both OLS and IV approaches (heteroscedasticity-based identification). The dependent variable, Δlog(stock), is the daily return of a firm's stock price. Notes: Standard errors are in parentheses, * p < 0.10, ** p < 0.05, *** p < 0.01. Standard errors are clustered at the firm level. Total Debt, Cash, Asset, Market2Book, Log(Asset), and Profitability are measured in the last quarter of the calendar year 2019. Beta and Momentum are calculated with 2019 data.*

Δlog(stock)	OLS						IV					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Δlog(oil)	0.166***	0.0761	0.0922	0.0710	0.0788	0.0157	0.0934	-0.161	-0.141	-0.387***	-0.377**	-0.371***
	(0.0544)	(0.0709)	(0.0667)	(0.0630)	(0.0615)	(0.0995)	(0.139)	(0.146)	(0.149)	(0.146)	(0.147)	(0.140)
Δlog(oil)$_{t-1}$	0.0389**	0.0391**	0.0385**	0.0386**	0.0380**	0.0379**	0.0940**	0.0947**	0.0885**	0.0890**	0.0885**	0.0885**
	(0.0160)	(0.0161)	(0.0163)	(0.0163)	(0.0164)	(0.0163)	(0.0414)	(0.0420)	(0.0421)	(0.0421)	(0.0422)	(0.0423)
Δlog(stock)$_{t-1}$	-0.0453	-0.0459	-0.0457	-0.0459	-0.0450	-0.0447	-0.0546	-0.0563	-0.0550	-0.0565	-0.0553	-0.0553
	(0.0599)	(0.0605)	(0.0612)	(0.0612)	(0.0614)	(0.0613)	(0.0605)	(0.0627)	(0.0634)	(0.0636)	(0.0638)	(0.0642)
Δlog(oil)*TotalDebt/Assets	0.623***	0.465**	0.471**	0.447	0.409	0.427	1.331***	0.881***	0.810**	0.528	0.479	0.477
	(0.191)	(0.210)	(0.231)	(0.266)	(0.265)	(0.278)	(0.372)	(0.323)	(0.348)	(0.342)	(0.344)	(0.349)
Δlog(oil)*Cash/Assets	-0.193*	-0.139	-0.0809	-0.0607	-0.141	-0.125	-0.117	0.0363	0.132	0.364*	0.256	0.255
	(0.106)	(0.112)	(0.173)	(0.138)	(0.169)	(0.177)	(0.279)	(0.266)	(0.289)	(0.217)	(0.256)	(0.250)
Δlog(oil)*Beta		0.125*	0.120*	0.118	0.132*	0.136*		0.354***	0.366***	0.334***	0.353***	0.352***
		(0.0636)	(0.0676)	(0.0703)	(0.0737)	(0.0779)		(0.113)	(0.119)	(0.108)	(0.111)	(0.111)
Δlog(oil)*Market2Book			-0.0217	-0.0218	-0.0138	-0.0105			-0.0363	-0.0374	-0.0264	-0.0267
			(0.0363)	(0.0362)	(0.0417)	(0.0412)			(0.0483)	(0.0469)	(0.0540)	(0.0533)
Δlog(oil)*log(Assets)				0.00413	0.00139	0.00164				0.0477**	0.0441**	0.0441**
				(0.0141)	(0.0154)	(0.0157)				(0.0198)	(0.0214)	(0.0211)
Δlog(oil)*Profitability					0.553	0.555					0.729	0.729
					(0.497)	(0.476)					(0.734)	(0.736)
Δlog(oil)*Momentum						0.0312						-0.00297
						(0.0389)						(0.0666)
constant	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	5,203	5,203	5,082	5,082	5,082	5,082	5,203	5,203	5,082	5,082	5,082	5,082
r2	0.083	0.085	0.085	0.085	0.086	0.086						
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	Yes

Table 4: The Role of Long-term Debt, Short-term Debt, and Cash.

