İLAYDA TANERİ THE U.S. SHALE OIL MARKET FORCES AND EXPORT BAN. Bilkent University 2020

THE U.S. SHALE OIL, MARKET FORCES AND EXPORT BAN

A Master's Thesis

by

İLAYDA TANERİ

Graduate Program in

Energy Economics, Policy and Security

İhsan Doğramacı Bilkent University

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To my dear family

THE U.S. SHALE OIL, MARKET FORCES AND EXPORT BAN

The Graduate School of Economics and Social Sciences

of

İhsan Doğramacı Bilkent University

by

İlayda Taneri

In Partial Fulfillment of the Requirements for the Degree of
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GRADUATE PROGRAM IN ENERGY ECONOMICS, POLICY AND SECURITY

İHSAN DOĞRAMACI BİLKENT UNIVERSITY

ANKARA

July 2020

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Energy Economics, Policy and Security.

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ABSTRACT

THE U.S. SHALE OIL, MARKET FORCES AND EXPORT BAN

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July 2020

Shale oil revolution after 2011 changed both the U.S. and world oil markets. In this thesis the market determinants of a shale oil production – Frac Count for the U.S is studied. The empirical evidence suggests that a positive shock to NYMEX, S&P500, rig count, WTI and the U.S. stocks increase the Frac Count but higher interest rate and the U.S. total oil production decrease Frac Count. After the U.S. became one of the major oil producers, it removed its crude export ban in December 2015. The empirical evidence also suggests that the shale oil industry gets more integrated with the financial system and be more efficient in its production process in the post 2016 era after the export ban has been removed.

Keywords: Frac Count, Oil Markets, Shale Oil

ÖZET

AMERİKAN ŞEYL PETROLÜ, PİYASA GÜÇLERİ VE İHRACAT YASASI

Taneri, İlayda

Yüksek Lisans, Enerji Ekonomisi ve Enerji Güvenliği Politikaları

Tez Danışmanı: Prof. Dr. Hakan Berument

Temmuz 2020

2011'den sonra şeyl petrol devrimi hem ABD hem de dünya petrol piyasalarını değiştirdi. Bu tez piyasa belirleyici şeyl petrol etkenleri arasında Frac Sayısı değişkenini kullanarak ABD'ye olan etkisini incelemiştir. Ampirik bulgular, NYMEX, S&P500, WTI ve petrol stoklara yönelik bir şokun Frac Sayısını artırdığını ancak yüksek faiz oranının ve petrol üretimin Frac Sayısını azaltacağını göstermektedir. ABD büyük petrol üreticilerinden biri olduktan sonra, Aralık 2015'te petrol ihracat yasağını kaldırdı. Yasa öncesi NYMEX Frac Sayısını olumlu etkilerken, S&P500 ve faiz oranının olumsuz etkilediği gözlenmiştir. Ancak yasanın kaldığı dönemden sonra yasa öncesinden farklı olarak S&P500 Frac Sayısını olumlu yönde etkilediği gözlemlenmiştir. Finansal değişkenlerle ilişkine yasa öncesi bakıldığında Frac Sayısı, teçhizat sayısını, WTI ve Brent/WTI olumlu etkilerken üretim, ihracat ve ithalat ve stokları olumsuz etkilemiş olmakla birlikte yasanın

kalkmasından sonra Frac Sayısının etkisi sadece ihracat/ithalatı etkilerken geriye kalan değişkenleri değişmemiştir.

Anahtar Kelimeler: Frac Sayısı; Petrol Marketleri, Şeyl Petrolü

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CHAPTER I

INTRODUCTION

In 2011, oil and gas production had begun in large quantities in oil-rich regions like West Texas and North Dakota, reshaping the U.S. and world oil and gas markets forever. This incident is re-defined in the literature as shale oil revolution. Shale oil or is also known as tight oil is an unconventional type of oil where its rock formations have a low permeability. Thus, shale oil production technique is different from conventional oil production process and involves different dynamics. The purpose of this thesis is to assess how the production in shale oil that is captured with the novel Frac Count data from Primary Vision is affected by market factors and how the Frac Count affects economic variables.

Due to its rock formation, the shale oil production process requires a hydraulic fracking method to 'open up' the rock formation for the oil to come out. The oil derived from oil shale literature goes back to hundred years. Before the emergence of shale oil boom ‘shale oil’ term would be used for oil produced by oil shale. Previously, oil shales would be mined crushed and heated to form ‘shale’ oil which is known as ex situ process. However, with recent technological improvements operators do not use ex situ process as much as anymore. Currently without mining and crushing the rock itself, operator conducts heating process known as pyrolysis directly to the oil shale known as in-situ process. Tight oil is generally found under low permeability formations like sandstone, carbonates and siltstone (Koplos, Tuccillo & Ranalli, 2014) whereas shale oil is formed under highly organic mudstone and shale. There is a debate whether to classify embedded tight and shale formations known as sandwich cake as tight oil (Jiang et al., 2016). Certain basins in the U.S have what is known as sandwich cake formations (Speight, 2019).

Hydraulic fracking method needs to be combined with horizontal drilling for the shale oil production. Horizontal drilling refers to the drilling technique that drills horizontally. In contrast, the hydraulic fracturing refers to the final process of well operations where chemically combined liquid consisting of water, proppant and chemicals is injected to the shale rock, allowing the oil and the gas to flow (The U.S. Energy Information Administration, EIA, 2018). As a result of technological advancements in the oil and gas sector which not only made untapped shale oil available for the U.S. due to limitations but also allowed the shale oil to be produced in large quantities.

