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The effects of financial leverage on the output decision of an exploration and production company

Michael Levine
University of Richmond

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by

Michael Levine

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Advisor: Dr. David North

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Michael Levine

University of Richmond

michael.levine@richmond.edu

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ABSTRACT: I examine companies focused on the exploration, production and exploitation of oil and gas assets to test whether there is a significant relationship between a firm's debt burden and its production decision. I am most interested in debt's effect on a firm's price elasticity of supply as this would allow me to conclude how a highly levered firm would react to changes in price relative to other firms. I use data from 81 publicly traded exploration and production companies with varying degrees of leverage over the last ten years. This time frame captures two price cycles for the oil and gas markets. What I find is that there does not appear to be a significant relationship between a company's debt burden and its price elasticity of supply. This result emerges both generally and in a low-price environment.

Keywords: Debt, Finance, Oil and Gas, Price Elasticity of Supply

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The Effects of Financial Leverage on the Output Decision of an Exploration and Production Company

I. Introduction

On July 3, 2008, the spot price for a barrel of West Texas Intermediate crude oil ("WTI") reached $145.31—an all-time high. Shortly thereafter, on December 23, 2008, the price of WTI fell to $30.28 cents, representing a decline of nearly 80%. It took a little less than three years for the price of WTI to again break $100.00 per barrel, which was maintained for a number of years by robust global demand as well as "swing production" from the Organization of Petroleum Exporting Countries ("OPEC"), meaning that OPEC would raise (lower) production to lower (raise) the price of oil to maintain price stability. This meant that times were prosperous for the global oil and gas industry as it enjoyed a sustained period of elevated prices, which typically fluctuated between $85.00 and $100.00 per barrel. See Chart One for a graph of the price WTI from January 2005 through June 2015.

While this all may seem anecdotal, it is significant. The reach of the oil and gas industry is substantial. The companies in my data set generated over $190 billion in revenues in FY 2014, and this represents just a small fraction of the total revenue earned globally. According to the Bureau of Labor Statistics, there are over 185,000 people employed in jobs related to oil and gas extraction. Oil has helped to reshape the world since the beginning of the 20th century. Nearly every product we consume on a daily basis has some relationship with oil, through either the production or distribution of that good. International relations have been focused around oil and having access to oil can provide significant power.

The time of stable, elevated prices following the dramatic fall in 2008 ushered in an era of prosperity for the oil and gas industry that coincided with groundbreaking technological innovation. The success of horizontal drilling coupled with hydraulic fracturing, a process known as "fracking", allowed exploration and production ("E&P") companies to explore, produce and exploit resourcerich source rock, known as shale. Fracking is very costly, with a well costing anywhere from $3 million to over $10 million to drill and complete.[1] Thanks to the price of oil staying elevated for so long, the land that contained the shale rock became increasingly valuable. This provided E&P companies with significant collateral and potential future cash flows with which to borrow against. The result was that the total debt of E&P companies ballooned to $169 billion in June 2015 from $81 billion at the end of 2010, an increase of nearly 110%.[2] The debt allowed companies to drill new shale wells at incredible rates. This led to impressive growth in production that raised domestic crude oil production to levels unseen since the 1970s. According to the Energy Information Administration, daily production of crude oil in the United States rose from a low of five million barrels per day in 2008 to over nine million barrels per day in August 2015. This boom in production has since become known as the "shale revolution" as it has lead the United States to once again be one of the largest oil and gas producing countries in the world and has lessened its dependence on foreign oil. See Chart Two for a graph of average domestic production in the United States from January 2005 through June 2015.

The surge in production led to increased global supply, which, for years, was met with sufficient demand and any mismatch between the supply and demand was typically "fixed" through production adjustments by OPEC. However, on Thanksgiving Day 2014, with global demand slowing, production reaching global highs and market share at risk, OPEC decided not to cut its production to support prices. The result of this decision has seen the price of WTI fall from its June 20, 2014 high of $107.95 to end 2015 at $38.17.[3] The high levels of debt that E&P companies borrowed relied on prices remaining high, but, at these depressed price levels, many companies are now facing serious liquidity concerns and, potentially, bankruptcy. The title of a Bloomberg article from September

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[1] According to Ernst & Young's 2014 *U.S. Upstream: Costs, prices and the unconventional treadmill* report.

[2] Data compiled by FactSet and accessed through http://oilprice.com/Energy/Oil-Prices/Can-The-Oil-Industry-Really-Handle-This-Much-Debt.html on November 26, 2015.

[3] The price of WTI continued to fall in the first few months of 2016, reaching a nearly 13-year low of $26.21 per barrel on February 11, 2016.

2015 sums up the situation very well — "U.S. Shale Drillers Are Drowning in Debt." According to the article, a substantial number of E&P companies have debt burdens that are at least 40% of their total enterprise value, which is roughly 600 basis points higher than the average debt-to-enterprise value ratio of the S&P 500.[4] The article claims that the recent fall in prices has placed a strain on these companies that puts nearly 400,000 barrels per day of production at risk.