*This table reports regression results regarding how the relationship between changes in oil prices and oil stock returns is mediated by long- and short-term debt and cash, with both the OLS approach and the IV approach (heteroscedasticity-based identification). The dependent variable, Δlog(stock), is the daily return of a firm's stock price. Notes: Standard errors are in parentheses, * p < 0.10, ** p < 0.05, *** p < 0.01. Standard errors are clustered at the firm level. Long-term Debt, Short-term Debt, Cash, Asset, Market2Book, Log(Asset), and Profitability are measured in the last quarter of the calendar year 2019. Beta and Momentum are calculated with 2019 data.*

Δlog(stock)	OLS						IV					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Δlog(oil)	0.170***	0.0832	0.0965	0.0822	0.0873	0.0249	0.0900	-0.150	-0.135	-0.384**	-0.377**	-0.371***
	(0.0581)	(0.0698)	(0.0665)	(0.0664)	(0.0660)	(0.105)	(0.152)	(0.148)	(0.150)	(0.151)	(0.149)	(0.144)
$\Delta log(\text{oil})_{t-1}$	0.0389**	0.0391**	0.0384**	0.0385**	0.0380**	0.0378**	0.0940**	0.0946**	0.0884**	0.0890**	0.0885**	0.0885**
	(0.0160)	(0.0161)	(0.0163)	(0.0164)	(0.0164)	(0.0164)	(0.0414)	(0.0420)	(0.0421)	(0.0421)	(0.0422)	(0.0422)
$\Delta log(\text{stock})_{t-1}$	-0.0452	-0.0458	-0.0457	-0.0458	-0.0449	-0.0446	-0.0546	-0.0563	-0.0550	-0.0564	-0.0553	-0.0553
	(0.0599)	(0.0605)	(0.0612)	(0.0612)	(0.0614)	(0.0613)	(0.0606)	(0.0627)	(0.0634)	(0.0636)	(0.0638)	(0.0642)
Δlog(oil)*STDebt/Assets	0.304	-0.472	-0.336	-0.292	-0.163	-0.0775	1.587	-0.556	-0.415	0.336	0.521	0.512
	(0.846)	(0.975)	(0.928)	(0.965)	(1.072)	(1.092)	(1.836)	(1.097)	(1.108)	(1.470)	(1.681)	(1.686)
Δlog(oil)*LTDebt/Assets	0.619***	0.444**	0.456*	0.441	0.405	0.424	1.334***	0.849***	0.788**	0.526	0.479	0.477
	(0.191)	(0.213)	(0.232)	(0.266)	(0.265)	(0.277)	(0.379)	(0.324)	(0.350)	(0.342)	(0.344)	(0.348)
Δlog(oil)*Cash/Assets	-0.196*	-0.146	-0.0942	-0.0798	-0.154	-0.137	-0.114	0.0254	0.112	0.359	0.257	0.255
	(0.108)	(0.111)	(0.174)	(0.140)	(0.172)	(0.180)	(0.290)	(0.269)	(0.293)	(0.225)	(0.259)	(0.252)
Δlog(oil)*Beta		0.132*	0.126*	0.124*	0.136*	0.140*		0.365***	0.375***	0.336***	0.352***	0.352***
		(0.0659)	(0.0688)	(0.0732)	(0.0762)	(0.0798)		(0.115)	(0.120)	(0.111)	(0.114)	(0.113)
Δlog(oil)*Market2Book			-0.0189	-0.0192	-0.0119	-0.00898			-0.0323	-0.0367	-0.0265	-0.0268
			(0.0359)	(0.0355)	(0.0411)	(0.0406)			(0.0478)	(0.0467)	(0.0538)	(0.0533)
Δlog(oil)*log(Assets)				0.00273	0.000368	0.000737				0.0473**	0.0442**	0.0441**
				(0.0148)	(0.0161)	(0.0164)				(0.0205)	(0.0217)	(0.0213)
Δlog(oil)*Profitability					0.541	0.544					0.730	0.730
					(0.494)	(0.475)					(0.743)	(0.746)
Δlog(oil)*momentum						0.0303						-0.00291
						(0.0392)						(0.0667)
constant	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	5,203	5,203	5,082	5,082	5,082	5,082	5,203	5,203	5,082	5,082	5,082	5,082
r2	0.083	0.086	0.085	0.085	0.086	0.086						
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	Yes

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Online Appendix

Appendix Table A1: List of U.S. oil firms in our sample

This table shows the list of U.S. oil firms used in our analyses. Chevron and Exxon Mobile are not on the list because they are classified as multinational companies by Compustat. Source: Compustat.