There are certain differences between conventional and shale oil production processes. In terms of their cost analyses, despite the breakeven prices in shale oil that has been dropping over the years, the breakeven prices for conventional oil had always been lower. The cost-per-barrel of conventional deposits changes depending on a country; however, one of the biggest conventional oil producers, Saudi Arabia can produce oil cheaply, sometimes under $10. While in the Middle East and North Africa, oil can be produced as under as $20 per barrel (Beattie, 2019). In the case of shale oil, the biggest shale oil producer, the U.S.' current breakeven price ranges between $40 and $60; only a few producers can reduce their costs to less than $35 (Hiller, 2020). Also, shale oil wells are observed to drop in their production throughout time. Even so, it is unclear though whether shale oil wells have shorter lifespan than conventional oil well; Nevertheless, the production phases of shale oil and conventional oil fields are different. For example, production wells in Permian's Wolfcamp shale declined close to 15% after five years (WoodMackenzie, 2019). Similarly, a separate study conducted by Goldman Sachs referring to shale oil industry that "the most transformative areas of global oil supply are between 7 to 15 years" (Cunnigham, 2018). Moreover, the quantity of shale oil production for each field are different from conventional oil since shale oil producers are smaller than conventional oil producers on their capital structure. As a result, shale oil producers are more sensitive to interest rates, financial conditions, and business cycles. Thus, since each operation field is smaller than the conventional to produce oil, to increase or decrease oil production is easier than conventional wells. Consequently, they may respond to market conditions faster.

For the assessment of market factors for the shale oil production, the U.S. data was employed. There are several reasons for this selection. First, shale oil became a new source of oil supply for the U.S. market, which reduces U.S. oil dependency to a certain extent. The U.S., which was among top importer oil, has now become among top producers. The U.S. has become the topmost crude oil producer (13.2%) in the world, followed by Russia (13%), Saudi Arabia (12.6%), Iraq (5.6 %), and Canada (5.2 %). The U.S. crude oil is mainly supplied from five states: Texas (40%) North

Dakota (11.5%), New Mexico (6.3%), Oklahoma (5%), and Alaska (4.5%) (EIA, 2019). Although the U.S. has decreased its import in a few years; however, domestic production, which accounts for 89%, is not enough to meet its oil demand. The U.S. produced 17.7 million barrels of oil per day, while it consumed around 20.5 million barrels of oil per day in 2018. (EIA, 2019). The domestic market in the U.S. also demands refined crude oil or petroleum products such as gasoline, diesel, heating oil and propane. Even when the U.S. has become a top producer, due to the characteristic of shale oil low sulfur content - very light crude the U.S. still needs to import heavy crude to blend with it crude to meet its domestic demand. The second reason is that oil and gas companies provide new jobs for the U.S. labor force, which had resulted in slowly restoring its economy during the economic crisis after 2008. In this way, the U.S. may come out from the effects of the 2008 recession faster than other countries. Last and the most importantly the U.S. was among the top importers of crude oil, just recently the U.S became one of the important oil exporters.

For the U.S. oil market, the U.S. had imposed the crude oil export ban that came into effect after the Arab oil embargo to Israel and its allies in 1975. The U.S. had enacted this ban to focus its domestic production on supplying its domestic oil market. Due to its oil production increase, the U.S. removed its oil production ban in 2016 that the U.S. had imposed in 1975.The purpose of this thesis is to assess how the shale oil production measure responds to market forces as well as how a remove of export ban in December 2015 on the US crude oil the U.S. had affects these responses.

For this thesis, the novel data from Primary Vision's Frac Count for the U.S. shale production used in which considers the number of tools and equipment used to make an oil well to start production. Frac Count is similar to production data, however there are specific differences among them. The critical difference is that Frac Spread Count use indicators such as chemical storage trucks, water trucks, sand, fluid storage tanks and wellheads to forecast the U.S. oil production. In contrast, the EIA dataset is dependent to information provided by oil companies and subject to measurement errors. If the EIA cannot retrieve the information of which includes all the operators in a state, then EIA does not include those operators in the sample and estimation and thus overall estimations will be biased. The EIA tries to tackle this problem using what it refers as calculating based on 'most recently complete month' for each state. The EIA calculates taking the number of months between the latest reported month and the month which the total production volume of a state is anticipated to be (EIA, 2018). Thus, the monthly production data set coming from the EIA is an estimation based on six-month average and the estimates are subject to the *Type-II* errors. Another important methodology flaw of EIA monthly estimation is that, unknown, deficient reporting or incorrectly handled mergers and property sales cause relative standard error to be large (EIA, 2018); The relative standard error is the percentage of standard error which is square root of the variance. The EIA states that, the error term is not significantly large, but it is possible "to miss the bigger event" (EIA, 2018). Related with the missing information coming from states, concerning methodology flaw of the EIA is that, some companies do not report their data, or they report a value that is out of expectations. If the EIA cannot retrieve and get a justifiable explanation from the company about the suspicious or missing data, then the data is imputed at the time of estimation. The EIA derives imputed variables for oil production using three-month average of the most recently available dataset. In short, the EIA oil production methodology has quite significant lags changing for each state. The EIA admits these concerning flaws, but explicitly state that they are aiming for 85% coverage of all states which is quite large error term.

