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Stock Returns, Oil Prices, and Leverage: Evidence from U.S. Firms

Md Ruhul Amin*` and Andre Varella Mollick**

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Abstract

This paper examines how the relationship between stock returns of U.S. firms and WTI oil prices is affected by leverage (debt to total assets) from 1990 to 2020. Results from our fixed-effect regression models suggest that leverage effects on stock returns are pervasive both in aggregate and cross-industry levels, while the mining industry is more sensitive. In addition to the positive oil price effects attenuated by leverage at the aggregate level, we observe stronger marginal effects of leverage only for the mining sector. Being more exposed to commodity prices, the positive effects of oil prices on stock returns in the mining sector are offset by large debt ratios. Asymmetries, effects of debt maturity structure, and implications are also discussed.

JEL Classification Numbers: D25, F65, Q40.

Keywords: Leverage, oil price returns, stock returns, United States.

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1. Introduction

As the most strategic input in the production process and transportation costs, oil price tends to have a significant cash flow claim, which in turn, leads to affect stock returns. Since rising oil prices increase the cost of running business operations and the discounting rate in the stock valuation (Sadorsky, 2008), fluctuations in oil prices continue to induce strong interest from investors, regulatory authorities (central banks), and academic researchers. However, though there is no consensus among academic researchers¹ on the effect of oil prices changes on stock returns, investigating how a firm-specific variable (e.g., leverage) that has also a cash flow claim affects this oil price and stock returns relation is largely ignored in the academic literature. In this study, we attempt to fill this gap in the literature by investigating whether a firm's leverage acts as an important channel in the relationship between stock returns and oil price returns.

In times of oil price collapse, the financial conditions of energy firms worsen due to the sudden decline in revenues. For example, in June 2014, the nominal Brent price² of crude oil began to drop rapidly, falling from \$112 to \$62 in December, which is a 6-month decline of 44% and the drop continued to early January of 2016 to \$31 per barrel, a cumulative decline of more than 70%. Combined with the high costs of building equipment and R&D expenditures of previous boom cycles, this leads to falling profits, which in turn result in lower stock returns of firms in the energy sector. Recent events induced by the very sudden decline in oil demand associated with the coronavirus (COVID-19) outbreak in March of 2020 illustrate the very fragile state of energy companies, which are associated with high levels of debt. Dezhnev (March 11, 2020) writes that “The main U.S. oil price, WTI, fell 25% on Monday while Brent crude, the international

¹ Negative oil price effects on stock returns are shown by Kling (1985) and Jones and Kaul (1996). On the other hand, positive oil price effects on stock returns are shown by Prabheesh et al. (2020) and Mohanty et al. (2011). In contrast, Chen et al. (1986) and Wei (2003) show evidence of no oil price changes effect on stock returns.

² See here <https://fred.stlouisfed.org/series/DCOILBRETEU>

benchmark, lost 24% in oil's biggest daily decline since 1991... Energy companies borrowed hundreds of billions of dollars to drill miles-long and multimillion-dollar wells, lay pipelines between customers and new drilling regions and maintain huge fleets of heavy machinery. Investors snapped up their bonds, which offered higher yields than many other forms of debt. ... A string of bankruptcies in the oil patch triggered a junk-bond selloff in 2015. North American oil-and-gas companies have more than \$200 billion of debt maturing over the next four years, according to Moody's Investors Service..."

Energy firms are heavily dependent on positive oil prices changes to generate enough cash flow. When oil prices increase, cash flows of energy firms also increase, which bolsters their ability to invest in research & development (R&D), expansion of production facility/wells, or other revenue-generating projects. This investment may result in positive stock returns of energy firms, which is well understood from the revenue channel of oil prices increase. However, little is known about the impact of oil prices changes on stock returns of aggregated/overall industry and manufacturing industry conditioning on firm characteristics (e.g., leverage).

Oil prices increase could influence stock returns of the overall industry or manufacturing industry through two potential channels. First, firms from the overall or manufacturing industry are heavily dependent on oil consumption. When oil prices increase, their operating costs and transportation costs increases. This increasing operating costs due to oil prices increase may have a direct impact on firms' internal financial resources to invest in profitable projects. When investment is sensitive to increasing operating costs from the operating cost channel of oil prices increase, it is reasonable to expect that oil prices increase may negatively affect stock returns of the aggregated industry. Second, oil prices increase may reflect the advancement of the overall economy or more value-increasing investment opportunities for firms. On one side, U.S. becomes

the net oil exporter from net oil importer (Rapier, 2017). The oil exporter status of the U.S. stems from substantially increased oil production due to the development of new techniques (Thorbecke, 2019). On another side, simultaneously, the U.S. Federal Reserve attempted to boost the economy by providing liquidity and support through a range of programs to financial markets and institutions. These scenarios best explain that oil prices increase represents overall economic development and opens profitable investment opportunities. Hence, from the economic development/investment opportunities channel of oil prices increase, when oil prices increase positively influences investment opportunities, it is also reasonable to hypothesize that oil price could positively affect stock price returns.

However, whatever the channel through which oil prices increase affects firms' stock returns, the marginal effect could vary conditioning on the degree of leverage or when firms are highly levered firms. Because leverage induces firms' cash flow constraints. The levered firm has a fixed debt servicing obligation in a given year. For example, leverage requires a significant amount of cash outlay to cover the repayment of interest and part or full principal on a debt for a particular period. Myers (1977) suggests that a firm's leverage reduces cash flow through interest payments and existing debt claims can make it difficult to raise additional external capital to finance a positive NPV project. Prior research suggests that investments are likely to increase with available cash (Rauh, 2006) and decrease with leverage (Lang et al., 1996). Rauh (2006) argues that firms must make financial contributions to their sponsored defined benefit pension plans for employees. This mandatory contribution negatively affects their ability to invest in new capital, R&D, or value-increasing acquisitions, when firms are financially constraints.

In this line of argument (cash flow constraints channel of leverage), it is reasonable to hypothesize that leverage could negatively affect the oil prices and stock returns relationship, no matter oil prices increase affect firms' stock returns from revenue channel or investment opportunities channel. If oil prices increase affects stock returns through the operating costs channel, we expect from the cash flow constraint channel of leverage that leverage will aggravate the negative effect of oil price increase on stock returns. It is also important to investigate the dissimilar effect across industries and over the different time periods with respect to the degree of firms' leverage. For example, the cross-industry and different times analysis can explain the previously documented mixed effects of oil prices on stock returns.

In this study, we cover a long period of US firms from 1990 to 2020, which is long enough to include four U.S. recessions, most recently the global financial crisis of 2007-2009 and the 2020 caused by COVID-19. We analyze the effect of oil price on US firms stock returns with respect to leverage considering full sample and cross-industries. Existing literature (see Davis and Haltiwanger, 2001, and Lee and Ni, 2002) suggests mixed and dissimilar oil effects across industries. Results are shown for the full sample and selected sectors (manufacturing, mining, and transportation) to illustrate the price and leverage channels on stock returns across these industries. Our results suggest that one standard deviation increase in a firm's leverage leads stock returns to drop by 3.99% for the sample of all firms. This effect is very close to manufacturing (stock returns drop by 3.49%) but the firm's leverage leads stock returns to drop by 9.39% in the mining sector and by 4.42% in the transportation sector. Consistent with the economic development or investment opportunities channel of oil prices increase, we find a positive effect of oil price on US firms' stock returns. As expected, the effect of oil price returns on stock returns is much higher in

mining than in manufacturing or transportation sectors. These results are in line with those of Boyer and Filion (2007) and Al-Mudhaf and Goodwin (1993). The well-known fact is that commodity price booms and busts are primarily driven by the fluctuations in global demand emanated from unexpected shifts in global real economic activity (Killian, 2009 and Jacks and Sturmer, 2020). This phenomenon explains more investment opportunities, which leads to a positive relationship between oil price and stock returns in overall firms. In line with our cash flow constraints hypothesis, we find that the positive effect of oil prices on US firms' stock returns is attenuated by the degree of leverage. As suggested by Denis and Denis (1993); Lang et al. (1996); and Raugh (2006), cash flow constraints further aggravate the stock returns due to reduction in investment, we find consistent evidence of leverage on our oil price and stock returns relationship. For the overall and the mining sector only, the interactive terms between oil price and leverage are negative and statistically significant, implying that the positive effects of oil prices on the mining companies' stock returns are offset by the large debt ratios. In our cross-sectional analyses, we show the asymmetric effect of leverage, upward and downward movement of oil price, debt maturity structures, and financial crisis on the relationship between oil price and stock returns.