AMEN PROPERTIES INC	HESS MIDSTREAM LP
AMPLIFY ENERGY CORP	HOUSTON AMERN ENERGY CORP
APA CORP	KIMBELL ROYALTY PARTNERS LP
BERRY CORP	KOSMOS ENERGY LTD
BLACK STONE MINERALS LP	MARATHON OIL CORP
BRIGHAM MINERALS INC	MATADOR RESOURCES CO
CALLON PETROLEUM CO/DE	MURPHY OIL CORP
CIMAREX ENERGY CO	OCCIDENTAL PETROLEUM CORP
CNX RESOURCES CORPORATION	PHX MINERALS INC
CONTANGO OIL & GAS CO	RANGE RESOURCES CORP
CONTINENTAL RESOURCES INC	RANGER OIL CORPORATION
COTERRA ENERGY INC	RESERVE PETROLEUM CO
DCP MIDSTREAM LP	ROYALE ENERGY INC
DEEP WELL OIL & GAS INC	SM ENERGY CO
DEVON ENERGY CORP	SOUTHWESTERN ENERGY CO
DIAMONDBACK ENERGY INC	SUMMIT MIDSTREAM PARTNERS LP
EOG RESOURCES INC	U S ENERGY CORP/WY
EQT CORP	VAALCO ENERGY INC
EVOLUTION PETROLEUM CORP	VOC ENERGY TRUST
FALCON MINERALS CORP	W&T OFFSHORE INC
GOODRICH PETROLEUM CORP	ZION OIL & GAS INC
HARVEST OIL & GAS CORP	

Appendix Table A2: Days with Significant Oil Supply News

This table shows the days identified as carrying significant oil supply news, linking to Seeking Alpha (www.seekingalpha.com) discussions.

Thursday, January 2, 2020	Top Iranian general killed in U.S. airstrike; Iran vows revenge; oil gains (updated)
Friday, January 3, 2020	Selloff deepens on Mideast strike; Oil +3.6%
Tuesday, January 7, 2020	Oil prices fall as Middle East supply fears recede
Monday, January 20, 2020	Supply threats push oil prices higher
Monday, February 3, 2020	Saudis seeking big short-term OPEC production cut - WSJ
Tuesday, February 4, 2020	Oil bounces as OPEC meets to assess virus impact on demand
Friday, February 7, 2020	Russia backs OPEC+ oil output cuts
Friday, February 21, 2020	Crude oil slips on reported Saudi-Russian rift
Monday, March 2, 2020	Oil surges ahead of OPEC meeting, potential production cut
Tuesday, March 3, 2020	OPEC committee recommends 600K bbl/day output cut
Wednesday, March 4, 2020	OPEC+ nears deal for 1M bpd in output cuts
Friday, March 6, 2020	Oil tumbles 4% on OPEC standoff, market selloff
Monday, March 9, 2020	"Historic" oil price war sends crude into downwards spiral
Tuesday, March 10, 2020	Oil stages 10% rebound rally after sharpest decline since 1991
Wednesday, March 11, 2020	Saudis boosting output even further; crude -2%
Friday, March 13, 2020	U.S. to buy 'large quantities' of oil for reserve, Trump says
Thursday, March 19, 2020	U.S. may intervene in Saudi-Russia oil standoff - WSJ
Friday, March 20, 2020	U.S. shale producers open talks with OPEC - WSJ
Tuesday, March 31, 2020	Energy shares rise as U.S, Russia agree to oil market talks
Wednesday, April 1, 2020	Trump, oil CEOs to meet about helping industry - WSJ
Thursday, April 2, 2020	Crude oil +10% on hopes for end to Saudi-Russian spat
Friday, April 3, 2020	Oil deal leaves questions unanswered; Crude +5%
Monday, April 6, 2020	Oil pares big losses as Saudis, Russia near deal
Tuesday, April 7, 2020	Oil -9% as oversupply concerns outstrip global deal hopes
Thursday, April 9, 2020	OPEC+ reaches deal on 10M barrel production cut - Reuters
Friday, April 10, 2020	Mexico makes production deal with Trump, part of OPEC+ agreement
Monday, April 13, 2020	Crude prices pull back from earlier gains as output deal 'too little too late'
Thursday, April 30, 2020	Crude up 16% as Norway adds to global supply cuts
Monday, May 11, 2020	Oil jiggy again on more Saudi production cut news
Wednesday, May 13, 2020	Saudi Arabia, Russia say they're committed to oil market stability
Wednesday, May 27, 2020	Oil prices dive as Russia considers easing supply cuts in July
Tuesday, June 2, 2020	Oil, energy stocks rally on tentative OPEC+ production deal
Wednesday, June 3, 2020	Saudi Arabia, Russia agree to extend output cuts - WSJ
Friday, June 5, 2020	Oil, energy stocks rally on tentative OPEC+ production deal
Monday, June 8, 2020	Oil slides as Saudis say extra cuts for a month only, but energy names rise
Monday, June 15, 2020	Oil rebounds on optimism over OPEC+ production pact