The focus of this paper is to empirically examine the effect of debt on a company that is primarily focused on the exploration, production and exploitation of oil and gas assets. Specifically, I explore how the debt level of a company may affect its price elasticity of supply. My hypothesis is that a higher level of debt will significantly affect the price elasticity of supply for an E&P company because the debt burden will constrain the firm from reducing output in order to sustain cash flows and avoid default. This paper is interesting because it is one of the first to suggest and empirically test the relationship between a company's capital structure and its price elasticity of supply. It is also interesting because of the significant amounts of leverage that exploration and production companies have borrowed over the past ten years, which fueled the capital investment that led to the supply glut and price rout facing global oil and gas markets.

Interestingly, I find that there does not appear to be a significant relationship between a company's debt burden and its price elasticity of supply, when controlling for a number of other factors. Companies with more debt do not seem to exhibit a significantly different price elasticity of supply than their less-leveraged rivals. This result emerges both generally and in a low-price environment.

The paper is structured as follows. Section II provides a review of existing literature and discusses the potential contributions of this paper. Section III presents my hypothesis and a simple theoretical model to support this hypothesis. Section IV describes the data and empirical methods

[4] Average debt-to-enterprise value ratio is as of December 31, 2015. Some members of the S&P 500 are also present in my data set.

used to test my hypothesis. Section V will then present the results of my analysis. Section VI concludes and offers direction for further research.

II. Literature Review

In traditional economics literature, the financing decision of a firm has been viewed separately from the production / output decision. This view began to change in the 1980's as economists began to consider how financial decisions might actually influence production decisions, and vice versa. There have been a number of theories introduced that can explain both positive and negative effects of debt on the output decision, but two theories are most relevant to my proposed research. These theories are the *limited liability effect* and the *theory of the long purse / predation*. These theories are discussed below followed by a brief discussion of potential contributions of my research to the existing literature.

a. Limited Liability[5]

Brander and Lewis (1986) are credited with one of the seminal papers on the limited liability effect of debt. This paper is also one of the first to view the output and financing decisions as interrelated. The limited liability effect relies on the fact that equity holders in a firm become residual claimants to cash flows when their firm raises debt. For this reason, equity holders will begin to make riskier operating and investing decisions in order to maximize their residual cash flows.[6]

The general conclusion of Brander and Lewis (1986) is that debt will cause a firm to increase its output in the product market in order to compete more aggressively, which will, in turn, reduce the output of that firm's rivals. In a 2004 working paper, Birge and Xu refer to this effect as the

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[5] Jensen and Meckling (1976) present the building blocks for Brander and Lewis (1986) limited liability theory by discussing the agency costs of both debt and equity. While the paper makes no attempt to link the financing and production decision, section 4 of the paper focuses on the agency cost of debt, in which Jensen and Meckling conclude that debt can cause managers to act riskier.

[6] This statement applies more directly to private equity holders that are more involved in the day-to-day operations of the firm. Public equity holders will not have enough control, unless they own a significant amount of the company, to affect the investment decisions of the firm. In this case, management may tend to act riskier in order to maintain solvency and remain employed.

strategic commitment effect as debt "commits" the firm to compete more aggressively, which creates a credible threat that the firm's rivals will react to by decreasing their output.

A number of subsequent articles have built upon Brander and Lewis' theory, including Wanzenried (2003), Campello (2006) and Haan and Toolsema (2008). Wanzenried (2003) presents a very compelling case that relates the limited liability effect with the choice of optimal capital structure under demand uncertainty. She offers a theoretical model linking the financing decision of a firm with the structure of the industry that the firm operates in. Her model relies on the assumption that firms use debt to "enhance their position in output markets." (Wanzenried 2003, p.188) She concludes that increased demand uncertainty will *increase* the equilibrium level of debt that a firm should raise because the firm will use the debt to better position itself among its competitors. However, Haan and Toolsema (2008) argue that Wanzenried makes an error in her analysis that results in the opposite findings when corrected. Haan and Toolsema claim the error is the result of a poor assumption by Wanzenried that can be linked back to Hughes, Kao and Mukherji (1998). These articles assume that the demand shock is known and that a firm will make its financing decision based on this known shock; however, Haan and Toolsema solve the model from the perspective that the financing decision is made without knowing the exogenous shock to demand. This has the effect of deterring firms from borrowing when they believe that demand uncertainty could be high because if the resulting demand shock is too great then the bondholders would receive all profits, leaving the equity holders with nothing. Alternatively, the firm could take on more debt to allow it to protect itself with excess cash and / or production if it knows that the shock will be large. As a result, their findings are quite different. Haan and Toolsema find that the optimal level of debt actually *decreases* as demand becomes more volatile because firms would be risk averse and prefer to produce less.

Regardless of how the limited liability effect influences the capital structure, the common theme is that the limited liability of debt will cause managers and equity holders to take on larger risks and increase output in order to maximize the value of the residual cash flows. This theory will be significant to this paper as it supports my theory and my hypothesis.

b. Long Purse / Predation

The long purse / predation theory of debt is different from limited liability effect in that it focuses on the activity of the rival firms in the face of a highly levered, thus financially constrained, firm. It states that the cash-rich firms have an incentive to increase their output in order to lower prices and drive the financially constrained firm to either reduce its investment, leading to lost sales, and potentially bankruptcy. In this way, the long purse theory connects the financing decision of one firm with the production decision of other firms.

