THE STUDY OF THE BULLWHIP EFFECT

IN THE OIL AND GAS INDUSTRY

By

MINA AZHAR

Bachelor of Science in Industrial and Systems Engineering

Korean Advanced Institute of Science and Technology

Daejeon, South Korea

2011

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
December, 2013

THE STUDY OF THE BULLWHIP EFFECT

IN THE OIL AND GAS INDUSTRY

Thesis Approved:

Dr. Tieming Liu

Thesis Adviser

Dr. Daniel Tilley

Dr. Camille DeYong

ACKNOWLEDGEMENTS

It would not have been possible to write this thesis without the help and support of the amazing people around me, to only some of whom it is possible to give particular mention here.

Above all, I would like to thank Allah SWT for giving me the strength and blessings to complete this thesis.

I would like to first show gratitude my advisor, Dr. Tieming Liu. For without his guidance and patience, this thesis would not have been possible. I am eternally grateful to Dr. Daniel Tilley for believing in me with this project, showing encouragement and guidance while giving me the opportunity to pursue the project for my thesis. I am truly thankful to Dr. Camille DeYong for showing me amazing support and guidance throughout this thesis and in Alpha Pi Mu.

I would like to thank my parents who have provided me guidance and emotional support throughout this study and in my life. They have supported me in pursuing knowledge as far as it will take me and I am forever blessed for that. I would like to thank my father, grandmother, sister and brother who have always been by my side and showed me love and encouragement. To Juan, I show my gratitude for the support, love and patience from the beginning and in pursuing my master's degree.

I would like to acknowledge the support of the New Product Development Center who has given me invaluable knowledge through real on-hands experience with problems in the industry. I am indebted to the department of Industrial Engineering and Management for facilitating my pursuance in knowledge and helping me shape my career path. I would like to thank Drs. Dalal, Glenn, Ingalls, Kamath, Kong, Pratt, and Swim for giving me immeasurable knowledge that will help me advance in my career.

Name: MINA AZHAR

Date of Degree: DECEMBER, 2013

Title of Study: THE STUDY OF THE BULLWHIP EFFECT IN THE OIL AND GAS INDUSTRY

Major Field: INDUSTRIAL ENGINEERING AND MANAGEMENT

Abstract: The New Product Development Center (NPDC) at Oklahoma State University (OSU) received problems reported by oil equipment suppliers. The specific problems the oil equipment suppliers experienced were frequent large labor adjustments due to large spikes in demand along with cyclic periods of high and low demand. When looking at data from the New York Stock Exchange (NYSE), it appeared that demand variability increased as it went up the supply chain in the oil and gas industry. From a supply chain management perspective, the specific problems reported by the oil equipment suppliers are similar to symptoms a company in an industry with the bullwhip effect present would experience. The investigation of this phenomenon used firm level data through a defined direct link of the levels in the oil and gas supply chain. Three research questions were posed: if the bullwhip exists in the oil and gas industry; if the highest level in the defined supply chain experiences the highest amount of demand variability; and if smaller sized companies are more susceptible to the bullwhip effect. The following results were found: most of the companies in the study and in the supply chain showed evidence of the bullwhip effect presence; the highest level in the supply chain did not appear to experience largest amount of demand variability; and the smaller companies demonstrated larger bullwhip effects. Other than the research questions, the study also provided evidence that: cyclicality was not widespread, but the largest demand was generally experienced by companies in the fourth quarter and lowest demand generally seen in the first quarter; larger integrated companies exhibited a lower bullwhip effect than smaller integrated companies; and the upstream level exhibited the largest bullwhip effect while the drilling and service and equipment level showed continuous improvement during the oil crisis in 2008.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

CHAPTER I

INTRODUCTION

1.1 Background

The New Product Development Center (NPDC) at Oklahoma State University (OSU) received problems reported by oil equipment suppliers. The specific problems the oil equipment suppliers experienced were frequent large labor adjustments due to large spikes in demand along with cyclic periods of high and low demand. When looking at data from the New York Stock Exchange (NYSE), it appeared that demand variability increased from downstream upwards the supply chain in the oil and gas industry. This behavior resembles that of a phenomenon known as the bullwhip effect. The bullwhip effect has been extensively studied in the retail industry. However, in the oil and gas industry, the behavior of the bullwhip effect has not been studied through a multiple level supply chain as it exists in the industry.

1.2 Statement of the Problem

From a supply chain management perspective, the specific problems reported by the oil equipment suppliers are similar to symptoms a company would experience, in an industry with the bullwhip effect present. Thus, the existence of the bullwhip effect and its impact on the companies in the oil and gas industry became the focus of the thesis. Investigation of this phenomenon in major levels of the oil and gas supply chain aimed to provide insight into the condition of the industry.

1.3 Introduction to the Bullwhip Effect

The bullwhip effect in industry is described through the magnified variability in demand and production, originating from the retailer level and amplifying as it moves up the supply chain affecting the upper-most suppliers. This resembles the crack of the bullwhip; it starts with smaller amplitude and as it moves through the whip, the amplitude increases.

The bullwhip effect was first analyzed by Forrester (1958) in his book "Industrial Dynamics" to create awareness for management on dynamic interactions in an industry. At that time it was known as the "Forrester Effect." Later Lee, Padmanabhan, and Whang (1997a) defined the bullwhip effect as the amplification of demand from a downstream site to an upstream site. Chen and Lee (2012) then defined two different measurements to quantify the bullwhip effect: distortion of information flow and distortion of material flow. The measurement used throughout the study to define the bullwhip effect was the distortion of material flow due to the practicality of using variance of production data instead of order data. Production data are readily available in company annual reports and orders are not.