Appendix Table A3: Stock Price-Oil Price of Elasticity for each U.S. Oil Firm

*This table shows the average oil price – stock price elasticity for each of the U.S. oil firms in our sample, according to Equation (12) (equivalent to column [5] of Table 1), between January 2, 2020, to June 30, 2020. Note: *** p<0.01, ** p<0.05, * p<0.1*

Name	Elasticity	Name	Elasticity
AMEN PROPERTIES INC	-.205	HESS MIDSTREAM LP	.732*
AMPLIFY ENERGY CORP	.900	HOUSTON AMERN ENERGY CORP	.149
APA CORP	.926	KIMBELL ROYALTY PARTNERS LP	.109
BERRY CORP	.295	KOSMOS ENERGY LTD	.862
BLACK STONE MINERALS LP	.020	MARATHON OIL CORP	.843
BRIGHAM MINERALS INC	.427	MATADOR RESOURCES CO	1.237
CALLON PETROLEUM CO/DE	1.433	MURPHY OIL CORP	.615
CIMAREX ENERGY CO	.882*	OCCIDENTAL PETROLEUM CORP	1.008
CNX RESOURCES CORPORATION	.122	PHX MINERALS INC	.198
CONTANGO OIL & GAS CO	.652*	RANGE RESOURCES CORP	.095
CONTINENTAL RESOURCES INC	.850	RANGER OIL CORPORATION	1.118
COTERRA ENERGY INC	.013	RESERVE PETROLEUM CO	-.000
DCP MIDSTREAM LP	.517	ROYALE ENERGY INC	.269
DEEP WELL OIL & GAS INC	-1.06*	SM ENERGY CO	1.165
DEVON ENERGY CORP	.767*	SOUTHWESTERN ENERGY CO	-.083
DIAMONDBACK ENERGY INC	.844*	SUMMIT MIDSTREAM PARTNERS LP	.351
EOG RESOURCES INC	.505	U S ENERGY CORP/WY	.105
EQT CORP	.064	VAALCO ENERGY INC	.460*
EVOLUTION PETROLEUM CORP	.049	VOC ENERGY TRUST	.198
FALCON MINERALS CORP	.529*	W&T OFFSHORE INC	.670**
GOODRICH PETROLEUM CORP	.211	ZION OIL & GAS INC	.195
HARVEST OIL & GAS CORP	-.481		

Appendix Table A4: The Role of Debt (Robustness Check)