In this thesis, Vector Autoregressive (VAR) model was used to assess the dynamic relationships among Frac Count from the Primary Vision and set of financial/macro-economic variables and how this dynamic relationships alter with the effects of the U.S. export ban before and after the upliftment of the prohibition of the export ban. In the model, I looked at how the U.S. Nationwide Frac Count (FSCN) is affected by ten macro financial variables as well as how FSCN affects these variables in the full sample. Additionally, the same analysis was conducted for the pre-ban (2014 - 2015) and post ban eras (2016 - 2020). The empirical evidence reveals that, a positive shock to NYMEX, S&P500, rig count, WTI and ending oil stocks increase the FSCN but higher interest rate and oil production decrease FSCN. After the U.S. became one of the major oil producers, it removed its crude export ban in December 2015. The empirical evidence suggests that the shale oil industry gets more integrated with the financial system and be more efficient in its production process in the post 2016 era after the export ban has been removed.

The next section will be discussing the literature. In section 3, data and the methodology which is used in this thesis in detail is discussed. In the fourth section, the empirical evidence is reported derived from the model, and in the last section, I conclude this thesis.

CHAPTER II

LITERATURE REVIEW

The initial literature focuses on economic benefits and consequences of shale oil. A group of authors argue that shale oil boom has contributed to the U.S. GDP and created jobs (Brown & Yücel, 2013; Eberhart, 2011; Malfone, 2013); while other authors focused on its environmental impacts such as being threat to ecological habitats (see, for example, Brittingham et al., 2014; Leahy, 2014, Souther, et al., 2014) and health consequences such as water pollution (see for example, Banerjee, 2015; Zhang & Yang, 2015). The literature also elaborates the competitiveness between the U.S. and OPEC producers (Ramady & Mahdi, 2015; Lemon, 2014; Salameh, 2013); while some few studies exclusively analyze shale oil's potential impact to African oil producers (Brune, 2015; and Ogunyiola, 2015).

More detailed studies analyzed the effect of shale oil on world oil prices. Some authors argued that the shale oil was one of causes of the world crude oil price crash in 2014 (Alvarez & Nino, 2017; Baffes et. al, 2015; Ellwanger, Sawatzky & Zmitrowicz, 2017); while some argue, there is not enough evidence supporting shale oil boom's impact on 2014 crude oil prices (Baumeister and Kilian, 2016; Killlan, 2017; Killian, 2015; Manescu & Nuno, 2015). However, a larger number of studeiesare more in conformation that, shale oil has negative impact to crude oil prices (Frondel & Harvoth, 2019). Similarly, an expected increase in shale oil supply decreases crude oil prices (Fueki et.al, 2018).

Related to the world crude oil prices literature, the chief economist of the British Petroleum also argued that, although shale oil is more responsive then conventional oil to price shocks, it is also more dependent to banking and financial systems resulting in exposing oil market to financial shocks and financial shocks increase price volatility in the oil market (Dale, 2015). The recent developments in the U.S banking sector shows the potential dilemma of the U.S which the author had signaled towards. Gupta (2019) states that, the lack of credit was heavy blow to already struggling shale industry. These developments will manifest on the U.S. economy as oil and gas sector contributes eight percent to the GDP (American Petroleum Institute, 2018).

The characteristics of shale oil production is important to better understand the effects of market forces on oil production. Shale oil production is more capital intensive than conventional oil production. Thus, oil companies have to drill more wells to cover their costs. In other words, they have to look for other wells while not reaping the benefits from their earlier investment. One of the weaknesses of shale oil production is that as soon as a well starts the production, the production reaches its peak production in the first week (Mauguri, 2013; McCracken, 2015). Additionally, if oil prices drop more than the marginal cost of oil production, the companies would slow down their operations by shutting down wells and or could terminate them

(Difiglo, 2014). Thus, shale oil production is more sensitive to market forces then the conventional oil production.

CHAPTER III

DATA AND METHODOLOGY

In order to assess the dynamic relationships among national Frac Count (*FSCN*) and set of financial and macro-economic variables; New York Mercantile Exchange oil price future contracts (*NYMEX*), Standard & Poor's 500 (*S&P500*), West Texas Intermediate (*WTI*), Brent/WTI ratio (*BRENT/WTI*), refinery utilization rate (*UTIL*), oil export/import ratio (*EXP/IMP*), the U.S. crude oil ending stock (*STOCK*), the U.S. crude oil production (*PROD*), Federal Funds Rate (*R*) and Rig Count (*RIG*) are employed. The Vector Autoregressive (VAR) model is used with the weekly observation starting from 2014 and ending in March 2020 consisting of 639 observations.

The primary variable of this thesis, *FSCN* gathered by considering the equipment that are needed to complete an oil well operation – chemical storage trucks, water trucks, sand, and frac fluid storage tanks, wellheads, frac blenders, and frac pumps (Primary Vision, 2019). *FSCN* considers the time of an oil well is completed and started its production. PV's dataset considers the U.S. eighteen region's shale basins. The PV's dataset also includes *RIG* which capture the number of oil wells being drilled in a particular field. It is important to mention that *RIG* does not mean the production. It merely shows how many wells have been drilled in a particular region. Since the production is realized very soon after the operations, it precedes the production in a very short period of time.

NYMEX Contract 4 is a future price of WTI that will be delivered in four months in the oil market and buyers use *NYMEX* contracts as a hedging tool to minimize their risk (Reiff, 2020). *PROD* defined as the total U.S. crude oil production in thousand barrels per day. Brent/WTI (*BRENT/WTI*) is the relative crude oil spot price of Brent to WTI. *UTIL* known as the refinery utilization rate (the percentage showing how much refineries derive from raw oil in the U.S.). The U.S. oil export/import ratio denoted by *EXP/IMP*. The U.S. ending oil stock is denoted by *STOCK*. All these data are taken from the EIA.