Although he does not make a connection between the production and financing decision, Tesler (1966) is credited with the seminal paper on the theory of the long purse. His theory is focused on how firms may earn monopoly profit—either through predatory pricing or the acquisition of rivals. Tesler argues that firms with ample funds can effectively threaten to engage in "cutthroat competition" by charging below cost in order to drive rivals out of the market. Later economists build upon this theory by relating it to the financing decision of the firm by introducing both the idea of financial constraints as well as the use of debt to raise cash. Bolton and Scharfstein (1990) discuss the concept of *rational predation*, which focuses on deterring the threat of predation from rivals while minimizing the agency problem that arises from this deterrence. Predation can be deterred by allowing the financially constrained firm to easily refinance; however, if it is not difficult for the firm to refinance, this will increase the agency costs for the firm because there will be little incentive for the firm to worry about servicing its debt. Thus, there is an optimal trade-off between the two.

Opler and Titman (1994) find that highly levered firms tend to record lower sales and profits than their rivals during downturns. While this conclusion is fairly obvious, the implications of their findings are that firms which require high levels of investment in research and development as well as firms in concentrated industries tend to do worse than firms facing the opposite conditions. These findings take Tesler's theory a step further as Opler and Titman incorporate the idea that high fixed costs (e.g. research and development) and industry structure can have a significant effect on the ability of cash-rich firms to engage in predatory behavior against financially constrained firms. Campello (2003) performs empirical analysis on the interaction between capital structure and product market competition. Whereas Opler and Titman were primarily focused on downturns in the market, Campello analyzes the financing and production decisions across entire business cycles. He finds that a highly indebted firm will perform worse than its rivals in a market downturn when its rivals have relatively low levels of debt. Alternatively, according to Campello's findings, a highly indebted firm will lose *less* market share when its rivals are also highly indebted. This is relevant to my research because the oil and gas industry is heavily indebted as a whole, meaning that I should expect to see relatively minimal loss in market share across firms in the oil and gas industry since most firms are highly indebted.

In short, the long purse / predation theory applies to firms who have become financially constrained due to over-levering themselves and are at risk of predation by rival firms who have ample resources with which to compete. Later research has found that both firm-level characteristics (e.g. costs) and industry-level characteristics (e.g. market concentration and debt position of rivals) can have significant effects on influence of the long purse / predation theory.[7]

c. Potential Contributions

The limited liability and predation theories are most applicable to my research because they both find that debt affects the output decision of a firm. In the limited liability effect, a firm will increase its output as a result of a higher debt level. The long purse theory states that if a company takes on too much debt it risks being forced out of the market by rival firms that are financially

[7] I keep this information in mind as I formulate my hypothesis as the U.S. exploration and production industry is both fragmented and highly levered. This means that the long purse theory may not be fully applicable to my research because of the competitive nature of the market and the financial constraints placed on the majority of producers. In fact, I find that the limited liability effect appears to be more applicable based on my results.

healthier. I believe that my research could find support for the limited liability theory while refuting the theory of the long purse. If my findings are consistent with my hypothesis, I will discover a situation where the limited liability effect causes a financially constrained firm to reduce its output by less than it otherwise would in the face of lower prices in order to remain a going concern. This would be reflected through a lower price elasticity of supply. The long purse theory would imply that the healthier firms would increase their output to drive constrained firms out of the market. My hypothesis would not support this conclusion because I believe that the debt level of a company will be the driving force to influence the price elasticity of supply and not acting as a signal to competitors. This means that less financially constrained firms would have a higher price elasticity of supply than their levered rivals; thus, any decrease in market prices would cause them to reduce output more drastically than the highly levered firms.[8]

III. Hypothesis & Model

The research question I address is "what is the effect of debt on the production decision of an E&P company?" My primary hypothesis is that higher levels of debt will lead a financially constrained firm to increase its output in order to remain a going concern during a dramatic price decline.[9] More specifically, I hypothesize that debt will have a significant, negative effect on a company's price elasticity of supply when a company is facing below-normal prices. My secondary hypothesis is that debt will generally have a negative impact on a company's price elasticity of supply because the debt provides an incentive for a company to commit to an output decision and attempt to maintain it regardless of price movements. Empirical support for this hypothesis is that when production is regressed on price and debt-load, as well as a number of controls, the coefficient on an interaction

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[8] This explanation actually supports my hypothesis, albeit from a different direction. I am saying that higher debt will lead to a lower price elasticity of supply, whereas this explanation states that less debt leads to a higher price elasticity of supply. In both cases, the sign on the coefficient would be the same.

[9] In essence, the firm will increase production in order to service its debt and maximize its residual claim. This is consistent with the limited liability effect of debt.

term between debt and prices will have a coefficient that is negative and significant. This would imply that debt has a negative effect on the price elasticity of supply and would confirm my suspicion that a heavily indebted firm will not react to an increase in prices in the same way that a less indebted firm would.