This study offers several contributions to the literature and to the understanding of how stock markets react to oil prices. Firstly, this paper blends the literature on firm leverage with the evidence on stock returns of firms to oil price movements: one on corporate debt and its effects on the stock market and another on the relationship between stock returns and oil prices over time and sectors of activity. Secondly, by providing evidence on how stock returns respond at the industry level, this paper complements studies quantifying the impact of oil prices on corporate bonds. Using a global sample from 2003 to 2015, Donders et al. (2018) measure how corporate bonds react to commodity prices. Weijermars et al. (2019) examine the negative 2014-2016 oil

price shock to verify the impact on the creditworthiness of North American oil companies. Thirdly, we strengthen the theory of leverage effect in the relationship between economic shocks (e.g., oil prices) and stock returns. We also complement Sadorsky (2008), who shows the oil price effect on firms of different sizes. We explore another important firm-level factor that influences the oil price effect on stock returns. Finally, we reconcile previously documented mixed findings of oil price on stock returns and recommend an important policy implication for energy firms on the degree of leverage to realize the positive effect of oil prices.

This paper is organized as follows. Section 2 reviews representative studies covering corporate debt and stock prices and between stock returns and oil prices. Section 3 describes the data and sample selection procedures. Section 4 summarizes the empirical methodology and the main hypotheses on oil price returns, leverage, and macroeconomic and firm-level controls. Section 5 presents the results for the whole industry and those for three industries varying greatly in oil price sensitivity, along with asymmetric effects of leverage and oil returns on stock returns, debt maturity structures, and time subsample analysis for before and after the global financial crisis. Section 6 concludes the paper.

2. Literature Review

Our study combines two strands of literature linking stock market returns to corporate debt and also how stock returns respond to oil prices over time and sectors. Leverage may amplify the downturn from oil prices in firms in the energy sector. As noted by Elliott and Eaton (March 2, 2020): “Many companies have financial hedges in place that insulate much of their production from falling crude and natural-gas prices, but in most cases, a sizable portion of production remains exposed. Those with hefty debt loads have particularly little room for error.” In the academic

literature, leverage explains a major portion of the stock returns premium in studies by Ozdagli (2012) and Obreja (2013). Choi and Richardson (2016) show that firms' equity volatility is largely associated with their financial leverage and argue that financial leverage does matter in explaining movements in equity volatility. Leverage may also have asymmetric effects on firms' outcomes. For example, for a sample of 6 Western European countries, Cathcart et al. (2020) have small and medium firms with higher default risk than their large peers. The cross-section of equity returns is heterogeneous within levered firms (Doshi et al., 2019) and investors experience significant return premiums of low leveraged stock (George and Hwang (2010)). Donangelo et al. (2019) show that levered firms' operating profits are more sensitive to economic shocks, such as oil prices and economic policy uncertainty.

The literature covering stock returns and oil price movements is very extensive. Recent works include Baur and Todorova (2018), who investigate the oil price sensitivity on the stock returns of the world's largest automobile companies. Ferrer et al. (2018) apply connectedness methods of time and frequency dynamics among stock prices of U.S. clean energy companies, crude oil prices, and key financial variables. Smyth and Narayan (2018) review the field and Herrera et al. (2019) provide a recent survey on the effects of oil on economic activity in the U.S. Several authors use frequency domain, dynamic correlations, and VAR methods.³

A class of papers adopts multifactor models of stock returns, with key macroeconomic factors and oil price returns measured in several ways. After Chen et al. (1986) find no responses from oil to U.S. stocks and Jones and Kaul (1996) find negative effects, other studies include

³ Frequency domain studies include Ciner (2013) and Creti et al. (2014), who verify the interdependence between stock markets and oil prices by oil importers and exporters using frequency domain plus cointegration. Reboredo and Rivera-Castro (2014) perform wavelet analysis for the U.S. and Europe. For time-varying evidence, Filis et al. (2011) compare oil-importing to oil-exporting countries and Degiannakis et al. (2013) provide evidence from Europe. For VAR approaches, see Park and Ratti (2008). For those expanding on the VAR methodology initiated by Killian and Park (2009), Kang et al. (2017) examine major oil and gas companies under monthly data.

Sadorsky (2001) for the Canadian oil and gas sector, El-Sharif et al. (2005) for the U.K., Boyer and Filion (2007) for Canada, Driesprong et al. (2008) for aggregate stock markets, Nandha and Faff (2008) for the responses of global sectors of activity, and Mohanty and Nandha (2011) for individual U.S. oil and gas companies. Higher frequency data studies by Arouri et al. (2011) use daily data with mixed effects in the Gulf Cooperation Council aggregate stock markets responding to oil prices. Narayan and Sharma (2011) put forward hypotheses for 560 U.S. firms listed on the NYSE with daily data from 2000 to 2008: oil prices affect sector returns differently, there are lagged effects, and there is strong evidence of size effects (using firm turnover rate to measure size). MGARCH estimates for U.S. stock returns (DJIA, S&P 500, NASDAQ and Russell 2000) by Mollick and Assefa (2013) with daily data from 1999 to 2011 confirm time-varying responses with strong positive effects of oil prices on stock returns from mid-2009 onwards following the recovery from the global financial crisis. Mollick and Nguyen (2015) find with daily data from 1992 to 2012 that stock returns of U.S. oil and gas companies have stronger oil price effects downwards, and that oil price effects increase over time.

Another body of work quantifies the volatility of oil prices and their effects on firm investment or the level of debt. Korotin et al. (2017) propose an algorithm to build an optimal debt structure to act as reducing financial risk in the case of an oil company subject to oil price uncertainty. Maghyreh and Abdoh (2020) employ annual data for estimating investment expenditures by firms on oil price uncertainty, controlling for firm-level attributes, such as leverage, cash flow, and profits. They use monthly data from 1984 to 2017 to obtain a measure of annual real oil price uncertainty and document asymmetries of oil price return uncertainty on investment: investment falls by more following volatility of positive oil price changes than that of negative changes.

Recent academic studies (Kim and Choi (2019) for U.S. oil and gas firms and Narayan and Nasiri (2020) for a sample of global firms) explain how capital structure moves with oil prices. Narayan and Nasiri (2020, p. 2) state that “Our study is the first to develop the relation between oil and corporate debt and show how oil prices and other oil market variables impact corporate leverage. In this regard, our work complements those of Kim and Choi (2019).” These recent papers documenting the response of leverage to oil price changes stand on the other side to those reviewed above that abundantly investigate the effect of oil prices on stock returns. However, this branch of literature lacks an investigation on the joint effects of leverage and oil price on U.S. firms’ stock returns. In this study, we attempt to fill this gap in the literature by investigating how the stock market responds to our two key factors: leverage (debt to assets) ratio and oil price returns.

Based on the extensive literature review and discussion in the Introduction, we hypothesize that oil price is negatively related to stock returns from the operating costs point of view of oil prices increase. Alternatively, we should also observe a positive relationship between oil price and stock returns from the advancement of real economic activities or investment opportunities point of view. For example, Chen et al. (2020) show that acceleration of China’s industrialization and urbanization demands for crude oil, which leads to positive oil price changes and an economic boom. If oil price changes promote economic activities or further investment opportunities, the hypothesized positive relationship between oil price and stock returns is justified. Additionally, based on cash flow constraints (outline in the Introduction section), we assume a negative (aggravating) effect of leverage on the relationship between oil price and stock returns when oil prices increase affect through revenue channel or investment opportunities channel (operating costs channel).

3. The Data & Sampling

We combine various datasets in this study. Our firm-level key independent variable (Leverage) comes from annual *Compustat* data. Stock returns and S&P 500 composite index data are from the CRSP database, measured as continuously compounded annually company returns using the daily CRSP stock returns. Following standard practice, we delete financial institutions [Standard Industrial Classification (SIC) Codes 6000-6999] and utility suppliers [Standard Industrial Classification (SIC) Codes 4900-4999]. The yield spread (the difference between 10-Year and 3-Month U.S. Treasury Constant Maturity rates) and WTI oil price data come from the Federal Reserve Bank of St. Louis. Fama-French factors are taken from the Kenneth R. French website. To address the effect of outliers, we winsorize all continuous variables at the bottom and top 1 percent. Our sample period begins in 1990 and ends in 2020, which includes four recessions in the U.S.: the 1990-1991, the 2001, the global financial crisis of 2007-2009, and the 2020 caused by COVID-19 in the first quarter of 2020. We exclude the observation year that has missing values. We use yearly frequency data and restrict the sample to a balanced panel data sample. Total firm-year observations are 16,244 with 524 unique firms.⁴

Figure 1 shows that stock returns and oil price returns are positively related, which is very clear from the global financial crisis onwards. Investors earn higher stock returns during upward oil price changes more recently. During pre-recession periods of 1998-2000 and 2006-2007, stock returns and oil price returns are negatively related, which preceded the more recent developments in U.S. oil production. Figure 2 shows that stock returns and leverage are negatively related,

⁴ An anonymous referee asked an update by the mid of 2021 to incorporate sufficient COVID-19 period. Our earlier sample was from 1990 to 2017 and we were able to update the dataset with three full years, which includes 2020, the first year of COVID-19. Our main research question focusing on debt and oil prices is a long-run one but future research may address COVID-19 aspects with higher frequency data. In the current set-up with 31 years of data reestimating the model for 2020 year alone would incur an approximate number of observations of 500, which is statistically possible to do, yet would not allow for the joint influence of debt and oil prices over time.

suggesting that investors of firms with high leverage experience lower stock returns, all else constant. As a firm indicator to total firm size (assets), leverage fluctuates, over the 1990-2020 period, in the range from a little below 0 to 0.765, while stock returns were negative mostly during the global financial crisis, as well as in the prior recessions of 1990 and 2001. A figure available upon request shows that WTI oil price returns and oil price return volatility alternate between negative and positive patterns.⁵

Table 1 shows the descriptive statistics for the variables used in this study. Panel A shows the sampling distribution by major industries. In our sample, the highest number of firms is from the manufacturing industry (about 61%), followed by the service industry (about 12%). Firms from the transportation and mining industries, respectively, represent about 6% of our total sample.⁶ Panel B shows the summary statistics for the variables in the regression. The mean (median) stock return is 17.2% (11.4%) with a standard deviation of 46.7%. The mean (median) oil price return is 1.7% (1.9%) with a standard deviation of 34.7%: This suggests that WTI returns have too much volatility compared to stocks, the other risky assets. Firms have on average around 22.0% debt (leverage) relative to their total assets with a standard deviation of 17%. In Panel C, the debt to asset ratio is highest in the transportation sector (28.4%) and lowest in the manufacturing sector (21.3%), with the mining sector in between with a 24% leverage ratio. Standard deviations of leverage to total assets are similar across the three sectors displayed in Panel C (from 16.1% to 17.2%).