Moreover, *R* is for Federal Funds Rate taken from the St. Louis's Federal Reserve Economic Data Delivery System. Lastly, *S&P500* which is an index consisting of 500 U.S companies taken from Yahoo finance. For the analysis, all the variables are taken in logarithms while for the interest rates and utility rates are in levels.
In order to assess how the *FSCN* are affected by various market statistics in a dynamic framework and how does the *FSCN* affect these variables I employed a VAR model. The VAR models are the dynamic models consisting of an n-equation n-variable linear specification, explaining the current variables of interest with their lag values (Stock & Watson, 2001). In this thesis, the Impulse Response Function analyses (IRF) are used for inferences. I have used the Cholesky decompression method for identifying shocks for the IRF's. Ordering variables in Cholesky decomposition is important because all the variables in the equation get affected by

the preceding variable before them concurrently, but at the same time they do not get affected by the next variable in the equation. The order of the variables are chosen such that financial variables are placed first, production data set as second and price data set as the third and trade and stock variables placed the last. For each group, it was placed by the most volatile to the least volatile. The lag order which was chosen for the VAR specification is two, as proposed by the Akaike Information Criteria.

CHAPTER IV

EMPRICAL RESULTS

In order to assess how *FSCN* a measure the shale oil production in the U.S. affected by economic variables, Figure 1 reports the impulse responses of *FSCN* when one-standard-deviation-stock is given of the various economic variables. Figure 2 for is the impulse response to these macroeconomic variables when one-standard-deviation shock is given to *FSCN*. The solid blue line is for the impulse responses, and two dotted red lines are for 95% confidence intervals. If the red line includes zero, then the null hypothesis cannot be rejected and if the impulse response is zero for that particular period then it is statistically significant.

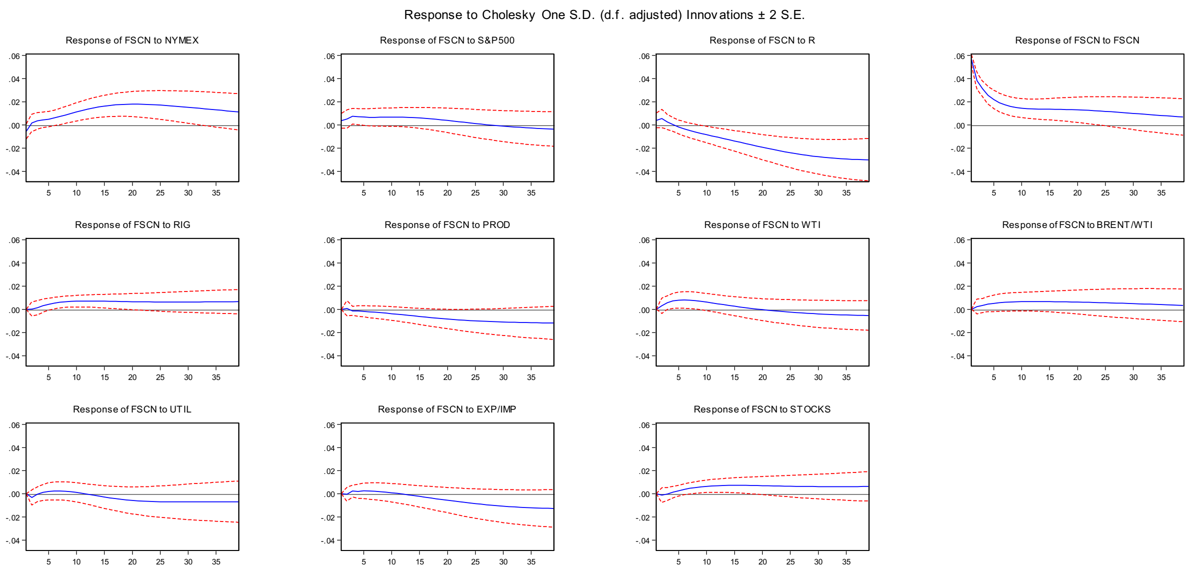

Figure 1: Response of National Frac Spread Count to Eleven Variables Between 2014 and 2020

Figure 1 suggests that one-standard-deviation-stock to *NYMEX, S&P500, RIG, WTI,* and *STOCKS* increase the *FSCN* in a statically significant fashion at least for one period. This effect is more lasting for *NYMEX* oil contracts, *RIG,* and *STOCKS*. The impact of higher stock return in *S&P500* makes financing of oil production easier. As for *S&P500*, *FSCN* initially increases, then the curve gradually declines until its 29th week. After the 30th week, it passes to the negative zone.

The increasing effect of higher oil prices captured by *NYMEX* and *WTI* on *FSCN* also make sense as well since the operation would be more profitable with higher oil prices. Oil and gas companies use *NYMEX* futures contracts for oil prices due to hedge their risks to cover up possible losses (Chen, 2020). *NYMEX* futures contracts, due to its transparent price mechanism and liquidity, are taken as an international benchmark in the crude oil markets, while *WTI* spot prices are historically known to be more volatile (Securities and Exchange, 2008). *NYMEX* affects *FSCN* positively between week 4th and 32nd week, while other periods are not statistically significant. *WTI* effects *FSCN* positively between 3rd week and 10th week in a shorter duration. The above reasons are indicating towards companies using *NYMEX* futures instead of *WTI* spot prices to make their production decrease. Therefore, when *NYMEX* increases, this generally means *FSCN* will also increase because the future prices are attractive for sellers to sell their commodities. So, the oil and gas companies would be motivated to explore new wells and upgrade their existing wells to increase their margin, as observed in the graph.