The bullwhip effect has been studied in single firms (Mack, 1953; Hammond, 1994; Lee, Padmanabhan, and Whang, 1997b; Holt, Modigliani, and Shelton, 1968; Terwiesch, Ren, Ho, and Cohen, 2005), whole industries (Anderson, Fine, and Parker, 2000; Blanchard, 1983; Zymelman, 1965) and multiple industries (Miron and Zeldes, 1988; Cachon, Randall, and Schmidt, 2007; Bray and Mendelson, 2012). The majority of the papers studying the bullwhip effect specifically in the oil and gas industry mainly focused on testing different strategies to mitigate the bullwhip effect using simulation (Zhang and Zhang, 2013; Huang, Yan, and Guo, 2007; Shizeng, Zhen, and Xiaoyuan, 2006; Jacoby, 2010). The gap found in the literature was that the behavior of bullwhip effect has not been studied through a multiple level supply chain as it exists in the oil and gas industry.

1.4 Scope and Methodology

The purpose of this study was to develop a useful and thorough analysis of the bullwhip effect on the oil and gas industry from the publicly available data from companies traded on the New York Stock Exchange (NYSE).

Three selection criteria were made when selecting the companies for the study. First, the companies selected should provide publicly available data that go at least as far back as the first quarter of 2004. The pattern of the oil price, as well as the majority of the production and demand of the companies before 2004 was different from the patterns between 2004 and 2012. This also allowed the research to focus on the behavior before, during, and after the oil crisis in 2008. Second, these companies should be directly involved in the oil and gas industry, i.e., companies that drill, explore, gather, store and process oil and gas and those who offer services and equipment to companies. The third criteria for the companies selected was that they should not have merged, split, or have been acquired within the timeline of 2004-2012 as the significant change in production and demand would have been biased.

Using the data of the companies, the study first analyzed the individual companies. The companies were then aggregated according to the supply chain level in which they belonged, and each group was analyzed as a representative of the level in the supply chain. Each level was then aggregated and observed as a whole supply chain representative of the oil and gas industry. In each analysis, the study measured the following:

1. Bullwhip Effect (BE) ratios as one value to see how the company/level behaved overall within 2004-2012 and in three different values to see how it behaved before, during, and after the oil crisis
2. Coefficient of Variation (C.V.) in demand and production
3. Cyclical patterns of production and demand, and

4. Size of firms.

The following formula was used throughout the study to verify the existence of the bullwhip effect:

$$\frac{Variance[Production]}{Variance[Demand]}$$

among downstream, midstream, upstream, drilling and service and equipment companies. The bullwhip effect was said to exist if the value was larger than 1.

1.5 Research Questions

We sought to analyze three research questions in this study. The suppliers reported having experienced large, inconsistent demands from their customers, who are large players in the industry. Highly unpredictable production was a result. This is a symptom a company in an industry with a prominent existence of the bullwhip effect would experience. Therefore, the existence of the bullwhip effect was questioned in the oil and gas industry through the first research question.

Research Question 1: Does the bullwhip effect exist in the oil and gas industry?

Based on bullwhip effect theory, the higher the demand goes up the supply chain, the more variability the player at that level will experience (Figure 1). Since the suppliers in Oklahoma supply service and equipment are at the beginning of the oil and gas supply chain, it is expected for them to experience the highest amount of variability compared to the lower levels they supply. This was determined as the second research question.

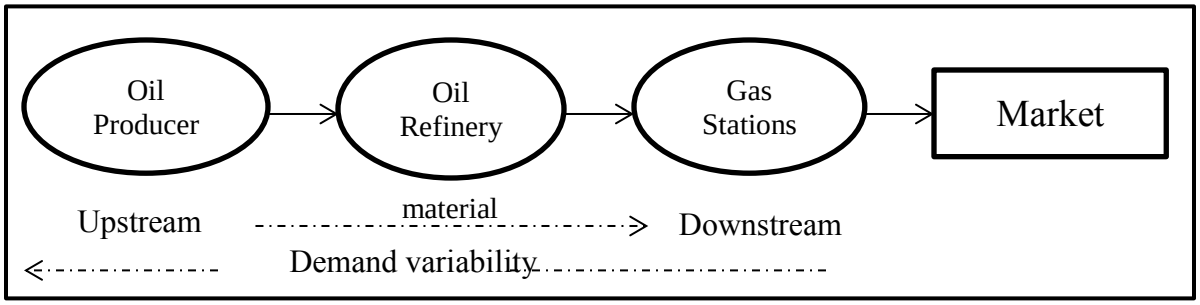


Figure 1. Oil and Gas Supply Chain

Research Question 2: Does the service and equipment level exhibit the highest demand variability in the supply chain?

Another observation this thesis aimed to analyze was if smaller sized companies were more susceptible to the bullwhip effect. Small companies have less capital and labor compared to large companies. Therefore, they have less capacity and tools to handle unpredictable situations. Small companies in the study were defined by NAICS‘s standard of small businesses based on the number of employees in the company. In addition, the companies that reported problems were smaller sized companies. This was stated as the third research question.

Research Question 3: Are smaller sized companies more susceptible to larger demand variability than larger sized companies?

The rest of the study is organized as follows. Related literature is reviewed in Chapter 2. The design of the investigation, analysis of the supply chain in the oil and gas industry and analysis of individual companies is in Chapter 3. The results are then used to answer the research questions in Chapter 4. Important conclusions on how this study will provide insight to Oklahoma’s suppliers and the industry along with possible further work is in Chapter 5.