⁵ Oil price return volatility is used as control in the empirical models below. The 2007-2009 crisis shows spikes in volatility of oil price returns with negative stock returns. Since then, both series have comoved more closely.

⁶ Maghyreh and Abdoh (2020) employ a comprehensive panel data set of U.S. firms from 1984 to 2017 and adopt a similar sample selection procedure as the one described above. They arrive at the following sector shares: 42.33% for manufacturing companies, 9.37% for transportation and communication companies, and 6.97% for mining companies.

4. Empirical Methodologies

In order to estimate the effect of oil price changes on the firm's stock returns, we employ the following fixed-effect model that allows for a constant term varying by company, i and allows for firm characteristics (leverage) and a set of controls including the aggregate market stock returns and the yield curve:

$$\text{Stock Return}_{it} = a_{0i} + \beta_1 \text{Leverage}_{it} + \beta_2 \text{Oil return}_t + \beta_3 \text{Oil return volatility}_t + \sum_{j=4}^n \beta_j \text{Controls}_{it} + \varepsilon_{it} \quad (1),$$

$$\text{Stock Return}_{it} = a_{0i} + \beta_1 \text{Leverage}_{it} + \beta_2 \text{Oil return}_t + \beta_3 \text{Leverage}_{it} * \text{Oil return}_t + \beta_4 \text{Oil return volatility}_t + \sum_{j=5}^n \beta_j \text{Controls}_{it} + \varepsilon_{it} \quad (2),$$

where the stock return is the dependent variable, measured as continuously compounded annually company returns using the daily CRSP stock returns. Our key independent variables are leverage and oil prices return. Leverage is the ratio of a firm's total debt to total assets from Compustat's yearly data. Oil prices return is the daily WTI log price difference compounded annually. Using lower frequency variables such as annual sales in dollars, Sadorsky (2008) estimates negative size effects on stock returns and negative oil price return effects for S&P 1500 firms from 1990 to 2006. Motivated by financial press accounts and studies of debt and firm performance, we pursue this fixed-effects model estimation approach further in this paper since leverage requires low-frequency data to examine our hypothesis that leverage offsets the impact of oil prices on the stock returns of firms. We explore the leverage ratio in stock return regressions

along with oil price returns. Recent approaches focusing on leverage ratio as endogenous in regressions include Kim and Choi (2019) for U.S. oil and gas firms and Narayan and Nasiri (2020) for a sample of global firms when explaining how capital structure (debt to equity or debt to assets) responds to oil prices. While stock returns move frequently, the share of debt to assets can only be observed by inspection of financial statements of firms to compute the extent of debt relative to assets. If the leverage effect is operative, increases in the debt to asset ratio will be priced negatively in the stock prices of companies.

We stipulate as follows in terms of the multiplicative interactive term $\text{Leverage} \times \text{Oil returns}$ in (2): X (oil price returns) is associated with an increase in Y (stock returns of firms) when condition Z is met (low level of debt to assets), but not when the level of debt is high. In (1), oil price returns have a constant effect on stock returns given by β_2 , while the model with interaction given by (2) implies that the effect of a change in X on Y depends on the value of the conditioning variable Z (leverage). With interactions, the partial derivative of stock returns to oil price returns becomes $\beta_2 + \beta_3 Z$, where Z can be evaluated at sample means.⁷

Oil return is the daily WTI log return compounded annually from the FRED database of St. Louis Federal Reserve.⁸ To the extent that oil prices contribute to revenues (mining companies) or costs (transportation companies), a market downwards movement in oil prices will aggravate the negative effect caused by debt for energy companies and mitigate the negative effect caused by debt for transportation companies. We investigate this hypothesis in this paper allowing for standard controls on stock returns. Oil return volatility is computed as the square root of the sum

⁷ Brambor et al. (2006) review multiplicative interactive models in political science and point out conditions that should be observed for their appropriate use: a conditional hypothesis is formulated, all constitutive terms should be included and interpreted properly, and the corresponding calculation of marginal effects.

⁸ See at <https://fred.stlouisfed.org/series/DCOILWTICO>

of squared daily WTI log price difference return for each year. The stance of monetary policy is considered by accounting for the yield spread, which is 10-Year Treasury Constant Maturity minus 3-Month Treasury Constant Maturity from Fred Reserve Economic Data⁹. By capturing the slope of the yield curve, the yield spread has several advantages over a specific interest rate to gauge whether the central bank has been accommodative or not. To incorporate market returns, we use either CRSP valued weighted (CRSP V-W) market return or S&P 500 stock returns. S&P500 stock return is the S&P 500 return, defined as: $(SPINDEX(t)/SPINDEX(t-1)) - 1$ and continuously compounded the S&P 500 return for annual returns. SMB (Small Minus Big) is the average return on the nine small stock portfolios minus the average return on the nine big stock portfolios from the Kenneth R. French website.¹⁰ HML (High Minus Low) is the average return on the two value portfolios minus the average return on the two growth portfolios, from the Kenneth R. French website.

Based on finance theory, β_1 is expected to exert negative effects on market valuation, at least after some critical level of debt is reached. The stock return response will be negative provided debt is “priced in” stock prices. This is also what we conclude from our data sample when we sort by quintiles firms by different levels of debt: the more debt, the lower stock returns. Our approach to obtaining the β_1 -coefficient from (1) or (2) above provides a straightforward interpretation on how stock returns respond to leverage ratios, oil price returns, and controls, without assuming the two-stage approach of including debt when explaining the oil price exposure in the next step.¹¹

⁹ See at <https://fred.stlouisfed.org/series/T10Y3M#0>

¹⁰ See at https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

¹¹ A related literature explores firm debt in a two-step procedure after firm stock returns are regressed on commodity prices and the aggregate stock market. Hong and Sarkar (2008) introduce firm leverage to affect the firm stock price response to commodity price when controlling for the aggregate market. Talbot et al. (2013) investigate the oil price exposure of 59 North American oil firms from 1999 to 2008 under fixed-effects models and document positive WTI

The extensive literature review between stock returns and oil price returns suggests that the β_2 -coefficient varies over time. When the U.S. economy was heavily dependent on oil imports in the 1970s and 1980s, the stock market responded negatively to higher oil prices. More recently, as the U.S. developed new techniques that substantially increased oil production, the impact turns out to be positive, as reported by Thorbecke (2019).

Recall that “the coefficient on X only captures the effects of X on Y when Z is zero. Similarly, it should be obvious that the coefficient on Z only captures the effect of Z on Y when X is zero. It is, therefore, incorrect to say that a positive and significant coefficient on X (or Z) indicates that an increase in X (or Z) is expected to lead to an increase in Y.” Brambor et al. (2006, p. 72.) The relevant interpretation is to look at the total effect on stock returns with respect to oil returns as the sum of the direct and indirect (marginal) effects: $\beta_2 + \beta_3 Z$.

On the controls, oil return volatility is expected to be positive since more volatility in oil prices tends to lead to higher stock prices with more trade volume. The yield spread is expected to be positive since a positively sloped yield curve tends to be good for business, thus pushing stock prices higher; conversely for an inverted yield curve which is normally taken to be an indicator of recessions. Jansen and Zervou (2017) provide time-varying effects of surprise increases on the Federal Funds rate on U.S. stock returns. The aggregate stock market is expected to have positive effects and close to 1 coefficient if firms respond in the same way to the overall market. The Fama-French factors (SMB, HML) are both expected to be positive since smaller firms tend to have higher returns than large ones and the average return on value portfolios (low book to market) is higher than growth portfolios (high book to market). Overall, all the controls in models (1) and (2)

price effects, negative oil price volatility, positive 10-year bond yield effects and positive cost-of-carry (6-month forward minus spot) effects.

(oil price volatility, yield spread, aggregate stock market, Fama-French factors) have positive signs, as expected in regressions assumed to explain stock returns.