*This table reports regression results regarding how the relationship between changes in oil prices and oil stock returns is mediated by total debt and cash, using the IV approach (heteroscedasticity-based identification). The dependent variable, Δlog(stock), is the daily return of a firm's stock price. Notes: Standard errors in parentheses, * p < 0.10, ** p < 0.05, *** p < 0.01. Standard errors are clustered at the firm level. Total Debt, Cash, Asset, Market2Book, Log(Asset), and Profitability are measured in the immediately previous quarter. Beta and Momentum are 2019 data.*

IV	Δlog(stock)					
	(1)	(2)	(3)	(4)	(5)	(6)
Δlog(oil)	0.171	-0.103	-0.0742	-0.352**	-0.350**	-0.301*
	(0.149)	(0.159)	(0.162)	(0.152)	(0.150)	(0.157)
Δlog(oil)$_{t-1}$	0.127***	0.128***	0.122***	0.123***	0.123***	0.123***
	(0.0394)	(0.0399)	(0.0396)	(0.0397)	(0.0397)	(0.0397)
Δlog(stock)$_{t-1}$	-0.0716	-0.0739	-0.0705	-0.0714	-0.0713	-0.0713
	(0.0666)	(0.0686)	(0.0696)	(0.0698)	(0.0698)	(0.0700)
Δlog(oil)*TotalDebt/Assets	1.132***	0.701**	0.598*	0.285	0.295	0.280
	(0.367)	(0.311)	(0.346)	(0.336)	(0.341)	(0.343)
Δlog(oil)*Cash/Assets	-0.202	-0.0810	0.0460	0.297	0.283	0.269
	(0.290)	(0.265)	(0.265)	(0.196)	(0.203)	(0.181)
Δlog(oil)*Beta		0.368***	0.390***	0.348***	0.353***	0.347***
		(0.125)	(0.133)	(0.120)	(0.133)	(0.132)
Δlog(oil)*Market2Book			-0.0503**	-0.0452**	-0.0432*	-0.0440*
			(0.0228)	(0.0204)	(0.0229)	(0.0224)
Δlog(oil)*log(Assets)				0.0545***	0.0534**	0.0534**
				(0.0202)	(0.0219)	(0.0215)
Δlog(oil)*Profitability					0.0907	0.0766
					(0.417)	(0.433)
Δlog(oil)*Momentum						-0.0236
						(0.0764)
TotalDebt/Assets	0.0701*	0.0620	0.0727**	0.0585	0.0625	0.0646
	(0.0372)	(0.0387)	(0.0344)	(0.0396)	(0.0791)	(0.0793)
Cash/Assets	0.0299	0.00394	0.00989	0.0219	0.0227	0.0231
	(0.0326)	(0.0281)	(0.0289)	(0.0263)	(0.0300)	(0.0305)
Market2Book			0.000839**	0.000893**	0.000875**	0.000896**
			(0.000377)	(0.000410)	(0.000412)	(0.000425)
log(Assets)				-0.00452	-0.00429	-0.00446
				(0.00784)	(0.00801)	(0.00795)
Profitability					-0.00118	0.00136
					(0.0865)	(0.0866)
constant	yes	yes	yes	yes	yes	yes
Number of observations	4,962	4,962	4,841	4,841	4,841	4,841
Firm fixed effects	yes	yes	yes	yes	yes	yes

Appendix Table A5: The Role of Short-term and Long-term Debt (Robustness Check)

*This table reports regression results regarding how the relationship between changes in oil prices and oil stock returns is mediated by long- and short-term debt and cash, using the heteroscedasticity-based identification). The dependent variable, Δlog(stock), is the daily return of a firm's stock price. Notes: Standard errors are in parentheses, * p < 0.10, ** p < 0.05, *** p < 0.01. Standard errors are clustered at the firm level. Short-term and Long-term Debt, Cash, Asset, , Market2Book, Log(Asset), and Profitability are measured in the immediately previous quarter. Beta and Momentum are 2019 data.*