To formally develop my hypothesis, I use a cash flow-based model that can explain why a firm may increase its production in response to falling prices. Consider the following variables:

Endogenous	**Exogenous**
Production (Q)	Price (P)
Debt (D)	Interest Rate (*i*)
	Lease-related fixed costs (L)
	Cost per barrel of production (v)
	Depreciation

The model assumes the following:

1. Firm is a price-taker.[10]
2. Firm is interested in maximizing the value of the firm and, subsequently, the cash flow to equity holders.
3. Managers of the firm are interested in remaining employed, which only occurs if the firm remains a going concern.
4. The firm makes its financing decision prior to the production decision.
5. The firm's debt is controlled by a number of covenants that it must stay in compliance with at the risk of default.
6. Debt is senior to equity (i.e. debt holders receive cash flows prior to equity holders).
7. There are no production or income taxes.
8. v is always less than P, in order to avoid the firm reaching a "shut-down" decision.

[10] I am able to make this assumption because an analysis of the industry concentration within my dataset yields a FY 2014 HHI of 470.5 and an average HHI of 992.7 over the observation period. HHI ranges from 0-10,000 with smaller values representing less concentrated industries.

Using these variables and assumptions, we can build a simple equation for the cash flow to equity holders, which we will call the residual cash flow:

$$Residual\ Cash\ Flow = TR - TC$$

Where TR is total revenue and TC is total cost. TR and TC will be defined as:

$$TR = PQ$$

$$TC = L + vQ + iD + Dep.$$

Thus,

$$Residual\ Cash\ Flow = PQ - (L + vQ + iD + Dep.)$$[11]

By removing *i*D and depreciation, you can derive the cash flow available to both debt and equity holders, which we will call the firm's earnings before interest, taxes and depreciation / amortization ("EBITDA"), giving us the following equation:

$$EBITDA = PQ - (L + vQ)$$[12]

This equation for EBITDA can be used to show how a firm may react to changes in price when it faces a number of different financial covenants. I will analyze two financial covenants that are common in all lending decisions as well as one that is indicative of a company's overall capital structure. These ratios will be the total leverage ratio, interest coverage ratio, and debt–to–enterprise value ratio.[13]

[11] It is worth noting that, if the firm wishes to maximize its residual cash flows, consistent with the limited liability effect, it will necessarily choose to increase production regardless of price changes because any incremental cash flows above TC will flow directly to equity holders, assuming that the firm views its demand as relatively inelastic.

[12] EBITDA is used because it is a good proxy for free cash flow. It represents the cash flow that is available to the firm for financing or investment decisions after all necessary operating costs have been deducted. It is used in a majority of financing decisions because it allows one to effectively analyze the amount of cash that a company generates that could be used to service debt.

[13] While only debt-to-enterprise value is tested in this paper, the total leverage ratio and interest coverage ratio are provided for illustrative purposes and to provide additional theoretical support to my hypothesis.

a. Total Leverage Ratio

The total leverage ratio will be defined as:

$$Total\ Leverage = \frac{Total\ Debt}{EBITDA}$$
$$= \frac{D}{PQ - (L + vQ)}$$

According to many loan agreements and bond indentures, this ratio will be required to remain *below* a predetermined level at the risk of default. Thus, if prices were to fall, *ceteris paribus*, the total leverage ratio would increase. If this increase was great enough, it could trigger default and place the firm in bankruptcy. However, if the firm wishes to avoid bankruptcy and maximize the cash flow to equity holders, it can *increase* its production in order to offset the fall in prices and prevent default.[14] This conclusion supports my hypotheses.

b. Interest Coverage Ratio

The interest coverage ratio will be defined as:

$$Interest\ Coverage = \frac{EBITDA}{Interest\ Expense}$$
$$= \frac{PQ - (L + vQ)}{iD}$$

Debt holders will require the interest coverage ratio to remain *above* a predetermined level. Any breach of this covenant could trigger default. Thus, if prices were to fall, *ceteris paribus,* the interest coverage ratio would begin to fall. If the decrease in this ratio were great enough, the firm could be forced to file for bankruptcy. However, if the firm wishes to avoid this outcome and equity holders do not want to see their residual cash flows eliminated, the firm could increase its production

[14] This assumes that a firm views its demand as relatively elastic, even though the overall industry demand for oil is typically considered to be inelastic. This assumption is accurate only if the firm is able to increase its output without an accompanying increase in production by many firms. If firms do jointly increase production, given the inelastic market demand, the increase in supply will likely lead to a price decrease that results in lower firm and industry revenue.

in order to increase EBITDA and raise its interest coverage ratio to remain in compliance. This conclusion supports my hypotheses.

iii. Debt–to–Enterprise Value

The debt–to–enterprise value ratio will be defined as:

$$Debt - to - Enterprise\ Value = \frac{Debt}{Enterprise\ Value}$$

Where enterprise value is defined as:

$$Enterprise\ Value = Debt + Market\ Capitalization$$

And market capitalization is defined as a multiple of residual cash flow, m:

$$Market\ Capitalization = m(Residual\ Cash\ Flow) \\ = m[PQ - (L + vQ + iD + Dep.)]$$

Thus, the debt–to–enterprise value ratio can be rewritten as:

$$Debt - to - Enterprise\ Value = \frac{D}{D + m[PQ - (L + vQ + iD + Dep.)]}$$

This ratio is often presented as a percentage and many lenders will closely monitor the ratio in making / monitoring their investments. Most investors prefer that a company maintain a debt–to–enterprise value below a certain percentage. Thus, if the price falls, *ceteris paribus*, the market capitalization of the firm will fall by roughly m times. If the price falls by enough, the debt–to–capitalization percentage may become too high and the company may face liquidity concerns and, potentially, bankruptcy. Since the firm is both interested in maximizing residual cash flows and remaining a going concern, the firm may choose to increase production in order to increase its residual cash flow, increase its market capitalization and decrease the percentage of debt relative to its overall enterprise value. This conclusion supports my hypotheses.