CHAPTER II

LITERATURE REVIEW

The research performed focused on the study of the bullwhip effect in the oil and gas industry. The literature reviewed in this chapter relates to existing studies on the bullwhip effect, specifically studies in the field of the oil and gas industry, and, compiled strategies that would seem fit for the companies that are experiencing the bullwhip effect at the top of the supply chain.

2.1 Studies on the Bullwhip Effect

The bullwhip effect was first discovered by Forrester (1958). He led the path by simulating decisions made by managers and thoroughly analyzing the dynamic interactions that exist in industries. He pointed out that the basic forms and policies an organization uses can cause undesirable time-varying behaviors in the supply chain. These varying behaviors were first known as the 'Forrester Effect' and are now named the bullwhip effect. Sterman (1989) simulated the supply chain with four players who make independent inventory decisions through his infamous "Beer Game." He concluded that the bullwhip effect was caused by the players' systematic irrational behavior. Both Forrester (1958) and Sterman (1989) observed the bullwhip effect through a controlled environment and focused on the behavior of the decision makers.

Using the definition and characteristics of the bullwhip effect, many papers sought to investigate its behavior and existence in different industries through a single firm. Mack (1953) investigated it in the apparel industry; Hammond (1994) and Lee, et al. (1997b) investigated it in the food industry; Holt, et al. (1968) and Terwiesch, et al. (2005) in the electronics industry.

However, Bray and Mendelson (2012) mentioned several pitfalls with single firm studies; they might have bias to show positive bullwhip effect results since a bullwhip effect would be expected.

There are studies that go beyond the behavior in single firms and focus on a whole industry. Blanchard (1983) investigated the automobile industry; Anderson et al. (2000) examined the machine tool industry through simulation; and Zymelman (1965) simulated how a policy would be able to reduce the amplitude of the goods cycle in the cotton textile industry.

Several papers took the study further and observed multiple industries. Miron and Zeldes (1988) compared the food, tobacco, apparel, chemicals, petroleum and rubber industry. Cachon et al. (2007) examined the existence and strength of the bullwhip effect in various industries through access of industry-level U.S. data. Here, they categorized the companies into three levels of a supply chain: manufacturing, wholesale and retail industry level. Bray et al. (2012) also looked at the bullwhip effect across the entire U.S. economy but further refined Cachon et al. (2007) by observing firm level data instead of industry level data and using quarterly data instead of monthly, which was also done in this study. In all three papers stated above, the bullwhip effect was seen to positively exist in the petroleum industry.

Several papers in the literature aimed to quantify the bullwhip effect and analyze its behavior in different settings. Papers including Chen and Lee (2012), Lee et al. (1997a) and Chen, Drezner, Ryan, and Simchi-Levi (2000) quantified the bullwhip effect as a ratio of variance of orders over variance of demand and stated that it existed if the value was larger than one. Chen and Lee (2012) categorized two different measures of the bullwhip effect: distortion of information flow and distortion of material flow. Distortion of information flow compared variance of orders with variance of demand while distortion of material flow compared variance of production over variance of demand. These formulas can be seen in Table 1. Papers modeling

different factors of the bullwhip effect, such as how it is related to supply chain costs and other implications, prefer using the information flow definition. The information flow measurement sees orders as input to the order-fulfillment process while the material flow measurement sees the outcome of it. However, for studies that investigate the bullwhip effect in multiple industries and firms, through annual reports or other forms of documentation, the material flow option is the more practical one since the companies do not show order data but production. Therefore, the material flow measurement was used throughout the study to measure the bullwhip effect. This measurement was also used in Cachon et al. (2007) and Bray and Mendelson (2012) where both papers quantified its orders as production through sales and inventory data.

Table 1. Two Different Bullwhip Effect Measurements

Distortion of Information Flow	**Distortion of Material Flow**
$\frac{Variance[Orders]}{Variance[Demand]} > 1$	$\frac{Variance[Production]}{Variance[Demand]} > 1$

Of literature available on the study of the bullwhip effect in multiple firms in the industry, Cachon et al. (2007) and Bray and Mendelson (2012) were most relevant to this study. Cachon et al. (2007) used two approaches to identify the bullwhip effect. First, they measured the existence in each industry then they analyzed if the bullwhip effect increased as it went up the levels of the defined supply chain. The three different levels were retail, wholesale and manufacturing. The amplification ratio for the manufacturing industry of the petroleum and coal industry was 3.86. Assuming this industry represents the Oklahoma oil and gas suppliers, this provided evidence that the bullwhip effect exists. Since Cachon et al. (2007) used industry-level data and did not explicitly link the levels of the supply chain directly; it made it difficult to find the source or pattern of the bullwhip. That is, whether it happens at the firm, or a certain level of the supply chain.

Bray and Mendelson (2012) extended Cachon et al. (2007)'s study by using quarterly and firm-level data instead of monthly and industry-level data and estimated the bullwhip at the level rather than through log differencing. Their study analyzed the phenomenon more extensively by testing for prevalence along with the existence of the bullwhip effect and decomposing the effect based on demand signal transmission lead times. The levels of the supply chain identified in their study were retail, wholesale, manufacturing and extraction. However, the oil and gas industry only fell in the manufacturing and extraction category, thus it was studied only on two levels. This thesis aimed to extend this study further, focusing on the oil and gas industry, by analyzing firm level data through a more direct link of the levels of the supply chain involved and in five levels of the supply chain. This thesis also aimed to include the investigation of the phenomenon in each firm and define any common or significant themes that exist.