We examine the relationship between stock returns and oil price returns incorporating leverage ratios using models (1) and (2) in a feasible generalized least squares (FGLS) panel data framework with variance-covariance matrix robust to serial correlation and heteroskedasticity. Firm fixed effects are included, which can be broadly interpreted as effects existing at firms correlated with leverage ratios. The approach is similar to Sadorsky (2008), who investigates firm size measured by annual sales.¹² We next explore asymmetries in the oil-stock relationship, which have been investigated by Sadorsky (2008), Ramos and Veiga (2013), and Tsai (2015), among others. We define oil returns up for positive WTI oil returns (0 otherwise) and oil return down for negative WTI oil returns (0 otherwise). A dummy variable for high leverage is also defined with 1 if leverage is above the sample median and 0 otherwise.

5. Results

a. Univariate analysis

Table 2 Panel A shows the bivariate correlation coefficients among variables. One of the key variables of interest is the firm's leverage, which has a negative but low correlation coefficient with stock returns: -5.9%. The other is oil price returns, which are positively correlated with stock returns with a correlation coefficient of 6.8%. Company stock returns are positively correlated

¹² The forecasting literature provides popular predictors for stock returns, in which dividend-price, dividend-yield, earnings-price, and book to market ratio have been tested along with macro components, such as interest rates or inflation. Wang et al. (2019) provide recent evidence for the U.S. equity premium.

with the market: 0.322 if S&P 500 is used as a market indicator and 0.335 if CRSP value-weighted is used as a market indicator.¹³

Table 2 Panel B shows double sorting stock returns based on oil price returns and firm's leverage. Our sample is divided into quintile groups based on oil price returns and leverage. The upper row (left column) with a number (1-5) represents a quintile group based on oil price returns (leverage). Consistent with our correlation matrix showing stock returns positively correlated with oil price returns, we find that when we move from oil returns first quintile (1) to top quintile (5), stock returns move from 14% to 23.6%. We see the same increasing trend for rows if we read the table from left to right column-wise. We also find that stock returns are negatively correlated with leverage. Inspecting Table 2 Panel B, from the top row (first quintile leverage) to the top quintile in the bottom row we see the negative effect of leverage on the relation between oil price returns and stock returns. At the bottom quintile of oil price returns, there is no significant differential effect of leverage on stock returns (see the difference $0.095 - 0.140 = -0.045$ and $t\text{-statistic} = -1.59$). However, we observe the differential effect of leverage on the stock returns from the second quintile of oil price returns. For example, in the second quintile of oil price returns, when a firm increases its leverage from the first quintile to the top quintile, its stock returns go down from 24.5% to 11.8% and their difference is highly statistically significant (-12.7% and $t\text{-statistics} = -4.56$). Going to a multivariate perspective as captured by equations (1) and (2), we expect the positive effect of oil returns on stock returns, which is documented to be time-varying for the U.S., to be attenuated by leverage.

¹³ An appendix, available upon request, provides the correlation coefficients by sector. For mining, stock returns correlate negatively with leverage and positively with stock returns. For manufacturing and for transportation, these correlation coefficients are smaller and closer to zero.

b. Multivariate analysis

Table 3 provides the results from our models (1) and (2) and forms the baseline of our analysis for all firms in our sample. The coefficients on leverage from all specifications are negatively and statistically significant, which suggests that stock returns fall with higher leverage, all else being constant. In column (1), the coefficient on leverage is -0.232 (t-statistic = -7.42), statistically significant at the 1 percent level. To provide an economic interpretation, recall the mean leverage ratio of 22.0% in Table 1 Panel B. Economically, the one standard deviation increases in a firm's leverage leads the stock return to drop by 3.99% [$-0.0399 = -0.232 \times 0.172$], which corresponds to an almost 18% reduction ($= -0.0399/0.22$) relative to the mean level of stock returns. This leverage effect is consistent with our cash flow constraint hypothesis of levered firms. Interactions between leverage and oil price returns in columns (2) and (4) are also statistically significant at the 5% significance level, which is consistent with our univariate analysis in Table 2 Panel B. The negative interactive coefficient of Leverage*oil returns, estimated from -0.145 to -0.170, goes in the same direction of the direct leverage effect: negative.¹⁴

Oil price returns have positive effects varying from 0.036 to 0.068 in the first two columns and remain positive and statistically significant in columns (3) and (4) when market returns are changed from S&P 500 to CRSP value-weighted portfolio. For the whole sample, the effect of oil price on stock returns is positive, consistent with our economic development/investment opportunities hypothesis that growing oil prices represent a robust economy. Note, however, that the net effect is reduced when we account for the debt of U.S. firms, the conditioning variable Z in the methodology section. Using column (2) of Table 3, the total effect on stock returns with respect to oil returns equals the sum of the direct and indirect (marginal) effect: $\beta_2 + \beta_3 Z$, which

¹⁴ If we use column (4) with its interactive term statistically significant at 5% the one standard deviation increases in firm's leverage leads the stock return to drop by 3.87% [$-0.0387 = -0.225 \times 0.172$].

means $0.036 = 0.068 - 0.145 \times 0.220$. Using column (4), the effect of oil price returns is reduced from 0.066 to $0.0286 = 0.066 - 0.170 \times 0.220$.

On the controls, oil return volatility has always positive and statistically significant effects on stock returns. The aggregate stock market has a close to 1 coefficient (0.958 for the S&P 500 and 0.970 for the CRSP value-weighted market portfolio in columns (2) and (4), respectively), in which the latter has Fama-French controls (SMB and HML) with positive effects as expected. The shape of the yield curve is more sensitive, however, to the definition of a market: it is estimated at 0.058 in columns (1) and (2) and become not statistically significant in columns (3) and (4) when CRSP value-weighted portfolio is used as the market. The likely explanation for the latter is that the CRSP value-weighted portfolio subtracts the risk-free rate, which does not happen when the S&P 500 is used as the aggregate stock market in columns (1) and (2). The positive coefficient of term spread means that spreads moving higher may reduce the likelihood of recession: a positively sloped yield curve impacts stock returns positively.

We move next to analysis under three industries with very different sensitivities to oil prices. Manufacturing tends to use oil as input and this sector represents a major part of the overall universe of firms, which is likely to display similar responses to what the overall sample shows in Table 3. Table 4 reports the results using models 1 and 2 for the manufacturing industry only. In column (1), the coefficient on leverage is -0.214, which is statistically significant at the 1 percent level and very close to the one reported for the full sample. After all, manufacturing firms represent 61% of the total firms. Economically, the one standard deviation increase in a firm's leverage leads the stock return to drop by 3.5% [$-0.0348 = -0.214 \times 0.163$], Oil price returns have positive effects in all columns. The volatility of oil returns has also positive coefficients and so are all the other controls, except for yield spread in columns (3) and (4). In contrast to Table 3, we obtain for the

manufacturing sector negative interactive coefficients but they are not statistically significant, estimated from -0.121 to -0.145 and in the same direction of the direct leverage effect. Interestingly, for the manufacturing sector debt does not reduce the effect of oil price on stock returns.¹⁵

Table 5 reports the results for models 1 and 2 for the mining industry only. Economically, a one standard deviation increase in a mining firm's leverage drops stock returns by 9.39% ($-0.0939 = -0.583 \times 0.161$). Interactions between leverage and oil return in columns (2) and (4) are highly statistically significant. Using column (2) of Table 5, the total effect on stock returns with respect to oil returns equals the sum of the direct and indirect (marginal) effect: $\beta_2 + \beta_3 Z$, which means $0.4664 = 0.587 - 0.749 \times 0.161$. Using column (4), the effect of oil price returns is reduced from 0.628 to $0.526 = 0.628 - 0.636 \times 0.161$. In mining, in addition to both strong direct effects (positive of oil prices and negative of leverage to assets), the interactive terms are quite strong and in the negative direction. These marginal terms reduce (or attenuate) the positive effects of oil prices for these firms.

This result is robust to the measure of aggregate market returns. As in the full and manufacturing industry samples, Table 5 presents effects from the yield curve on stock returns only under S&P stock returns and not when the CRSP V-W is the market. The statistical significance of volatility of oil price returns also depends on the market definition: positive but not statistically significant in columns (1) and (2) when the S&P is the market and statistically significant in columns (3) and (4) when the CRSP V-W is the market.

Table 6 reports the results using models 1 and 2 for the transportation industry only, in which the leverage effect is also found to be negative (at 10% levels in columns (1) to (3)) but no

¹⁵ This changes from our earlier sample until 2017 when the interactive effects were -0.181 and -0.210, statistically significant at 10% and 5% respectively, for the manufacturing sector.

effect due to oil price returns. With the one standard deviation increases in the transportation sector firm's leverage, the stock return drops by 4.4%. ($-0.044 = -0.257 \times 0.172$). Since there are no statistically significant effects of oil price returns, the leverage effect is what makes the return of transportation companies lower. The interactive term of oil price and leverage is negative but not statistically significant. In contrast to Tables 3 to 5, Table 6 shows negative effects of volatility of oil price returns and positive effects of yield curve spread, which lose statistical significance changing the measure of market returns.