The relative price of *BRENT/WTI* also increases the *FSCN*. This might be due to higher export potential of the U.S. oil. Higher U.S. *STOCKS* may also increase *FSCN*. The effect of *STOCKS* is permanent; it dies out after 46 periods (not reported), and this is statically significant for the first 18 periods. It is seen that as *STOCKS* increases, *FSCN* starts to increase after the 7th period till the 18th period in a statically significant function. Shock to *STOCKS* effects *FSCN* positively between 7th till 18th week.

On the other hand, higher interest rates and production decreases the *FSCN*. This makes sense because as the cost of borrowing increases or the production, including production that comes from conventional oil fields. *R* affects *FSCN* with an increase initially however, the impulse response declines gradually falls after the 3rd week. In short, *FSCN* gradually increases when a shock is given to *NYMEX* and *WTI*. Second, as a result of the shock given to *S&P500*, *FSCN* increases until 30th week and then after the 30th week, it drops down to negative zone however after the 30th week is statically insignificant and when a shock is given to *R, FSCN* declines sharply. These findings are sensible. While for the rest of the variables except *RIG, WTI* and *STOCKS* are statistically insignificant. Although these three variables are overall statically insignificant as well; there are periods observed in these variables where they affect *FSCN* positively which is statistically significant.

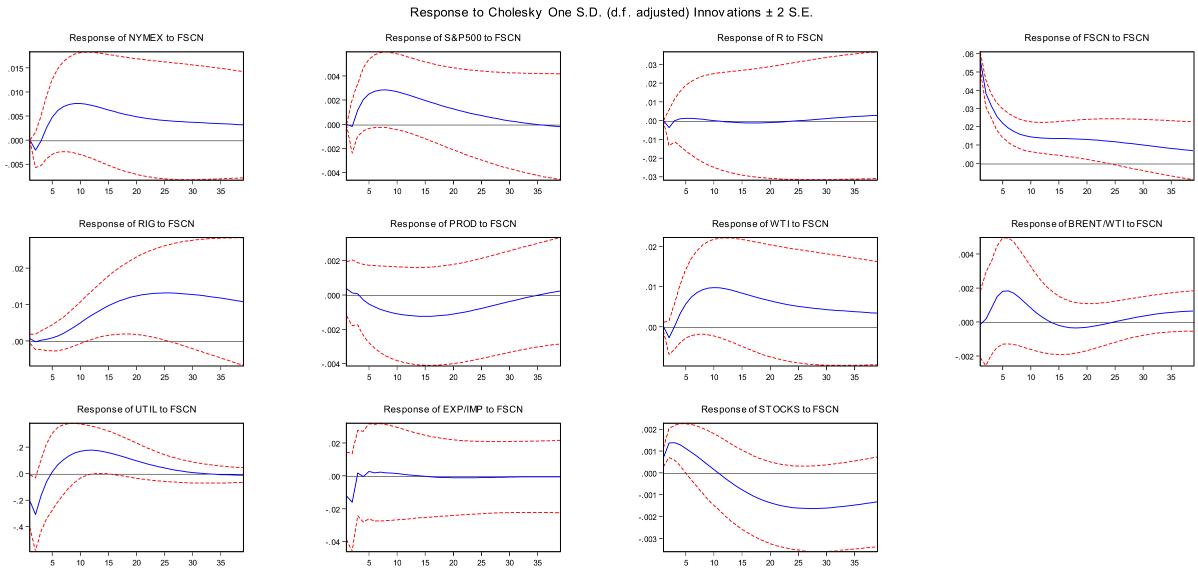

Figure 2: Response of Eleven Variables to National Frac Spread Count Between 2014 and 2020

Figure 2 suggests that one-standard-deviation-shock to *FSCN* increases *RIG*, *UTIL,* and *STOCKS* in a statically significant function. For *RIG,* it is statistically significant between 11th and 26th periods, for *UTIL* it is between 13th and 15th periods at the margin and as for *STOCKS* it is the first seven period. *UTIL* starts from the negative zone then, a sharp increase where it passes to the positive zone is observed between the 2nd and 10th weeks. Then *UTIL's* curve gradually declines which drops down to the negative zone from 36th week. *EXP/IMP* also starts from the negative zone but sharply increases passing to the positive zone starting from 3rd till 4th weeks, then the curve gradually declines to drop to the negative zone from 6th week till 24th weeks. From 25th week and onwards the curve stays close to the zero. *STOCKS* start from the positive zone but declines gradually dropping to the negative zone through time starting from 3rd week. These results are sensible as in each *FSCN*, there may be more than one rig. Thus, companies are likely to increase production, rig count and utilization rate. Additionally, higher *FSCN* can be taken as an indicator of crude production and this increases crude *STOCKS*.