2.2 Studies on the Bullwhip Effect in the Oil and Gas Industry

The previous papers mentioned only stated the bullwhip effect exists in the oil and gas industry but did not further investigate the phenomenon specifically in that industry. Miron and Zeldes (1988), using two different production measures defined by the Commerce Department and Federal Reserve Board, showed that the bullwhip effect for seasonal data was 2.73 and 7.91, respectively. Cachon et al. (2007) showed a ratio of 1.35 in wholesale and 2.95 in manufacturing for the petroleum industry. Since the oil and gas industry was briefly mentioned in the prevalent papers on the bullwhip effect, this section compiled those papers that studied the bullwhip effect explicitly in the oil and gas industry.

The few papers found that specifically analyzed bullwhip effects in the oil and gas industry were categorized by simulation and non-simulation based papers. Papers that used simulation focused mainly on how the bullwhip effect was affected when certain strategies were used. Zhang and Zhang (2013) observed the bullwhip effect in the processed oil supply chain in

China using System Dynamic Analysis and Anaylogic Simulation Software. They found that delay was the main reason of the existence of the bullwhip effect and used Goal Programming and Analytical Hierarchy Process model to mitigate it. Huang et al. (2007) simulated H∞ method to reduce the bullwhip effect and analyzed how it behaved on multiple Chinese companies, including a petrochemical company. Jacoby (2010) simulated costs of the bullwhip effect in the industry when different oil prices were implemented. Shizheng et al. (2006) simulated a supply chain management based on a single petroleum company and quantified the bullwhip effect through warp wave quantifying. Sherhart (2013) did not use simulation and studied a specific problem where the bullwhip effect exists within British Petroleum. The papers that did study the oil and gas industry did not study the bullwhip effect in multiple levels of the supply chain as it existed in the industry which was done in this study.

2.3 Strategies to Counteract the Bullwhip Effect in the Oil and Gas Industry

Most of the strategies that exist on mitigating the bullwhip effect are to help industries that are characteristically different than the oil and gas industry. Problems such as order batching and price fluctuations due to discounts are not significant to the oil and gas products. Few papers provided strategies specifically to mitigate the bullwhip effect in the oil and gas industry and even fewer applied to an oil and gas company.

Multiple papers were found that analyzed different decision making models to mitigate the bullwhip effect in oil and gas companies. Zhang et al. (2000) used the Goal Programming model along with the Analytical Hierarchy Process model to provide a better model for the decision maker when analyzing a petrochemical complex. The Goal Programming model addresses multiple objectives of sustainability goals such as social, economic, resources and environmental. Conversely, the Analytical Hierarchy Process model evaluated the priorities of the goals and the weights of their decision variables. Huang et al. (2007) focused on applying an H∞

method to reduce the bullwhip effect on petrochemical company. Sherhart (2013) used Theory of Constraints to mitigate the effect within British Petroleum.

The remaining papers included for this section mostly emphasized the importance of coordination to increase efficiency of the supply chain and reduce the impact of the bullwhip effect.

Jacoby (2010) studied the bullwhip effect in the oil and gas industry and suggested tightly coordinating demand and capacity activities for companies in the oil and gas industry. He stated that it can be done by sharing production, sales and inventory information with suppliers. It can also be done by sharing supply risk by indexing prices and using options and futures contracts. The last solution was for the player in the supply chain to share the risk of building new capacity to keep up with demand. These strategies could be used in all levels of this study's defined supply chain but mostly among upstream, downstream, and midstream where the product is oil and gas.

Bessant et al. (2003) surveyed six industries in UK that used supply chain learning (SCL) as a strategy. SCL points to the learning shared between a small number of firms that are close together in the supply process. In each industry there was a supply chain coordinator (SCC) that leads the program. Focusing on the oil and gas industry, the main objective sought in SCL was to have a comprehensive supply chain management program. When implementing the program, they established long-term contracts with contractors and all appropriate practices were addressed between the customer and supplier. They also established constant dialog between customer and suppliers; addressing day-to-day activities and moving focus to not only on material management but also on services. The benefits were savings of £1 billion; the first-tier supplier saved 5% of total costs and the second-tier supplier was helped by the first-tier supplier and was able to reduce lead time from 14 weeks to 16 days. This was done by committing to share information,

establishing measurement systems to capture visible results and setting up co-operative ideas to improve the supply chain.

Longwell (2002), a former director and executive vice president of Exxon Mobil Corporation, mentioned the biggest challenge in the oil and gas industry was keeping up with demand. He stated that this was due to a decreasing supply and an increasing demand that was seen throughout the years. To tackle this problem, Exxon Mobil developed partnerships that gave mutual benefits with the government. Exxon Mobil also worked out reasonable tax and fiscal regimes that recognize long lead times and risks involved in what they do. He stated that maintaining these partnerships will be the key to their success.

The following papers still focus on coordination but are more applicable for the suppliers of the service and equipment level and the drilling level since manufacturing was the main way of production. Anderson et al. (2000) studied an industry that was most similar to the service and equipment level in this study's supply chain, which was the machine tool industry. They observed similar fluctuations in demand and cyclical workforce level due to keeping up with those fluctuations. For the machine tool industry, they suggested that the suppliers take the lead in creating a better relationship with their customers. This was meant to initiate learning from each other. The machine tool users get the most from their equipment and the suppliers have advance knowledge of their customer's needs and greater stability as they discuss policies in reducing supplier volatility. Bray and Mendelson (2012) summarize best practices of Caterpillar from several papers. They focused on working with the suppliers by promising not to change the amount of their order within a three month period and reducing long lead times by sharing their order forecasts. They required written statements from their suppliers on how they plan to counteract the bullwhip.

CHAPTER III

ANALYSIS

3.1 Population and Sample

The population for this study consists of all companies that are involved in the oil and gas industry. Their business includes providing drilling services, exploration, and gathering, storing and processing oil and gas. The population also includes companies who provide services and equipment to support these activities. The sample was obtained from companies listed in the New York Stock Exchange (NYSE). This was deemed a good representation since NYSE is the world's largest stock exchange by market capitalization.