Tables 7 and 8 display the asymmetric effects on stock returns of firm leverage and oil price returns, respectively. High leverage is a dummy variable with 1 if any firm-year observation leverage is above the sample median, and 0, otherwise. In column (1) of Table 7. Panel A, the coefficient on leverage dummy is -0.051, which is statistically significant at the 1 percent level. On average, firms whose leverage ratios are above the sample median have lower stock returns, which is lower by 5.1% compared to firms having leverage below/equal to the sample median. Consistent with our cash flow constraints hypothesis for leverage, this suggests that highly financially leveraged firms have a greater negative impact of leverage on their stock returns. The marginal effects are in the interaction terms, which are also statistically significant, and in the direction of leverage (negative). Firm debt reduces the total effect of oil prices on stock returns. Using column (2) of Table 7, the total effect on stock returns with respect to oil returns equals $0.052 = 0.063 - 0.051 \times 0.220$, versus a reduction in column (4) to $0.047 = 0.060 - 0.058 \times 0.220$ (at the mean level).

Table 7, Panel B reports the results from our additional tests to delve more deeply into the relationship among stock returns, oil price returns, and leverage with respect to debt maturity

structure¹⁶. More specifically, we investigate whether our previous findings vary across firms with different debt maturity structures. Recall from our cash flow constraint argument that firms that have higher debt need to outlay a lump sum amount of cash for debt servicing each year. For example, Myers (1977) suggests that a firm's leverage reduces cash flow through interest payments and existing debt claims can make it difficult to raise additional external capital. Among others, Rauh (2006) implies a decrease in investment following the cash shortage of a firm. Lang et al. (1996) also suggest lower investment due to a higher degree of firm leverage. When leverage has a fixed claim on cash flow, its marginal effect should vary across firms with different debt maturity. For example, firms with short-term debt need to pay interest on long-term debt and the principal amount of short-term debt immediately. Then, we should observe a stronger marginal effect of leverage on firms with short-term debt than on firms with long-term debt. Because firms with long-term debt need to pay only interest immediately.

We define long-term debt as the ratio of debt maturing in three, four, five, or more years to total debt. A firm is defined as a firm with a long-term (short-term) debt maturity structure when the value of its long-term debt is higher (equal to or lower) than the value of long-term debt of our sample median. We verify in Table 7 Panel B that the coefficients of leverage are negative for both groups of firms. When we look more closely, we see that the magnitudes of leverage coefficients are larger for firms with short-term debt maturity structure than those of firms with long-term debt maturity structure, which is consistent with our cash flow constraints hypothesis. The coefficients on leverage range from -0.180 to -0.159 in columns (1) to (4) with long-term debt maturity and from -0.309 in column (6) to -0.317 in column (7) with short-term debt maturity. This suggests that if the debt is more of short-term nature the direct effect of leverage (captured by coefficient

¹⁶ We thank anonymous referee for suggesting us to investigate the effect of debt maturity structure on our estimated relationship.

Lev) is larger than when debt is more of long-term. However, the interactive terms between leverage and oil price returns are negative and statistically significant only for firms with a short-term debt maturity structure. This suggests that leverage attenuates the positive effect of oil prices on stock returns for firms with a more short-term debt maturity structure due to their cash flow constraints.

In order to capture the asymmetric effect of oil prices up and down, we employ several different models that allow us to account for different types of interaction effects, specifically, the marginal effects of oil price return up (or down) interacting with leverage. We report Table 8 for the whole sample. The rising oil prices deteriorate stock returns (though not consistent across models) while decreasing oil prices consistently ameliorate stock returns. In column (1), when we test the coefficient difference between oil prices up and oil prices down, we see that firms have experience 19.1% ($0.148 - (-0.043)$) more stock returns when oil prices down from up, which is statistically significant at 1 percent level ($t\text{-statistic} = 6.3078$). This suggests an asymmetric effect of oil prices on stock returns with oil price decrease having a greater impact on stock returns more than the oil price increase¹⁷. However, when we turn our attention to the only marginal effect of oil prices up and leverage, and oil prices down and leverage, we observe very strong asymmetric oil prices effect on stock returns, which are similar to those reported in Sadosky (2008). For example, in column (4), ignoring the signs of the coefficients of the interaction terms: oil prices down and leverage is 0.341 and oil prices up and leverage is -0.510, which are highly statistically significant. The absolute value of the coefficient on the interaction between oil prices up and leverage is greater than that on the interaction between oil prices down and leverage. The

¹⁷ This result is contrary to that reported in Sadosky (2008) due to different sample period estimations. He suggest that positive oil price movement has greater impact on stock returns than negative oil price returns. While he analyzes a sample of US firms from 1990 to 2006, we analyze a sample of US firms from 1990 to 2020. We argue that the post-financial crisis and advancement in the overall economy drive this result.

coefficients on leverage remain, as before, negative and statistically significant on stock returns: -0.232 and -0.117 in columns (1) and (4) and a little lower when interactive terms are included in the regressions. Overall, our results suggest a strong oil prices asymmetric effect on US firms' stock returns.

Existing literature on oil effect on stock returns is mixed and inconclusive. For example, Kling (1985) shows that stock market declines follow after increasing crude oil price. Jones and Kaul (1996) suggest a negative relation between oil prices changes and stock market returns. On the other hand, Prabheesh et al. (2020) find evidence of a positive co-movement between oil price returns and stock price returns during the COVID-19 period. Mohanty et al. (2011) show that stock markets have significant positive exposures to oil price shocks. Chen et al. (1986), in contrast, provide evidence of no oil price changes effect on stock returns, while Wei (2003) concludes that decline in stock prices cannot be explained by an oil price increase.

In this section, we attempt to reconcile these divergent findings on the oil price effect. We divide our sample into two parts based on a major event of the financial crisis period (2008-2009). The reason to take the financial crisis period as a division point of two subsamples is two fold: 1) after this period, US oil production started to increase drastically due to the development of new techniques and shale wells (Thorbecke, 2019). For example, Rapier (2017) writes that "Net imports of crude oil and products to the U.S. fell from 12.5 million BPD in 2005 to 4.7 million BPD in 2015. The U.S. began exporting finished products and even crude oil into the market". 2) As per section 13(3) of the Federal Reserve Act, the Federal Reserve attempted to boost the US economy by providing liquidity and support through a range of programs to financial markets and institutions. Considering these two situations, we assume that the oil price effect may vary over time. Our pre-financial crisis period consists of a subsample before 2008 and the post-financial

crisis period runs from 2010 onwards, in order to exclude the abrupt changes in stock returns caused by market volatility during the crisis years of 2008 and 2009.

Results¹⁸ (reported in Table 9) from this subsample analysis suggest that oil price returns affect stock returns differently across time, which is consistent with the stocks and oil literature reviewed earlier. In the pre-financial crisis period, oil price returns affect negatively stock returns, varying from -0.049 in column (2) to -0.112 in column (1). This goes in line with the operating costs channels and the U.S. economy as importing oil and thus their company stock prices responding negatively to oil price increases. This finding is consistent with those who report a negative oil price effect on stock returns (see, Kling, 1985 and Jones and Kaul, 1996). For the pre-crisis subsample, leverage has negative effects on stock returns: varying from -0.354 in column (4) to -0.381 in column (1). The interactive terms are also negative and statistically significant in both columns (2) and (4) and therefore amplify/aggravate the negative effects of both direct leverage and WTI returns. For the post-financial crisis, however, only leverage coefficients continue to be negative in all columns and statistically significant at 1%, which holds very well for the definition of the aggregate stock market. While oil price returns have strong positive effects, the interactive terms are both meaningful and estimated negatively at -0.032 and -0.008 in columns (6) and (8), respectively. This result is consistent with the investment opportunities channel. The positive oil effect results from the US oil-exporting and improvement of the overall economy, which is consistent with the findings of Prabheesh et al. (2020) and Mohanty et al. (2011). This

¹⁸ Results from the subsamples analysis only for mining industry suggest that oil prices return positive affect stock returns for pre and post financial crisis periods, which is consistent with the revenue channel of oil prices increase. Results are available on requests.

subsample analysis reconciles the previously documented lack of consensus of results of oil price effects on stock returns.

6. Concluding Remarks

We investigate in this paper the general proposition of how leverage and WTI oil prices affect stock returns. We use a comprehensive dataset of U.S. firms and follow Sadorsky (2008) by controlling for oil price volatility, the yield curve, and the aggregate stock market, measured as either the S&P 500 or the CRSP value-weighted minus risk-free rate. An unanswered question is whether the combination of commodity prices and corporate debt is priced in stock returns. In case it is, one is interested in quantifying the degrees due to varying exposures to commodity prices and the extent of debt across sectors.