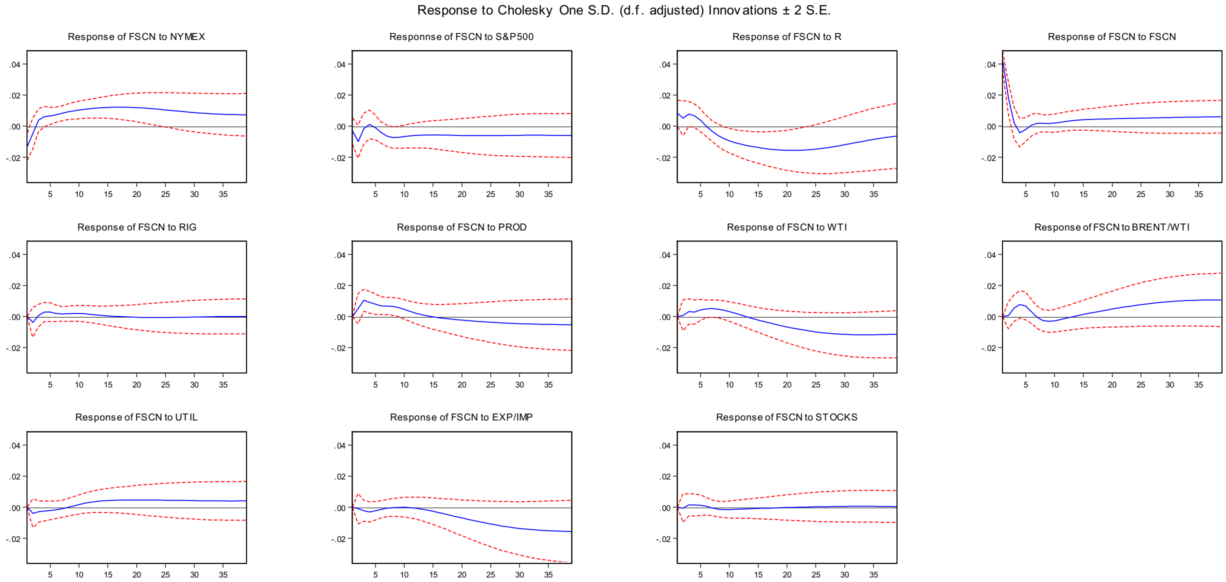

Figure 3: Response of FSCN to Eleven Variables between 2014 – 2015

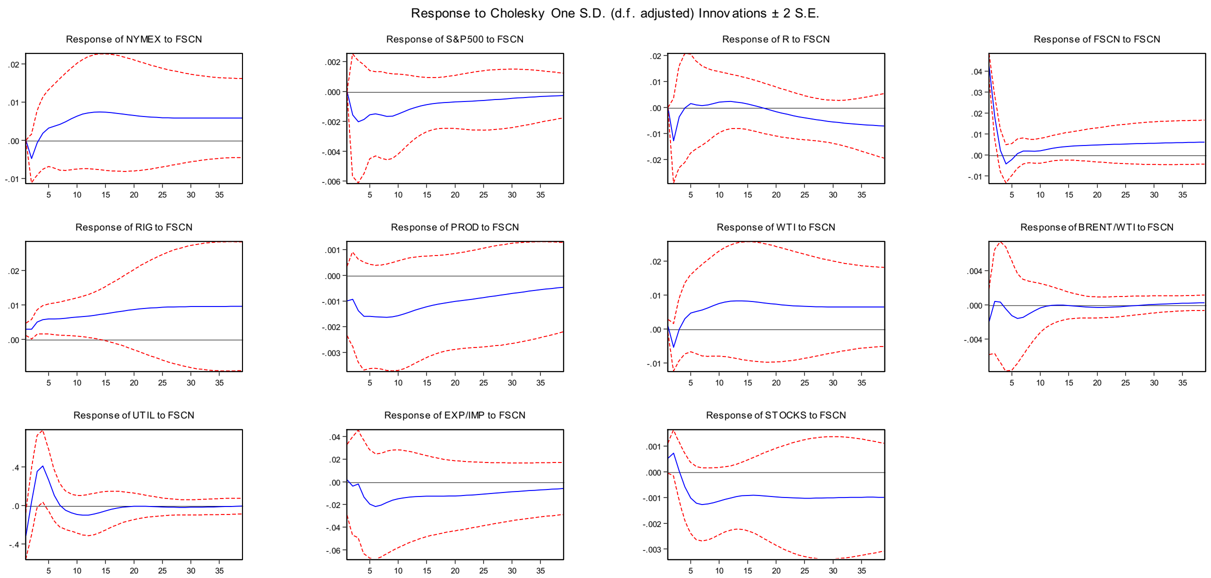

Figure 4: Responses of Eleven Variables to FSCN Between 2014 – 2015

In 1975 the U.S. imposed a ban on crude oil export as a response to the Arab oil embargo. With the shale revolution the U.S. had increased its oil production. Thus, starting 2016, the U.S. has lifted this export ban. In order to see if this ban had an effect on the *FSCN*, then I split the sample into pre-ban 2014 – 2015 and post-ban 2016 – 2019 eras. Figures 3 and 4 report the impulse response before the ban. Whereas the figures 5 and 6 show after the ban has been lifted for 2016 – 2019. The estimates are mostly robust with a few exceptions. When the effects of eleven variables is looked at, then it was observed that *NYMEX* contracts positively affect the *FSCN* after the removal of the ban that was negative during ban. *RIG* did not have a statistically significant effect during the ban, but Rig count has a statistically significant effect on *FSCN* after the removal of ban. During the ban production had a positive effect on *FSCN* but this effect disappears after the ban is removed. All these suggest that shale oil industry is more integrated with the financial system and get more efficient in its production in the post-2016 era after the export ban has been removed.