IV	Δlog(stock)					
	(1)	(2)	(3)	(4)	(5)	(6)
Δlog(oil)	0.170	-0.0929	-0.0658	-0.346**	-0.344**	-0.292*
	(0.161)	(0.161)	(0.164)	(0.156)	(0.155)	(0.162)
$\Delta log(\text{oil})_{t-1}$	0.127***	0.128***	0.122***	0.123***	0.123***	0.123***
	(0.0394)	(0.0399)	(0.0396)	(0.0397)	(0.0397)	(0.0397)
$\Delta log(\text{stock})_{t-1}$	-0.0717	-0.0736	-0.0702	-0.0713	-0.0713	-0.0713
	(0.0668)	(0.0687)	(0.0696)	(0.0699)	(0.0699)	(0.0701)
Δlog(oil)*STDebt/Assets)	1.263	-0.830	-0.691	-0.128	-0.122	-0.203
	(1.905)	(1.443)	(1.510)	(1.603)	(1.585)	(1.572)
Δlog(oil)*LTDebt/Assets)	1.132***	0.674**	0.578*	0.281	0.291	0.275
	(0.372)	(0.314)	(0.348)	(0.337)	(0.341)	(0.344)
Δlog(oil)*Cash/Assets	-0.204	-0.0870	0.0388	0.290	0.276	0.261
	(0.294)	(0.265)	(0.265)	(0.201)	(0.210)	(0.187)
Δlog(oil)*Beta		0.378***	0.398***	0.351***	0.356***	0.350***
		(0.126)	(0.134)	(0.122)	(0.136)	(0.134)
Δlog(oil)*Market2Book			-0.0495**	-0.0451**	-0.0430*	-0.0438*
			(0.0229)	(0.0204)	(0.0228)	(0.0223)
Δlog(oil)*log(Assets)				0.0539***	0.0528**	0.0528**
				(0.0204)	(0.0223)	(0.0217)
Δlog(oil)*Profitability					0.0908	0.0762
					(0.418)	(0.433)
Δlog(oil)*momentum						-0.0246
						(0.0769)
STDebt/Assets	-0.0452	-0.0691	-0.0502	-0.0942	-0.0838	-0.0819
	(0.122)	(0.131)	(0.134)	(0.127)	(0.119)	(0.118)
LTDebt/Assets	0.0804*	0.0739*	0.0851**	0.0720*	0.0908	0.0933
	(0.0433)	(0.0444)	(0.0403)	(0.0421)	(0.0945)	(0.0947)
Cash/Assets	0.00567	-0.0144	-0.00818	-0.00678	-0.00487	-0.00414
	(0.0386)	(0.0410)	(0.0425)	(0.0411)	(0.0395)	(0.0398)
Market2Book			0.000760**	0.000813**	0.000830**	0.000852**
			(0.000382)	(0.000409)	(0.000394)	(0.000404)
log(Assets)				-0.00527	-0.00418	-0.00431
				(0.00780)	(0.00777)	(0.00770)
Profitability					0.0143	0.0172
					(0.0908)	(0.0910)
Constant	yes	yes	yes	yes	yes	yes
Number of observations	4977	4809	4809	4809	4809	4809
Firm fixed effects	yes	yes	yes	yes	yes	yes

Appendix Table A6: The Role of Debt Before and After the Commercial Paper Funding Facility (CPFF) Program.

*This table reports IV regression results regarding how the relationship between changes in oil prices and oil stock returns is mediated by total debt and cash before the announcement of the Commercial Paper Funding Facility (CPFF) Program on March 17, 2020 (Panel A) and after the announcement (Panel B). The dependent variable, Δlog(stock), is the daily return of a firm's stock price. Notes: Standard errors are in parentheses, * p < 0.10, ** p < 0.05, *** p < 0.01. Standard errors are clustered at the firm level. Firm fixed effects are included. Total Debt, Cash, Asset, Market2Book, Log(Asset), and Profitability are measured in Q4-2019. Beta and Momentum are 2019 data.*