We show that leverage reduces the total effect of oil prices on stock returns, consistent with our hypothesis regarding the impact of oil prices on stock returns through a conditioning variable at the firm level. As reviewed in the Introduction, the financial press refers to highly leveraged energy firms affected more when there is an oil price collapse. Domanski et al. (2015) discuss the higher level of debt in the oil and gas sector globally at about \$2.5 trillion, 2.5 times higher than in 2006. Their insight for the oil and gas sector is that “greater leverage may have amplified the dynamics of the oil price decline.” Adopting a reverse causation mechanism than the one in this paper, Narayan and Nasiri (2020) treat debt to assets as endogenous and, for a global sample of firms, show that oil factors have negative effects on the capital structure (market debt ratio) of energy firms: both oil spot and future prices reduce market debt ratio by at least 10% from one standard deviation increases in oil price growth.

Adopting the multifactor approach to stock returns, our findings provide support for the proposition that leverage effects are quite substantial and vary across sectors. The coefficients of leverage in stock return regressions are found to be negative and statistically significant in all cases, varying from -0.21 to -0.23 in manufacturing, from -0.23 to -0.26 in transportation, and from -0.58 to -0.61 in mining. For the full sample and only for the mining sector, we find that the interactive term of Leverage*oil returns contributes to lowering the overall response of the stock market to oil price returns. Allowing for asymmetries, firms whose leverage ratios are above the sample median have lower stock returns, estimated between 5.0% and 5.2%, compared to firms having leverage below or equal to the sample median. We also find that the marginal effect of leverage on stock returns is more pronounced in firms with a more short-term debt maturity structure. This is consistent with the conditioning role of debt to assets in our hypothesis. We also find larger effects of debt to assets - jointly with oil prices - in mining compared to manufacturing or transportation sectors.

Policy implications derived from this study deal with how to best accommodate the higher sensitivity of stock prices to the joint combination of exogenous oil prices and debt. Given what we find in this study for mining firms versus the whole industry or manufacturing and transportation sectors, only in the mining sector, the interactive terms between leverage and oil prices are statistically present. Being more exposed to commodity prices, the positive effects of oil prices on stock returns are offset by large debt ratios in companies operating in the mining sector, which has been reported in the financial press. Mining companies should therefore reduce the stock of debt with respect to their assets to make possible the “pass-through” from oil prices to the stock market. Finally, this study suffers from some limitations; 1) grounded on the cash flow claim of leverage, we show its attenuating effect on the relationship between oil price and stock returns.

Our assumption lies on the contemporary negative relation between leverage and cash flow claim. As Shenoy and Koch(1996) suggest that though leverage has a negative effect on cash flow, across time, it has a positive effect on cash flows in the future. In this study, we leave the long-run effect of leverage considering cash flow constraints for our future colleagues to investigate. 2) we argue that the oil price increase represents an advancement of the overall economy. But we do not investigate whether oil prices responded to some other economic forces and vice-versa. The mixed findings on the effect of oil prices can be better understood if the underlying causes of oil price increase are explored. For future work, leverage ratios can be compared to popular predictors of stock returns in the forecasting literature reviewed by Wang et al. (2019). Debt to assets ratios, in combination with macroeconomic indicators and oil prices, may explain the out-of-sample variation of the equity premium, which is left for further research.

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Conflict of interest

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Appendix A: Variable Definitions.

Variables	Definitions
Dependent variables	
<i>Stock returns</i>	Continuously compounded annually company return using the daily CRSP stock return.
Independent variables	
<i>Leverage (Lev)</i>	The ratio of total debt to total assets (<i>Compustat</i> items: $(dlc+dltt)/at$).
<i>Oil returns (OilRet)</i>	The daily WTI log price difference compounded annually.
<i>Oil return volatility (OilRetVol)</i>	The standard deviation of daily WTI log price difference return for each year.
<i>Oil return up (OilRetup)</i>	The compounded only positive WTI oil returns and coded zero if the returns are negative.
<i>Oil return down (OilRetdown)</i>	The compounded only negative WTI oil returns and coded zero if the returns are positive.
<i>High leverage</i>	A dummy variable indicating 1 if the firm's leverage is above the sample median, and 0, otherwise.
<i>Long-term/Short-term debt maturity</i>	A firm is defined as a firm with a long-term debt maturity structure if the ratio of debt maturing in three, four, five, or more years ($dd3 + dd4 + dd5$ or more) to total debt ($dlc + dltt$) is above the sample median, and, otherwise, defined as a firm with short-term debt maturity structure.
Control variables	
<i>S&P 500 return</i>	S&P 500 return is the return on the Standard & Poor's Composite Index defined as: $(SPINDEX(t)/SPINDEX(t-1)) - 1$. Continuously compounded the S&P 500 return for annual.
<i>Market return</i>	CRSP VWRETD indices contain continuously compounded daily returns, including all distributions, on a value-weighted market portfolio (excluding American Depository Receipts (ADRs)).
<i>Spread</i>	10-Year Treasury Constant Maturity Minus 3-Month Treasury Constant Maturity
<i>SMB</i>	SMB (Small Minus Big) is the average return on the nine small stock portfolios minus the average return on the nine big stock portfolios. From the Kenneth R. French website.
<i>HML</i>	HML (High Minus Low) is the average return on the two value portfolios minus the average return on the two growth portfolios, From the Kenneth R. French website.

Figure 1: Stock returns and WTI oil price returns (Positive relation more recently).

This figure provides a graphical illustration of stock returns and WTI oil price returns in Section 2 and shows how stock returns vary with oil price returns over time. The left axis (solid line) represents stock returns while the right axis (dashed line) represents oil price returns.

Figure 2: Stock returns and leverage (Negative relation)

This figure provides a graphical illustration of stock returns and leverage in Section 2 and shows how stock returns vary with oil price returns over time. The left axis (solid line) represents stock returns while the right axis (dashed line) represents the firm's leverage.

Table 1: Descriptive statistics

This table reports sampling distribution by industry and summary statistics for measures of firm's leverage, oil price returns, stock returns, and macro-economic control variables. Our sample consists of 16,244 firm-year observations (balanced panel) with 524 unique firms covering the period 1990-2020. The key dependent variable is stock returns, whereas the key independent variables are firm's leverage and oil price returns. Panel A provides the sampling distribution of our sample. Panel B (C) provides summary statistics of variables used in our estimations for the full sample (different industries). All continuous variables are winsorized at the top and bottom 1% level. Appendix A provides more details of all variables.

Panel A: Industry affiliation (Firm-year)

Industry	Freq.	Percent	Cum.
<i>Agr forest fish</i>	62	0.38	0.38
<i>Construction</i>	434	2.67	3.05
<i>Manufacture</i>	9889	60.88	63.93
<i>Mining</i>	899	5.53	69.47
<i>Others</i>	155	0.95	70.42
<i>Retail trade</i>	1240	7.63	78.05
<i>Service</i>	2015	12.40	90.46
<i>Transport</i>	899	5.53	95.99
<i>Wholesale trade</i>	651	4.01	100.00
Total	16244	100.00	

Panel B: Summary statistics (Full sample)

Variable	N	Mean	SD	P25	Median	P75	Min	Max
<i>Stock return</i>	16244	0.172	0.467	-0.110	0.114	0.357	-0.707	2.158
<i>Leverage</i>	16244	0.220	0.172	0.077	0.203	0.326	0.000	0.765
<i>Oil returns</i>	16244	0.017	0.347	-0.292	0.019	0.249	-0.619	0.985
<i>Oil returns volatility</i>	16244	0.025	0.011	0.018	0.022	0.030	0.011	0.070
<i>S&P 500 returns</i>	16244	0.093	0.166	-0.007	0.114	0.235	-0.385	0.341
<i>MKT returns</i>	16244	0.094	0.177	0.001	0.117	0.237	-0.383	0.352
<i>Spread</i>	16244	1.693	1.060	0.868	1.528	2.729	-0.056	3.495
<i>SMB</i>	16244	0.014	0.106	-0.059	0.015	0.079	-0.286	0.245
<i>HML</i>	16244	0.005	0.168	-0.096	0.008	0.097	-0.463	0.397

Panel C: Summary statistics by industry

Variable	Manufacturing Industry			Mining Industry			Transportation		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
<i>Stock return</i>	0.177	0.117	0.467	0.129	0.077	0.485	0.137	0.103	0.365
<i>Leverage</i>	0.213	0.202	0.163	0.244	0.233	0.161	0.284	0.273	0.172
<i>Oil returns</i>	0.017	0.019	0.347	0.017	0.019	0.348	0.017	0.019	0.348
<i>Oil returns volatility</i>	0.025	0.022	0.011	0.025	0.022	0.011	0.025	0.022	0.011
<i>S&P 500 returns</i>	0.093	0.114	0.166	0.093	0.114	0.166	0.093	0.114	0.166
<i>MKT returns</i>	0.094	0.117	0.177	0.094	0.117	0.177	0.094	0.117	0.177
<i>Spread</i>	1.693	1.528	1.060	1.693	1.528	1.060	1.693	1.528	1.060
<i>SMB</i>	0.014	0.015	0.106	0.014	0.015	0.106	0.014	0.015	0.106
<i>HML</i>	0.005	0.008	0.168	0.005	0.008	0.168	0.005	0.008	0.168
<i>Unique firm</i>	319			29			29		
<i>N</i>	9,889			899			899		

Table 2: Univariate Analysis

This Table presents the Pearson correlation among variables used in our analysis and comparisons of stock returns across oil price quintiles conditioning on firm's leverage. We create quintile groups of oil price returns and firms' leverage into low and high levels, respectively. Panel A provides the correlation among variables. Panel B provides double sorting stock returns based on oil price returns and the firm's leverage. All continuous variables are winsorized at the top and bottom 1% level. Appendix A provides more details of all variables.