IV. Data & Methods

The data I use to test my hypothesis is from three sources: S&P CapitalIQ, CompuStat and Bloomberg. The data are financial and operating statistics from a total of 81 publicly traded companies. The companies were chosen based on their primary operations. That is, the companies had to be primarily focused on the exploration, production and exploitation of domestic oil and gas assets. There are a few companies with E&P operations overseas as well as a few companies with midstream (i.e. transportation) and downstream (i.e. refining and marketing) operations. I have decided to remove companies with substantial midstream and downstream operations because these operations act as a hedge against the upstream operations by providing supplemental cash flows.

My data set includes annual data over the past ten fiscal years. The data begin in fiscal year 2005 and end in fiscal year 2014. This is a particularly interesting time period as it captures two full "boom and bust" cycles in the price of both oil.[15] An observation is described based on the company and the time period. For example, one company's data observed over one year of operations would be classified as a company – year. In total, the data represent 810 company – years.

I performed three layers of "filters" to clean up the data in order to remove any insufficient data points:

1. Does the company – year contain revenue information? If no, the observation was dropped from the data set.
2. If the company – year contains revenue information, does it also provide production information? If no, the observation was dropped from the data set.
3. Does the company year contain positive capitalization information? If no, the observation was dropped from the data set.

These criteria reduce the sample size to 465 company – years. This represents 57% of the original data set.

[15] It would be preferred to have data that would extend as recently as possible since the price of oil has continued to fall to levels that have not been seen in over a decade. Unfortunately, this data will not be available during the course of my research but would offer an excellent opportunity to revisit this research questions once the data become available. I believe my results would be materially different if this data could be included.

The primary data points that I am interested in are total production, enterprise value, total debt, debt-to-enterprise value, total cash, total assets, cash-to-assets and WTI spot prices. See Table One for an overview of summary statistics.

I will consider a number of OLS regressions in order to test my hypothesis. The data will be classified based on the subscripts *i* and *t* where *i* represents an individual company and t represents the year. The base model specification for these regressions will be:

$$\begin{aligned} ln\left(Total\ Production_{i,t}\right) \\ &= \beta_0 + \beta_1\, ln\left(Price_{i,t}\right) + \beta_2\left(Debt\ Measure_{i,t-1}\right) + \beta_3\left(Interaction\ Term_{i,t}\right) \\ &+ \beta_4\left(\frac{Cash_{i,t-1}}{Assets_{i,t-1}}\right) + \sum \gamma_{i,t} + \varepsilon_{i,t} \end{aligned}$$

The debt measure represents the level of a company's debt relative to its enterprise value, the interaction term represents the product of the natural log of prices and the debt measure, the percent of cash relative to assets will be used as a control for liquidity, γ represents various other control variables, and ε represents an error term. It is worth noting that there could be some potential endogeneity and collinearity concerns with this estimation method. I seek to reduce these problems by including a number of controls, which include the proportion of company's cash relative to its assets, various industry-level controls and firm-level fixed effects. Additionally, since the (expected) price of oil could have an effect on a firm's capital structure decision, there may be a potential for multicollinearity across these or other explanatory variables. If this appears to be an issue when I am running regressions, I may need to gather more data either by expanding my data set to include more companies, more years or both. I also reduce this affect by lagging my debt measure so that the financing decision is made prior to the price realization, which I believe is more realistic to how a company would make its production decision.

I am interested in the effect of debt on a company's price elasticity of supply, so I will take the natural log of both production and prices in order to observe the effect of a percent change in prices on the percent change in production. It is also logical for me to include interaction terms between debt and the natural log of prices within my regression specification. This will allow me to more directly observe the effect of debt on the price elasticity of supply.

V. Results

I ran a progression of four different sets of two regressions for a total of eight regressions. Each set regresses the natural log of total production ("LN Production") against the natural log of price ("LN Price"), the previous year's debt-to-enterprise ratio ("D / EV"), an interaction term between LN Price and D / EV ("LN Price x D / EV"), the previous year's cash-to-assets ratio ("Cash / Assets"), company fixed effects and various controls for yearly effects and technological innovation.[16] The differences in each regression are the interaction terms and controls that are used. A discussion of the specific models I ran follow this paragraph, but what I find is that across all eight regressions the coefficient on D / EV is not statistically significant, indicating that debt does not appear to have an influence on the output decision of a firm. I also find that the coefficient on LN Price x D / EV is not significant across all eight regressions, which means that debt does not significantly affect the price elasticity of supply. To test the effect of debt in a low-price environment, an additional interaction term was included. The previous interaction term was interacted with an indicator for prices in the bottom 25th percentile ("Bottom 1/4 Prices"). This Bottom 1/4 Prices does not show any significant relationship between debt and the price elasticity of supply in a low-price environment, indicating that debt does not have a significant effect on the price elasticity of supply in times when firms are facing depressed market prices. See Table Two for a detailed overview of the regression results.