This sample was further narrowed down to companies that had publicly available data as of the first quarter of 2004. The pattern of the oil price before 2003 and after 2003 was considerably different. From 1990 to 2003, prices stayed around 20$/barrel. After 2003, prices increased substantially. However, in 2003 multiple events occurred (loss of production capacity in Iraq and Venezuela and increased OPEC production (Williams, 2013)), which made it a momentous period on its own. Since this study includes analysis of how the companies behaved before and after the oil crisis in 2008, it would be harder to conclude the behavior before 2008 if other large events were present without further analysis. Therefore the sample only includes companies' data from 2004 to 2012. The study did not include companies that have been acquired, merged or split into multiple independent companies to avoid bias in significant change in production and demand.

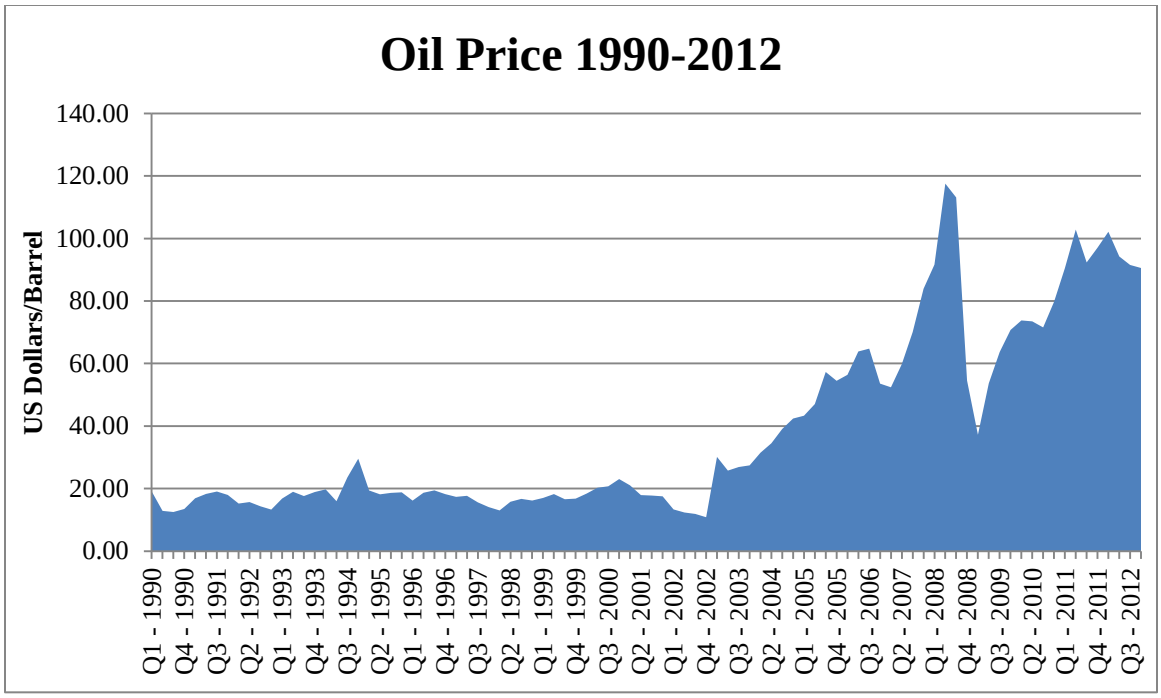


Figure 2. Oil Price 1990-2012

The pattern of the oil price can be seen in Figure 2. The oil prices used were obtained from the database of U.S. Energy Information Administration. The crude oil domestic first purchase price was used for the oil price since this price is associated with the physical and financial transfer of domestic crude oil off the property on which it was produced making it directly related to the supply chain.

It is a common practice for studies to adjust seasonality in the data. However this study did not adjust for seasonality for two reasons: (1) EconMatters (2013) stated that oil and gas is a highly seasonal product hence additional adjustments on data would prevent observation in its actual state and; (2) in multiple studies, it has been proven that any analysis of production/inventory behavior excluding seasonality would fail to exploit most of the variation in the data which was mostly there due to the seasonal fluctuations existing in the data. For example, Miron and Zeldes (1988) found that seasonal variation accounts for more than half of the total variation in the data, Ghali (1987) found that seasonal adjustment of the data was an important factor in rejecting the production smoothing model, and Ward (1978) found evidence that firms

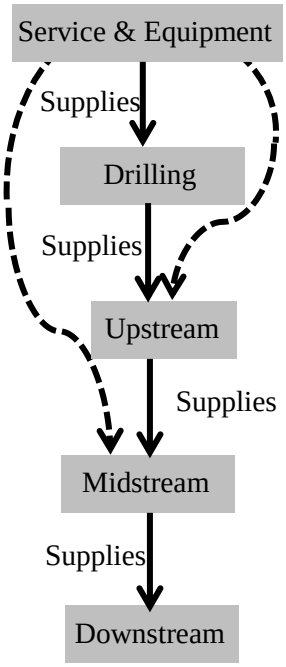
alter production rates differently depending on the seasonal and non-seasonal variations in demand. Therefore, analyzing data "as is" with its seasonality will best represent the industry.

3.2 Design of Investigation

The companies gathered from the NYSE database were categorized according to the most appropriate supply chain level in terms of their business. The companies were then analyzed for the bullwhip effect individually and aggregately in each level of the supply chain. Both analyses will include quarterly analysis and differentiation before and after 2008 to find any common behaviors.