Panel A: Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) <i>Stk Returns</i>	1.000								
(2) <i>Lev</i>	-0.059	1.000							
(3) <i>OilRet</i>	0.068	-0.017	1.000						
(4) <i>OilRetVol</i>	-0.062	0.080	-0.171	1.000					
(5) <i>S&P500Ret</i>	0.322	-0.002	0.154	-0.144	1.000				
(6) <i>MktRet</i>	0.335	0.001	0.173	-0.109	0.977	1.000			
(7) <i>Spreads</i>	0.081	-0.064	-0.064	-0.210	-0.142	-0.021	1.000		
(8) <i>SMB</i>	0.194	-0.021	0.104	0.053	-0.086	0.041	0.470	1.000	
(9) <i>HML</i>	0.047	-0.061	-0.191	-0.453	-0.218	-0.272	0.147	0.232	1.000

Panel B: Double sorting stock returns

<i>Leverage</i>	<i>Oil price returns</i>				
	Low (Q-1)	2	3	4	High (Q-5)
Low (Quintile 1)	0.140	0.245	0.219	0.231	0.236
2	0.165	0.186	0.203	0.220	0.185
3	0.114	0.195	0.194	0.199	0.186
4	0.083	0.178	0.173	0.217	0.130
High (Quintile 5)	0.095	0.118	0.142	0.186	0.101
Diff. [5]-[1]	-0.045	-0.127***	-0.077***	-0.045*	-0.134***
	(-1.59)	(-4.56)	(-2.89)	(-1.81)	(-4.49)

Table 3: Baseline regressions results (Full sample)

This table presents the results from FGLS panel data models (1) and (2) for the full sample, where the key dependent variable is stock returns, which are continuously compounded annually company returns using the daily CRSP stock return. The key independent variables are firm's leverage, measured by total debt scaled by total assets, and oil price returns, measured by the daily WTI log price difference compounded annually. All other independent variables are defined in Appendix A. Columns (1) and (3) report results from the model (1) whereas columns (2) and (4) report results from the model (2). t-statistics are computed using robust standard errors and reported in parentheses. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Variable	(1)	(2)	(3)	(4)
	<i>Stock Returns</i>			
<i>Lev*OilRet</i>		-0.145** (-2.02)		-0.170** (-2.39)
<i>Lev</i>	-0.232*** (-7.42)	-0.231*** (-7.38)	-0.227*** (-7.33)	-0.225*** (-7.29)
<i>OilRet</i>	0.036*** (2.98)	0.068*** (3.33)	0.029** (2.36)	0.066*** (3.32)
<i>OilRetVol</i>	1.067*** (3.02)	1.051*** (2.97)	1.750*** (4.52)	1.726*** (4.44)
<i>Spreads</i>	0.058*** (14.82)	0.058*** (14.77)	0.004 (1.12)	0.004 (1.05)
<i>S&P500Ret</i>	0.957*** (37.39)	0.958*** (37.37)		
<i>MktRet</i>			0.969*** (41.40)	0.970*** (41.35)
<i>SMB</i>			0.604*** (13.45)	0.606*** (13.46)
<i>HML</i>			0.365*** (11.93)	0.365*** (11.96)
Constant	0.009 (0.55)	0.009 (0.56)	0.069*** (4.19)	0.070*** (4.22)
N	16244	16244	16244	16244
Adj. R2	0.127	0.127	0.162	0.163

Table 4: Leverage and oil returns on stock returns (manufacturing industry)

See Notes to Table 3. t-statistics are computed using robust standard errors and reported in parentheses. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Variable	(1)	(2)	(3)	(4)
	<i>Stock Returns</i>			
<i>Lev*OilRet</i>		-0.121 (-1.24)		-0.145 (-1.50)
<i>Lev</i>	-0.214*** (-5.33)	-0.213*** (-5.30)	-0.225*** (-5.72)	-0.224*** (-5.69)
<i>OilRet</i>	0.060*** (4.15)	0.086*** (3.20)	0.039*** (2.70)	0.070*** (2.74)
<i>OilRetVol</i>	1.285*** (3.04)	1.275*** (3.01)	1.212*** (2.66)	1.193*** (2.61)
<i>Spreads</i>	0.060*** (11.78)	0.060*** (11.77)	0.001 (0.26)	0.001 (0.23)
<i>S&P500Ret</i>	1.002*** (31.43)	1.003*** (31.40)		
<i>MktRet</i>			0.996*** (33.95)	0.996*** (33.95)
<i>SMB</i>			0.686*** (11.83)	0.688*** (11.81)
<i>HML</i>			0.290*** (7.69)	0.290*** (7.68)
Constant	-0.005 (-0.27)	-0.005 (-0.27)	0.088*** (4.32)	0.088*** (4.32)
N	9889	9889	9889	9889
Adj. R2	0.140	0.140	0.176	0.177

Table 5: Leverage and oil returns on stock returns (Mining industry)

See Notes to Table 3. t-statistics are computed using robust standard errors and reported in parentheses. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Variable	(1)	(2)	(3)	(4)
	<i>Stock Returns</i>			
<i>Lev*OilRet</i>		-0.749*** (-4.00)		-0.636*** (-3.34)
<i>Lev</i>	-0.583*** (-4.80)	-0.574*** (-4.79)	-0.608*** (-5.37)	-0.601*** (-5.45)
<i>OilRet</i>	0.383*** (7.14)	0.587*** (8.06)	0.461*** (8.28)	0.628*** (8.81)
<i>OilRetVol</i>	-0.558 (-0.29)	-0.675 (-0.35)	6.086*** (3.18)	5.638*** (2.92)
<i>Spreads</i>	0.056*** (3.29)	0.056*** (3.28)	0.009 (0.68)	0.007 (0.53)
<i>S&P500Ret</i>	0.441*** (4.99)	0.431*** (4.78)		
<i>MktRet</i>			0.669*** (8.88)	0.652*** (8.44)
<i>SMB</i>			0.658*** (4.25)	0.704*** (4.59)
<i>HML</i>			1.070*** (9.43)	1.034*** (9.03)
Constant	0.144* (1.73)	0.144* (1.74)	0.026 (0.38)	0.039 (0.57)
N	899	899	899	899
Adj. R2	0.145	0.153	0.278	0.284

Table 6: Leverage and oil returns on stock returns (Transportation Industry)

See Notes to Table 3. t-statistics are computed using robust standard errors and reported in parentheses. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Variable	(1)	(2)	(3)	(4)
	<i>Stock Returns</i>			
<i>Lev*OilRet</i>		-0.366 (-1.16)		-0.399 (-1.29)
<i>Lev</i>	-0.257* (-1.94)	-0.250* (-1.86)	-0.229* (-1.68)	-0.221 (-1.60)
<i>OilRet</i>	-0.035 (-0.74)	0.065 (0.62)	-0.021 (-0.52)	0.090 (0.92)
<i>OilRetVol</i>	-2.610** (-2.08)	-2.674** (-2.10)	-1.130 (-0.79)	-1.153 (-0.79)
<i>Spreads</i>	0.034*** (3.22)	0.034*** (3.22)	0.003 (0.23)	0.002 (0.18)
<i>S&P500Ret</i>	0.821*** (11.55)	0.820*** (11.27)		
<i>MktRet</i>			0.847*** (11.06)	0.847*** (10.67)
<i>SMB</i>			0.252 (1.69)	0.251 (1.66)
<i>HML</i>			0.368*** (3.22)	0.374*** (3.24)
Constant	0.142*** (2.96)	0.141*** (2.98)	0.142*** (2.79)	0.140*** (2.78)
N	899	899	899	899
Adj. R2	0.162	0.164	0.189	0.192

Table 7: Asymmetric effects of firm leverage on stock returns

This table presents fixed-effects panel data models of (1) and (2) allowing for asymmetric effects of firm's leverage and debt maturity structure, where the dependent variable is stock returns, which are continuously compounded annually company returns using the daily CRSP stock returns. Oil price return, measured by the daily WTI log price difference compounded annually. All other independent variables are defined in Appendix A. Panel A reports results on high versus low leverage of firms. High leverage is a dummy variable indicating 1 if the firm's leverage is above the sample median, and 0, otherwise. Panel B reports results on firms' degree of debt maturity structure. A firm is defined as a firm with a long-term debt maturity structure if the ratio of debt maturing in three, four, five, or more years ($dd3 + dd4 + dd5$ or more) to total debt ($d1c + d1tt$) is above the sample median, and, otherwise, defined as a firm with short-term debt maturity structure. Columns (1) and (3) report results from the model (1) whereas columns (2) and (4) report results from the model (2). t-statistics are computed using robust standard errors and reported in parentheses. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Panel A: High leverage dummy