a. Model One and Model Two

Models one and two represent the base regression specifications from which I added various controls to test for robustness of the results across the dataset. Model one regresses LN Production

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[16] The cash-to-assets ratio is used as a control for companies who may have necessary cash on hand, relative to their assets, to service their debt. This would limit the distress effect that debt may have on a firm.

against LN Price, D / EV, LN Price x D / EV, and Cash / Assets. Model two contains this same set of predictors plus the Bottom 1/4 Prices interaction term.

What I find in both model one and two is that LN Price has a significant positive effect on LN Production. This was expected as it is generally understood in economics that suppliers tend to face a positive price elasticity of supply.[17] D / EV is not significant in either regression. This means that a company with more debt relative to its enterprise value does not seem to produce significantly more or less than a less-indebted firm. This finding is interesting as it would seem to contradict both the limited liability effect and the long purse / predation theory. In model one, LN Price x D / EV is not statistically significant. This contradicts my secondary hypothesis that debt will have a negative influence on a company's price elasticity of supply because the debt provides an incentive for a company to commit to an output decision and attempt to maintain it regardless of price movements. It would appear that debt does not have this effect on a company. When Bottom 1/4 Prices is included in model two, I find that neither this variable nor LN Price x D / EV are statistically significant, meaning that debt, again, does not appear to significantly influence the price elasticity of supply for an E&P company. This contradicts both my primary and secondary hypotheses.

b. Model Three and Model Four

Models three and four build on models one and two by including a control for technological innovation that has occurred in the oil and gas industry. This variable ("Technology") is calculated by dividing the current fiscal year's industry-wide total production by the previous fiscal year's industry-wide capital expenditure. This provides a value for the amount of barrels that a dollar of investment will provide. More efficient (read: better) technology would yield more barrels per dollar, so this variable helps to control for changes in technology that have occurred over the observation period.

[17] More than anything, this results provides assurance that the dataset is acceptable as a negative coefficient or insignificant result would raise suspicion.

The results for models three and four are similar to those seen in models one and two. LN Price is still significant while D / EV, LN Price x D / EV and Bottom 1/4 Prices are all insignificant. These results continue to contradict both my primary and secondary hypotheses.

c. Model Five and Model Six

Models five and six contain the same predictors as models three and four but now I have included a dummy variable ("Fracking Indicator") that indicates for years when fracking became prevalent—2010 through 2014. It is over this time frame that both total and average production in the oil industry increases dramatically due to the advent of fracking. In fact, the coefficient on this dummy variable is both statistically and economically significant. It indicates that production is roughly 50% higher for a company when fracking is commonplace.

The results for models five and six are similar to those seen in models one through four. LN Price is still significant although the coefficient has fallen from around 1.500 to below 1.000. This is the effect of the fracking dummy helping to act as a control. D / EV, LN Price x D / EV and Bottom 1/4 Prices all remain insignificant. These results continue to contradict both my primary and secondary hypotheses.

d. Model Seven and Model Eight

Models seven and eight remove the technology variable but keep all other predictors included in models five and six. I did this because it could be argued that the Fracking Indicator could be controlling for the technological innovation that occurred simply through the advent of fracking, so I wanted to test it on its own. I also added a new interaction term that multiplies LN Price by D / EV and the Fracking Indicator ("LN Price x D / EV x Fracking Indicator"). The purpose of adding this variable is to test whether fracking has had a significant effect on the relationship between debt and the price elasticity of supply because it so dramatically changed the entire oil and gas industry. I find that this variable is not significant in either models seven or eight, indicating that fracking does not appear to have influenced this relationship.

The results for models seven and eight are the same the other six regressions. LN Price is significant and the coefficient remains below 1.000, consistent with the introduction of the Fracking Indicator in models five and six. D / EV, LN Price x D / EV and Bottom 1/4 Prices remain insignificant. These results continue to contradict both my primary and secondary hypotheses. At this point, I can conclude that I cannot confirm either of my hypotheses.

VI. Conclusion

The results presented do not support either of my hypotheses. The lack of significance of Bottom 1/4 Prices across all regressions indicates that my primary hypothesis that debt will have a negative effect on a company's price elasticity of supply in a low price environment cannot be accepted. This means that I have found evidence that debt does not affect a company's price elasticity of supply and that it, consequently, does not appear to influence the output decision of a firm. This finding is inconsistent with the limited liability effect and the long purse / predation theory. Additionally, the lack of significance of LN Prices x D / EV across all regressions indicates that my secondary hypothesis that debt will generally have a negative effect on the price elasticity of supply regardless of the price environment cannot be confirmed. I believe these findings could have significant implications for oil and gas companies because I have presented evidence that the financing decision of a firm does not appear to affect its output decision. This could partly explain why the oil and gas industry has become so highly indebted over the past decade.