The supply chain was structured into five separate levels: Service and Equipment, Drilling, Upstream, Midstream, and Downstream. To accurately categorize the companies correctly, the purpose of each level of the supply chain is defined in Table 2:

Table 2. Description of Each Level of the Supply Chain

Supply Chain Level	Description
	• Provides service/solutions and equipment • Supplies the Drilling level with its solutions and equipment to help in obtaining the oil and gas
	• Provides drill rig equipment and services • Supplies the Upstream level through drilling equipment and services
	• Explores and produces oil and gas • Supplies the Midstream level with the oil and gas that was obtained
	• Gathers, stores and transports oil and gas • Supplies the Downstream level through service of transporting and storing oil and gas
	• Refines and processes crude oil and natural gas • Sells and distributes the processed oil and gas to consumers

The supply chain was designed in order to best capture direct flow of material from upstream to downstream levels in the oil and gas industry. In reality, not all companies supply just one level in this defined supply chain. When analyzing the companies in the service and equipment level, it appeared that most of the companies provided solutions and equipment to various levels of the supply chain. For example, Schlumberger offers real-time software services to increase drilling efficiencies which relates to the drilling level, but also offers software and services to optimize oil and gas production relating to the upstream level while offering chemicals to support maximum production flowing through pipelines for the Midstream level. The service and equipment level will be analyzed with the level it mostly directly supplies in chapter four. However, throughout the study, the companies are categorized to the most appropriate level according to the largest revenue from their offerings to a certain level compared to their offerings to other levels.

The research questions addressed in this thesis are summarized in Table 3:

Table 3. Research Questions and Hypotheses

1st Research Question	Does the bullwhip effect exist in the oil and gas industry?
2nd Research Question	Does the service and equipment level exhibit the highest demand variability in the supply chain?
3rd Research Question	Are smaller sized companies more susceptible to larger demand variability than larger sized companies?

3.3 Analysis of Individual Companies

This section analyzed each individual company in terms of their behavior in production and demand from 2004 to 2012. The companies in the sample were first categorized according to their sizes: small or large. GPO (2013) states the size standards and based the standards on the number of employees or annual receipts in millions of dollars. NAICS specified definitions for small companies based on specific industries; the study grouped some of these industries to represent the appropriate level of the supply chain defined in the study. The definitions for each level were applied to each company in the level. Companies larger than the standards were considered large companies. For simplicity, the sizes of the companies were classified based on the number of employees. This was done to answer the third research question. These classifications are shown in Table 4.

Table 4. Classification of Small Business Standards According to Supply Chain Level

NAICS U.S. Industry Title	Supply Chain Level	Annual Receipts (millions of dollars)	Number of Employees
Oil and Gas Field Machinery and Equipment Manufacturing	Service and Equipment	-	500
Support Activities for Oil and Gas Operations		35.50	-
Drilling Oil and Gas Wells	Drilling	-	500
Crude Petroleum and Natural Gas Extraction	Upstream	-	500
Natural Gas Liquid Extraction		-	500
Pipeline Transportation of Crude Oil	Midstream	-	1,500
Pipeline Transportation of Natural Gas		25.50	-
Pipeline Transportation of Refined Petroleum Products		-	1,500
Petroleum Refineries	Downstream	-	1,500
Natural Gas Distribution		-	500

From the definitions of Table 4, the following numbers of small and large companies were found in each level as indicated in Table 5.

Table 5. Small and Large Companies

	Service and Equipment	Drilling	Upstream	Midstream	Downstream	Total
Small Companies	2	-	28	6	2	38
Large Companies	16	7	23	10	9	65
Total	18	7	51	16	11	103

When analyzing the individual companies multiple factors were considered in addition to the BE. First, the C.V. of demand was calculated for each company to see if the demand was highly variable. Second, the study looked at the plots of production and demand across time from 2004 to 2012 to see the behavior of the companies in that time period. The graphs were further examined to see if any cyclical patterns were present in the industry through observation of obvious up and downs in production and demand in each company. Companies were said to have cyclical patterns if repetitive increase and decrease of production/demand was seen in any of the three time periods: before, during and after the oil crisis. Third, a separate analysis of behavior around the crisis was done from evaluating the bullwhip effect before, while, and after the oil crisis in 2008.

3.3.1 Downstream

Eleven companies were categorized in the downstream level. The categorization of the companies in this level along with relevant data is shown in Table 6.

Table 6. Data on Companies in the Downstream Level

Name of Company	Avg. Number of Employees	Size	BE Ratio	C.V. of Demand	Plotted Production and Demand Pattern
Valero	21,329	Large	1.12	0.33	Non-cyclic
AmeriGas	6,317	Large	2.63	0.36	Cyclic
Tesoro	4,949	Large	1.18	0.34	Non-cyclic
Atmos Energy	4,320	Large	1.26	0.49	Cyclic
AGL Resources	3,340	Large	1.01	0.57	Cyclic
Southwest Gas	2,430	Large	1.50	0.55	Cyclic
WGL Holdings	1,582	Large	0.72	0.77	Cyclic
World Fuel Service	1,313	Large	1.04	0.64	Non-cyclic
UGI Utilities	1,275	Large	0.22	0.91	Cyclic
South Jersey Gas	434	Small	0.81	0.63	Cyclic
Delta Gas	154	Small	0.66	0.61	Cyclic

The small companies in the sample, South Jersey Gas and Delta Gas, did not exhibit the bullwhip effect; 0.81 and 0.66, respectively. The large companies in this level exhibited the bullwhip effect having ratios above 1 except for WGL Holdings and UGI Utilities, which did not exhibit the effect. This was deemed reasonable since the downstream level is at the lowest level of the supply chain, thus closest to the market so the demands they experience are expected to be relatively constant.