Variable	(1)	(2)	(3)	(4)
	<i>Stock Returns</i>			
<i>Highlev*OilRet</i>		-0.051** (-2.16)		-0.058** (-2.49)
<i>Highlev</i>	-0.051*** (-5.40)	-0.050*** (-5.32)	-0.052*** (-5.57)	-0.051*** (-5.48)
<i>OilRet</i>	0.037*** (3.04)	0.063*** (3.49)	0.030** (2.47)	0.060*** (3.39)
<i>OilRetVol</i>	0.956*** (2.72)	0.943*** (2.68)	1.682*** (4.34)	1.662*** (4.28)
<i>Spreads</i>	0.059*** (15.19)	0.059*** (15.17)	0.005 (1.34)	0.005 (1.29)
<i>S&P500Ret</i>	0.956*** (37.36)	0.957*** (37.36)		
<i>MktRet</i>			0.969*** (41.39)	0.970*** (41.41)
<i>SMB</i>			0.603*** (13.45)	0.605*** (13.45)
<i>HML</i>			0.369*** (12.12)	0.369*** (12.15)
Constant	-0.016 (-1.06)	-0.016 (-1.07)	0.045*** (2.97)	0.046*** (2.98)
N	16244	16244	16244	16244
Adj. R2	0.125	0.125	0.161	0.161

Panel B: Debt maturity structure

Variable	Long-term debt maturity				Short-term debt maturity			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Stock Returns</i>								
<i>Lev*OilRet</i>		-0.045 (-0.40)		-0.079 (-0.73)		-0.249* (-1.95)		-0.258** (-2.03)
<i>Lev</i>	-0.180*** (-3.47)	-0.179*** (-3.47)	-0.160*** (-3.17)	-0.159*** (-3.17)	-0.311*** (-5.57)	-0.309*** (-5.53)	-0.317*** (-5.65)	-0.315*** (-5.62)
<i>OilRet</i>	0.045** (2.47)	0.058 (1.62)	0.041** (2.11)	0.063* (1.83)	0.020 (1.19)	0.074** (2.16)	0.028 (1.62)	0.084** (2.48)
<i>OilRetVol</i>	0.754 (1.60)	0.749 (1.59)	2.083*** (3.50)	2.070*** (3.46)	0.928 (1.56)	0.910 (1.53)	1.902*** (2.91)	1.883*** (2.88)
<i>Spreads</i>	0.052*** (9.11)	0.052*** (9.08)	0.002 (0.39)	0.002 (0.36)	0.062*** (10.15)	0.062*** (10.15)	0.009 (1.44)	0.009 (1.42)
<i>S&P500Ret</i>	0.946*** (27.46)	0.946*** (27.44)			0.937*** (24.65)	0.938*** (24.59)		
<i>MktRet</i>			0.977*** (30.00)	0.977*** (29.97)			0.955*** (26.50)	0.956*** (26.44)
<i>SMB</i>			0.541*** (7.84)	0.542*** (7.83)			0.591*** (8.79)	0.591*** (8.80)
<i>HML</i>			0.467*** (10.57)	0.467*** (10.58)			0.359*** (7.90)	0.359*** (7.94)
Constant	0.016 (0.67)	0.016 (0.67)	0.051* (1.89)	0.051* (1.90)	0.024 (0.91)	0.024 (0.90)	0.078*** (2.80)	0.078*** (2.79)
N	7257	7257	7257	7257	7257	7257	7257	7257
Adj. R2	0.130	0.130	0.175	0.175	0.124	0.124	0.157	0.158

Table 8: Asymmetric effects of oil price return on stock returns (Full sample)

See Notes to Table 7. Oil return up (OilRetup) is the compounded only positive WTI oil returns and coded zero if the returns are negative. Oil return down (OilRetdown) is the compounded only negative WTI oil returns and coded zero if the returns are positive. t-statistics are computed using robust standard errors and reported in parentheses. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Stock Returns</i>								
<i>Lev*OilRetup</i>		-0.381*** (-3.33)				-0.434*** (-3.80)		
<i>Lev*OilRetdown</i>			0.062 (0.50)				0.029 (0.24)	
<i>Lev*OilRetup</i>				-0.510*** (-4.09)				-0.562*** (-4.51)
<i>Lev*OilRetdown</i>				0.341** (2.53)				0.337** (2.57)
<i>Lev</i>	-0.232*** (-7.42)	-0.180*** (-5.03)	-0.224*** (-6.34)	-0.117*** (-2.66)	-0.227*** (-7.34)	-0.167*** (-4.80)	-0.223*** (-6.36)	-0.105** (-2.45)
<i>OilRetup</i>	-0.043** (-2.24)	0.042 (1.24)	-0.043** (-2.24)	0.070* (1.96)	0.023 (1.22)	0.120*** (3.74)	0.023 (1.22)	0.148*** (4.33)
<i>OilRetdown</i>	0.148*** (6.32)	0.146*** (6.25)	0.134*** (3.73)	0.071* (1.86)	0.036 (1.56)	0.034 (1.46)	0.030 (0.84)	-0.040 (-1.06)
<i>OilRetVol</i>	1.306*** (3.76)	1.241*** (3.56)	1.303*** (3.76)	1.206*** (3.46)	1.735*** (4.48)	1.650*** (4.21)	1.733*** (4.48)	1.602*** (4.07)
<i>Spreads</i>	0.058*** (14.79)	0.058*** (14.75)	0.058*** (14.78)	0.058*** (14.77)	0.004 (1.10)	0.004 (0.99)	0.004 (1.10)	0.004 (1.00)
<i>S&P500Ret</i>	0.936*** (34.28)	0.938*** (34.30)	0.936*** (34.29)	0.938*** (34.33)				
<i>MktRet</i>					0.967*** (37.38)	0.968*** (37.36)	0.967*** (37.39)	0.968*** (37.36)
<i>SMB</i>					0.606*** (13.52)	0.611*** (13.53)	0.606*** (13.52)	0.613*** (13.54)
<i>HML</i>					0.361*** (12.08)	0.361*** (12.12)	0.361*** (12.08)	0.360*** (12.06)
Constant	0.031* (1.82)	0.020 (1.18)	0.029* (1.67)	0.007 (0.39)	0.072*** (4.04)	0.060*** (3.45)	0.071*** (3.88)	0.048*** (2.65)
N	16244	16244	16244	16244	16244	16244	16244	16244
Adj. R2	0.129	0.129	0.128	0.130	0.162	0.164	0.162	0.164

Table 9: Subsample analysis on the financial crisis (Full sample)

This table reports the relation between oil price return and stock return conditioning on firm's leverage in the context of the financial crisis: the pre-financial crisis period consists of a subsample before 2008 (1990-2007) and the post-financial crisis period begins after 2009 (2010-2020). All other independent variables are defined in Appendix A. Columns (1) and (3) report results from model (1) whereas columns (2) and (4) report results from model (2). t-statistics are computed using robust standard errors and reported in parentheses. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Variable	Pre-financial crisis period: 1990-2007				Post-financial crisis period: 2010-2020			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Stock Returns</i>								
<i>Lev*OilRet</i>		-0.284*** (-3.00)		-0.308*** (-3.30)		-0.032 (-0.23)		0.008 (0.06)
<i>Lev</i>	-0.381*** (-6.86)	-0.366*** (-6.48)	-0.370*** (-6.83)	-0.354*** (-6.44)	-0.157** (-2.00)	-0.158** (-2.00)	-0.132* (-1.68)	-0.132* (-1.67)
<i>OilRet</i>	-0.112*** (-6.78)	-0.049* (-1.78)	-0.101*** (-4.42)	-0.032 (-1.05)	0.198*** (7.38)	0.206*** (4.93)	0.062** (2.23)	0.060 (1.36)
<i>OilRetVol</i>	1.615** (2.06)	1.619** (2.07)	1.870** (2.06)	1.863** (2.05)	0.532 (1.33)	0.526 (1.31)	-0.583 (-1.07)	-0.584 (-1.07)
<i>Spreads</i>	0.058*** (12.79)	0.058*** (12.85)	-0.000 (-0.03)	-0.000 (-0.04)	0.055*** (7.76)	0.055*** (7.76)	0.012 (1.55)	0.012 (1.55)
<i>S&P500Ret</i>	0.662*** (17.91)	0.666*** (18.02)			1.131*** (20.23)	1.132*** (20.12)		
<i>MktRet</i>			0.733*** (19.18)	0.737*** (19.30)			1.020*** (19.02)	1.020*** (18.83)
<i>SMB</i>			0.697*** (13.99)	0.700*** (14.01)			0.455*** (4.52)	0.455*** (4.47)
<i>HML</i>			0.120** (2.15)	0.120** (2.14)			0.188*** (4.30)	0.188*** (4.30)
Constant	0.089*** (3.66)	0.085*** (3.46)	0.157*** (5.40)	0.153*** (5.27)	-0.042 (-1.39)	-0.042 (-1.37)	0.050 (1.53)	0.050 (1.53)
N	9432	9432	9432	9432	5764	5764	5764	5764
Adj. R2	0.085	0.086	0.120	0.121	0.151	0.151	0.165	0.164