Going forward, I would like to run these same regressions on an updated dataset that includes fiscal year 2015 and 2016 because my primary hypothesis was inspired by the events that have transpired in the oil and gas industry since Thanksgiving Day in 2014 and my dataset currently does not capture this timeframe. My primary hypothesis is focused on times when firms face liquidity concerns and the risk of bankruptcy, and this period of time would capture the continued fall in the price of oil that has seen a number of E&P companies file for bankruptcy. As well, I would like to test my data using an interaction term that includes an indicator for distress instead of low prices.[18] I strongly believe that the results presented in this paper would materially change if these changes were made to the dataset.

Nonetheless, these findings do present a foundation for further research into the link between debt and the price elasticity of supply, and they are relevant to many potential populations, namely economists, oil and gas professionals and financiers. It would be interesting to see additional research conducted that would examine this connection in other industries and potentially analyze how the relationship may differ for an industry that is not as capital intensive or competitive as oil and gas.

[18] After testing my data and analyzing my results, it became apparent to me that I was using low prices to proxy for distress when, in reality, I should have used an indicator for distress from the beginning. An appropriate variable to capture this would be the Altman z-score that is used to test for a company's bankruptcy risk, where a value below 1.8 indicates that bankruptcy is highly likely. Another potential variable would be credit ratings.

VII. Tables and Figures

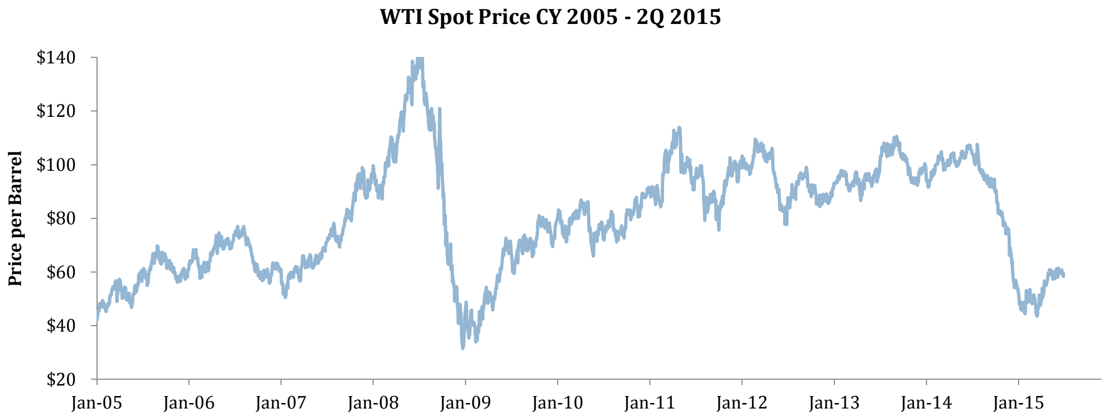

Chart One.

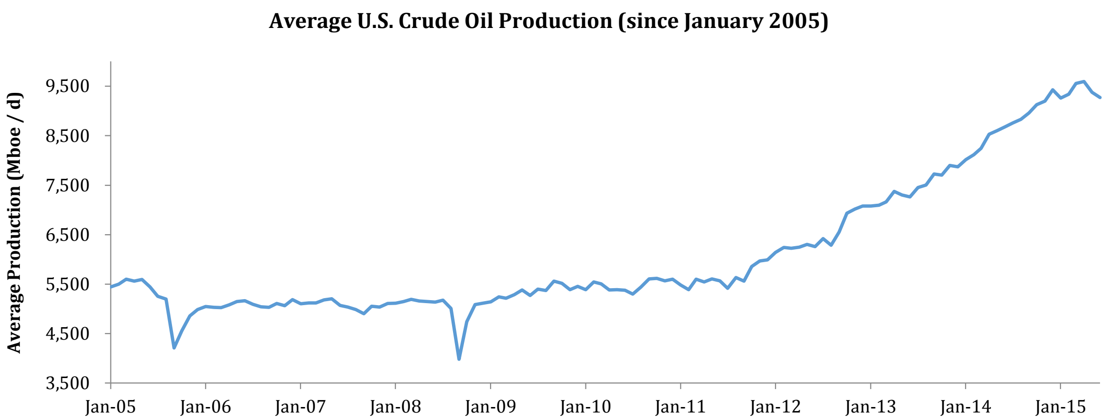

Chart Two.

	N	Minimum	Maximum	Mean	Std. Deviation
Total Production	465	0.00	312.50	44.19	71.07
Total Debt	465	0.00	$ 21,275.00	$ 2,257.35	$ 3,305.54
Enterprise Value	465	$ 7.47	$ 80,624.31	$ 9,499.28	$ 14,362.44
Debt - to - Enterprise Value	465	0.00%	93.25%	27.13%	19.39%
Total Cash	465	0.00	7,088.00	348.37	911.85
Total Assets	465	24.36	69,275.00	9,100.39	14,298.71
Cash - to - Assets	465	0.00%	55.77%	4.39%	7.79%
WTI Spot Price	465	$ 58.07	$ 100.28	$ 86.09	$ 13.25

Table One.