When examining the C.V. of demand, the five smallest companies have the highest coefficients and the largest four companies have the lowest coefficients. This indicates that the smaller companies in the downstream level exhibit a more volatile demand than that by the larger companies. However, since they did not exhibit high bullwhip effect ratios, it appears that they were more capable of keeping up with the high volatility in demand.

Looking at the graphs of plotted production and demand of each company at the downstream level, it appeared that the amount of cyclicality a company experiences in production and demand does not reflect the magnitude of their bullwhip effect ratio. Eight companies in this level appeared to have cyclical production and demand. Five out of eight of the companies in the sample that had cyclical patterns were the ones with the lowest bullwhip effect ratios of the sample. UGI Utilities had the lowest bullwhip effect value in the sample, 0.22, yet cyclicality was evident. Figure 3 plots the production and demand of UGI Utilities along with the oil price to align the oil crisis along with the production and demand the company experienced at that time. It appears that UGI Utilities had repetitive ups and downs in production and demand, except in 2007 and 2008 where demand spikes much higher than production. The plotted graphs for each company in the downstream level can be seen in Appendix 1.

When observing the behavior of the companies at the downstream level at the time of the crisis, any obvious deviations on the plotted production and demand graphs of each company and any noticeable bullwhip effect values around 2008 were recorded. From Table 7, the middle column, 2007-2009 BE, did not show any noteworthy large values during the crisis.

Table 7. Bullwhip Effect Ratios Before and After the Oil Crisis in the Downstream Level

Company	2004-2006 BE	2007-2009 BE	2010-2012 BE
Valero	1.47	1.11	1.21
AmeriGas	2.28	2.15	3.16
Tesoro	1.26	0.94	1.18
Atmos Energy	1.40	1.03	1.67
AGL Resources	1.01	0.46	1.31
Southwest Gas	1.80	1.35	2.06
WGL Holdings	0.84	0.48	0.97
World Fuel Service	1.03	1.00	1.03
UGI Utilities	0.86	0.09	0.74
South Jersey Gas	0.65	0.69	1.65
Delta Gas	0.56	0.57	0.99

However, there were companies with considerably lower values during the oil crisis such as UGI Utilities and AGL Resources. UGI Utilities experienced two large spikes in demand whereas production did not reach close as high indicated in Figure 3.

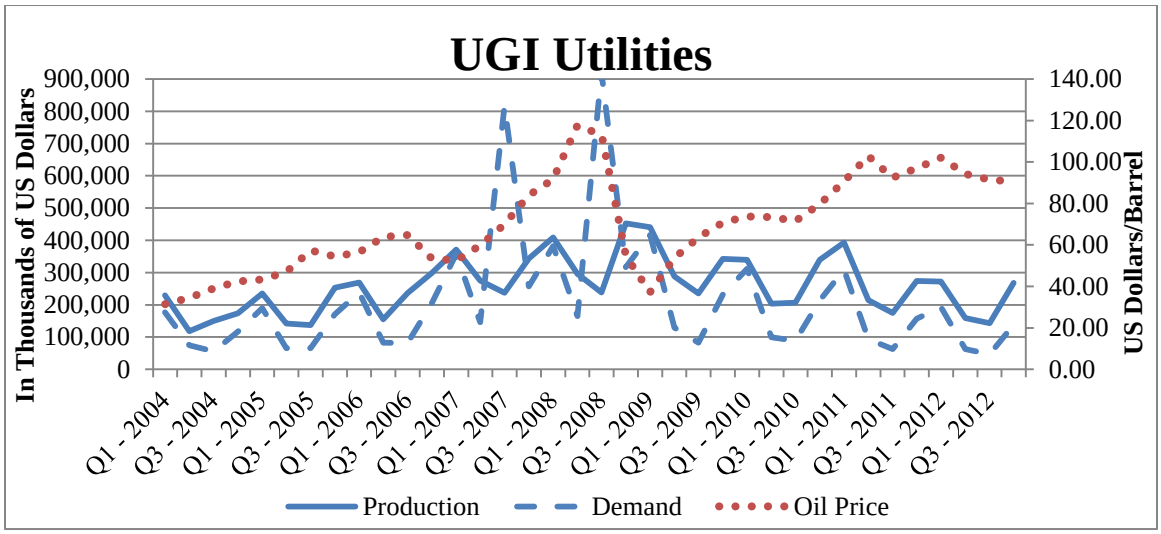


Figure 3. UGI Utilities Plotted Production and Demand

Figure 4 indicates that AGL Resource's production and demand pattern were cyclical. However, during the oil crisis, production did not decrease as much as demand. Thus, causing the company to have a lower bullwhip effect at that time period.