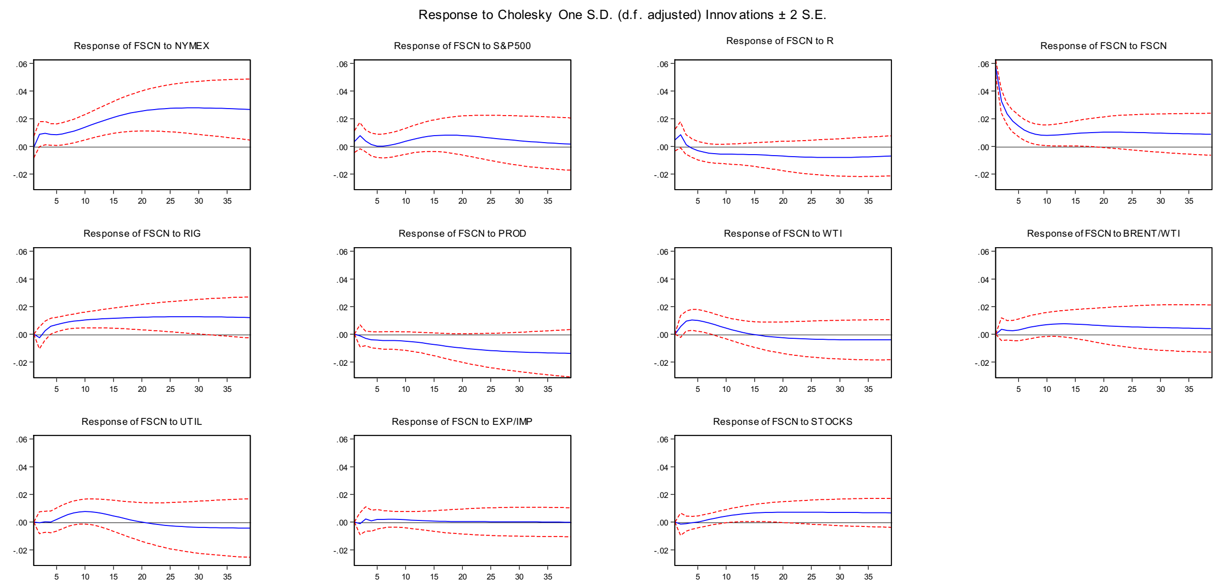

Figure 5: Response of FSCN to Eleven Variables between 2016 – 2020

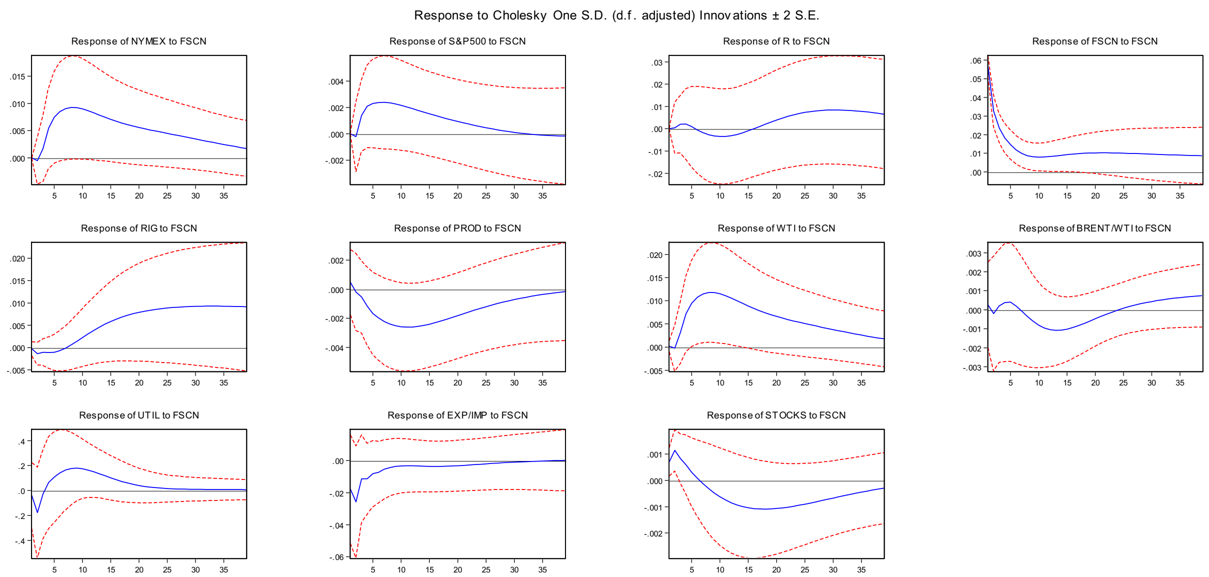

Figure 6: Response of Eleven Variables to FSCN between 2016 – 2020

The tight oil data is available from the EIA of the U.S. As stated in the introduction, this data is subject to measurement errors. Nevertheless, the exercise was repeated for the full sample by using the tight oil data rather than *FSCN*. The impulse responses are reported in Figure 7 and 8. The impulse responses are mostly parallel but have wider confidence bands. This further validates the use of *FSCN* as a production measure of shale oil in this thesis.