	Model							
	One	**Two**	**Three**	**Four**	**Five**	**Six**	**Seven**	**Eight**
Intercept	-1.344	-1.496	-1.867	-1.847	0.783	1.023	2.065**	1.801
	(-1.532)	(-1.440)	(-1.109)	(-1.090)	(0.476)	(0.616)	(1.982)	(1.638)
LN Price	1.495***	1.531***	1.590***	1.590***	0.893***	0.879***	0.666***	0.736***
	(7.839)	(6.613)	(4.908)	(4.902)	(2.751)	(2.704)	(2.878)	(2.950)
D / EV	0.018	0.018	0.018	0.018	0.008	0.007	0.012	0.010
	(1.583)	(1.545)	(1.541)	(1.529)	(0.726)	(0.639)	(1.090)	(0.845)
LN Price x D / EV	-0.119	-0.119	-0.115	-0.115	0.034	0.030	0.015	0.019
	(-0.469)	(-0.469)	(-0.452)	(-0.454)	(0.139)	(0.125)	(0.063)	(0.080)
LN Price x D / EV x Bottom 1/4 Prices		0.018		0.008		0.075		0.061
		(0.273)		(0.106)		(0.301)		(0.752)
Cash / Assets	-0.035***	-0.035***	-0.035***	-0.035***	-0.034***	-0.034***	-0.034***	-0.034***
	(-6.543)	(-6.541)	(-6.529)	(-6.517)	(-6.741)	(-6.784)	(-6.688)	(-6.724)
Technology			4.094	3.410	13.674	7.488		
			(0.364)	(0.263)	(1.270)	(0.608)		
Fracking Indicator					0.498***	0.509***	0.594***	0.564***
					(6.656)	(6.736)	(5.726)	(5.064)
LN Price x D / EV x Fracking Indicator							-0.100	-0.060
							(-1.497)	(-0.700)
Company Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pr > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Adjusted R^2	90.6%	90.6%	90.6%	90.5%	91.5%	91.5%	91.5%	91.5%
Number of observations	465	465	465	465	465	465	465	465

***Significant at the 0.01 level.
**Significant at the 0.05 level.
*Significant at the 0.10 level.

LN Price = Natural log of the average spot price for a given fiscal year.

D / EV = Previous fiscal year end's debt balance divided by the previous fiscal year end's enterprise value.

LN Price x D / EV = Interaction term between the natural log of the average spot prices multiplied by the previous fiscal year's debt-to-enterprise value.

LN Price x D / EV x Bottom 1 / 4 Prices = Interaction term between the natural log of the average spot prices multiplied by the previous fiscal year's debt-to-enterprise value then multiplied by a dummy variable that indicates for an average price that was in the bottom 25th percentile.

Cash / Assets = Previous fiscal year's cash balance divided by the book value of the previous fiscal year's assets.

Technology = Current fiscal year's total production divided by previous fiscal year's capital expenditures.

Fracking Indicator = Dummy variable that indicates for the years 2010 through 2014, when fracking really gained in traction in the oil & gas industry.

LN Price x D / EV x Fracking Indicator = Interaction term between the natural log of the average spot prices multiplied by the previous fiscal year's debt-to-enterprise value then multiplied by a dummy variable to indicate for years when fracking became prevalent.

Table Two.

VIII. References

Birge, John R. and Xiaodong Xu. "Joint Production and Financing Decisions: Modeling and Analysis." Working Paper, Northwestern University, 2004.

Bolton, Patrick and David S. Scharftstein. "A Theory of Predation Based on Agency Problems in Financial Contracting." *The American Economic Review* 80 (March 1990): 93-106.

Brander, James A. and Tracy R. Lewis. "Oligopoly and Financial Structure: The Limited Liability Effect." *The American Economic Review* 76 (December 1986): 956-970.

Campello, Murillo. "Capital structure and product markets interactions: evidence from business cycles." *Journal of Financial Economics* 68 (2003): 353-378.

Campello, Murillo. "Debt Financing: Does it boost or hurt firm performance in product markets?" *Journal of Financial Economics* 82 (2006): 135-172.

Haan, Marco A. and Linda A. Toolsema. "The strategic use of debt reconsidered." *International Journal of Industrial Organization* 26 (2008): 616-624.

Hughes, John and Jennifer L. Kao and Arijit Mukherji. "Oligopoly, Financial Structure and Resolution of Uncertainty." *Journal of Economics & Management Strategy* 7 (Spring 1998): 67-88.

Jensen, Michael C. and William H. Meckling. "Theory fo the Firm: Managerial Behavior, Agency Costs and Ownership Structure." *Journal of Financial Economics* 3 (October 1976): 305-360.

Opler, Tim C. and Sheridan Titman. "Financial Distress and Corporate Performance." *The Journal of Finance* 49 (July 1994): 1015-1040.

Tesler, L.G. "Cutthroat competition and the long purse." *The Journal of Law and Economics* 9 (October 1966): 259-277.

Wanzenried, Gabrielle. "Capital structure decisions and output market competition under demand uncertainty." *International Journal of Industrial Organization* 21 (2003): 171-200.