Panel A: Before the announcement of the Commercial Paper Funding Facility (CPFF) Program

	Δlog(stock)					
Δlog(oil)	0.480**	0.134	0.176	-0.505**	-0.477*	-1.098***
	(0.237)	(0.302)	(0.282)	(0.255)	(0.266)	(0.380)
Δlog(oil)$_{t-1}$	0.209***	0.212***	0.196***	0.191***	0.192***	0.191***
	(0.0749)	(0.0762)	(0.0740)	(0.0730)	(0.0733)	(0.0734)
Δlog(stock)$_{t-1}$	-0.0217	-0.0250	-0.0226	-0.0181	-0.0186	-0.0175
	(0.0667)	(0.0679)	(0.0678)	(0.0668)	(0.0670)	(0.0669)
Δlog(oil)*TotalDebt/Assets	2.597***	1.987**	1.978**	1.193	1.068	1.234
	(0.873)	(0.905)	(0.998)	(0.989)	(0.984)	(1.061)
Δlog(oil)*Cash/Assets	-0.585	-0.378	-0.145	0.513	0.202	0.432
	(0.502)	(0.520)	(0.807)	(0.626)	(0.718)	(0.760)
Δlog(oil)*Beta		0.481*	0.475*	0.388	0.434	0.476
		(0.251)	(0.267)	(0.260)	(0.269)	(0.291)
Δlog(oil)*Market2Book			-0.0609	-0.0668	-0.0382	-0.0321
			(0.117)	(0.118)	(0.134)	(0.126)
Δlog(oil)*log(Assets)				0.133**	0.123**	0.126*
				(0.0566)	(0.0608)	(0.0657)
Δlog(oil)*Profitability					1.897	1.861
					(1.723)	(1.564)
Δlog(oil)*Momentum						0.314*
						(0.167)
Number of observations	2,150	2,150	2,100	2,100	2,100	2,100
Firm fixed effects	yes	yes	yes	yes	yes	yes

Panel B: After the announcement of the Commercial Paper Funding Facility (CPFF) Program

	Δlog(stock)					
Δlog(oil)	-0.159	-0.371**	-0.345*	-0.410*	-0.406*	-0.108
	(0.159)	(0.185)	(0.208)	(0.249)	(0.247)	(0.174)
$\Delta log(\text{oil})_{t-1}$	-0.0970*	-0.0970*	-0.101*	-0.101*	-0.101*	-0.102*
	(0.0532)	(0.0532)	(0.0543)	(0.0543)	(0.0543)	(0.0543)
$\Delta log(\text{stock})_{t-1}$	-0.0682	-0.0689	-0.0694	-0.0702	-0.0696	-0.0714
	(0.0726)	(0.0753)	(0.0762)	(0.0766)	(0.0767)	(0.0785)
Δlog(oil)*TotalDebt/Assets	0.760**	0.386*	0.257	0.183	0.169	0.0725
	(0.314)	(0.203)	(0.234)	(0.211)	(0.210)	(0.211)
Δlog(oil)*Cash/Assets	0.0874	0.215	0.324	0.384	0.352	0.292
	(0.314)	(0.310)	(0.268)	(0.278)	(0.298)	(0.246)
Δlog(oil)*Beta		0.294***	0.317***	0.308***	0.314***	0.295***
		(0.113)	(0.116)	(0.111)	(0.112)	(0.0774)
Δlog(oil)*Market2Book			-0.0508	-0.0508	-0.0473	-0.0711
			(0.0694)	(0.0679)	(0.0696)	(0.0690)
Δlog(oil)*log(Assets)				0.0125	0.0114	0.0102
				(0.0141)	(0.0144)	(0.0127)
Δlog(oil)*Profitability					0.219	0.204
					(0.541)	(0.655)
Δlog(oil)*Momentum						-0.145***
						(0.0532)
Number of observations	3,053	3,053	2,982	2,982	2,982	2,982
Firm fixed effects	yes	yes	yes	yes	yes	yes