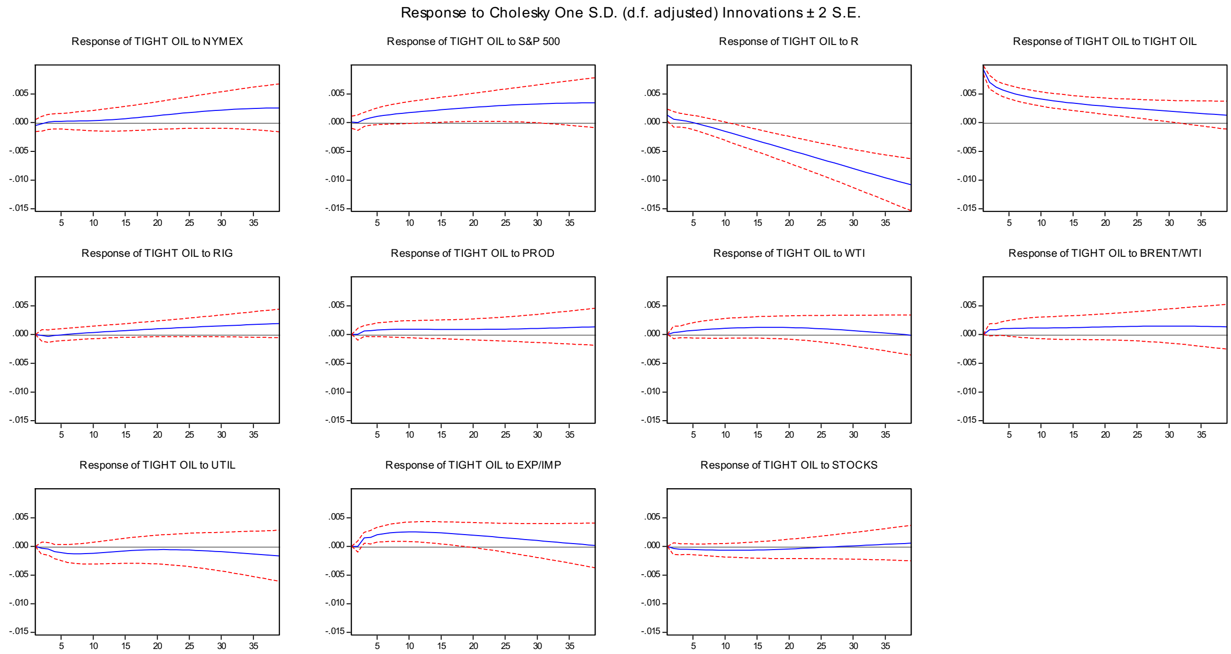

Figure 7: Response of Tight Oil to Eleven Variables Between 2014 and 2020

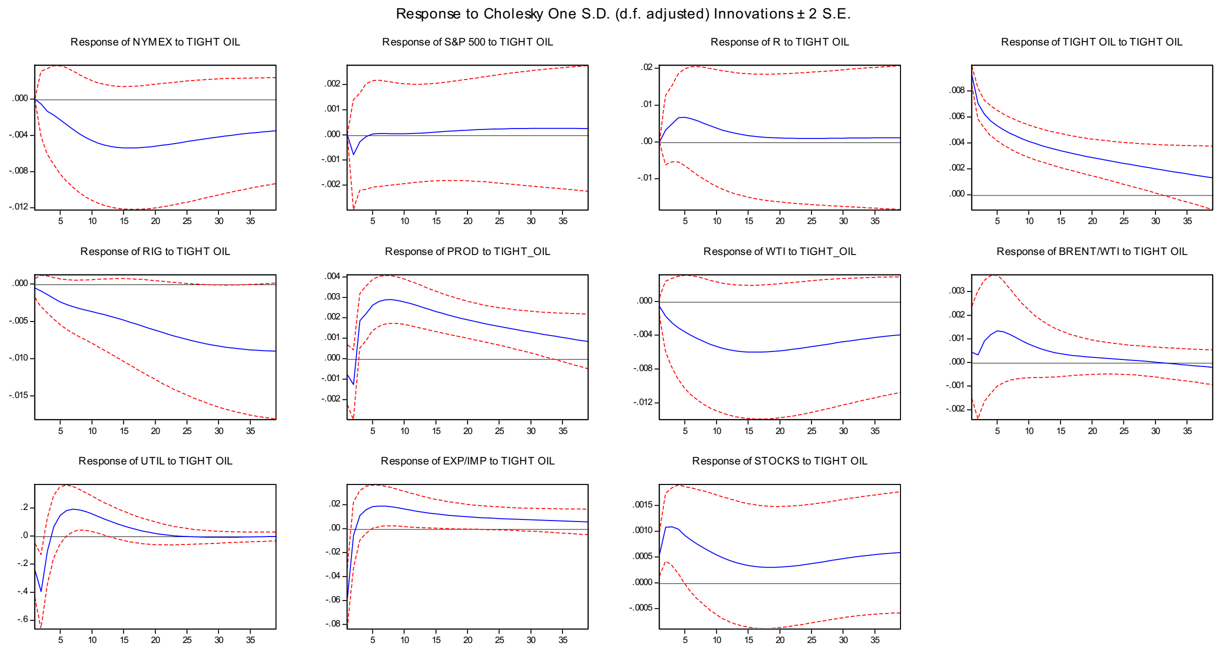

Figure 8: Response of Eleven Variable to Tight Oil Between 2014 and 2020

CHAPTER V

CONCLUSION

The thesis assesses how a measure of shale oil – frac count responds to various macroeconomic variables as well as how the frac count affects economic variables.

FSCN gradually increases when a shock is given to *NYMEX*. Second, as a result of the shock given to *S&P500*, *FSCN* increases till 30^{th} week and then after the 30^{th} week, it drops down to negative zone however after the 30^{th} week is statically insignificant and when a shock is given to *R, FSCN* declines sharply. These findings are sensible. Figure 2 suggests that FSCN increases *RIG*, *UTIL, and STOCKS* in a statically significant function while FSCN decreases EXP/IMP negatively. While for the rest of the variables except *RIG, WTI* and *STOCKS* are statistically insignificant. Although these three variables are overall statically insignificant as well there are periods observed in these variables where they affect *FSCN* positively which is statistically significant. An increase in interest rates affects the Frac Count in the ban era post-2015. The evidence is not statistically significant. Once the ban has been removed, the response of Frac Count to production, stocks and rig count are statically significant. This may mean that shale oil companies may have more access to an external source such as taking credits elsewhere.

When one - standard deviation shock is given during the ban-era rig count increased and utility rate increased, but in the post-ban era, the stock market sharply increased more, and stocks to FSCN declines gradually.

Overall, this thesis successfully shows that a direct measure of shale oil responds to macroeconomic and financial variables, in the post 2016 era, frac counts are affected by interest rates, U.S. production but more affected by NYMEX, WTI. This make sense since as the shale oil producers are more established and access to financial markets the former two variables are less effective.

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