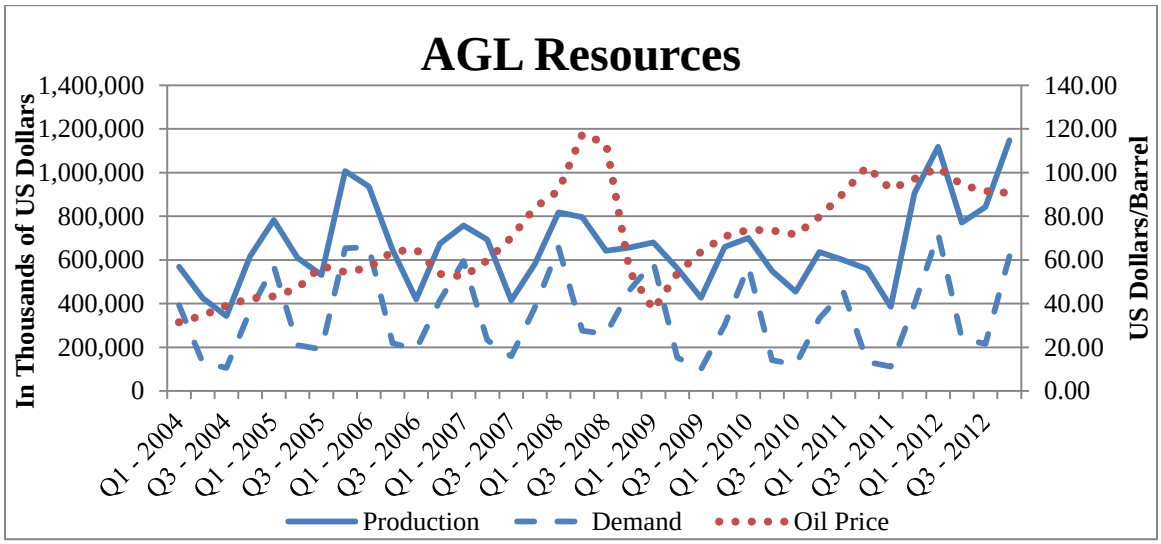


Figure 4. AGL Resources, LP Plotted Production and Demand

In the downstream level, only the small companies had an increasing value from 2004 to 2012. The large companies exhibited a dip of the BE ratio during the crisis but increased again afterwards.

Relationships between the size of the company, the bullwhip effect, and the variability of the production and the demand are shown in Figures 5 through 8. Figure 5 provides evidence that companies with larger demand variability incur smaller bullwhip effect. This is because the production capacities are usually limited and difficult to adjust. If the demand variability is already high, the company has to do some smoothing in its production schedules.

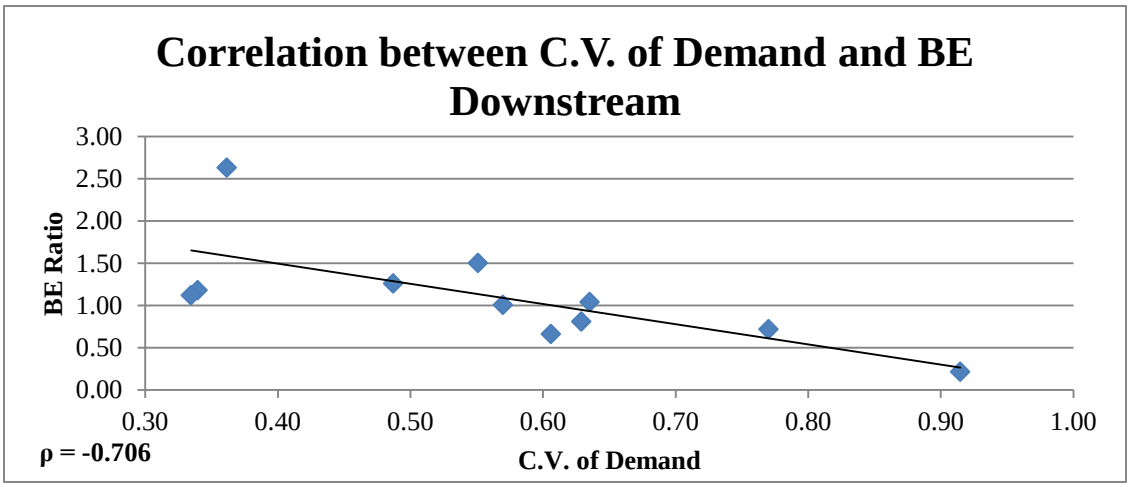


Figure 5. Correlation between C.V. of Demand of Downstream Companies and BE Ratio

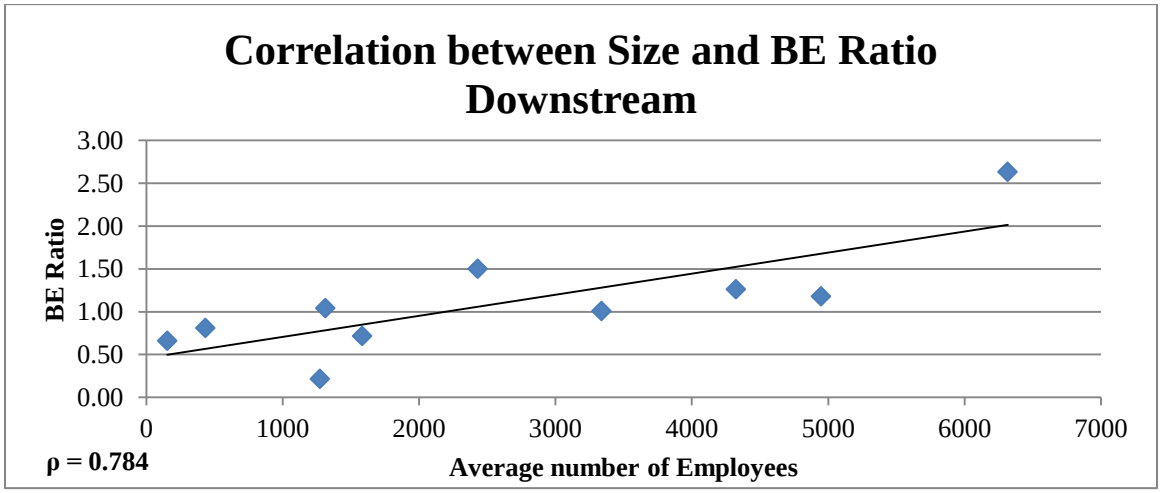


Figure 6. Correlation between Size of Downstream Companies and BE Ratio

Figure 7 shows smaller companies have larger demand variability. This is because small companies typically have small demand so the same level of variation will result in larger C.V. of demand for small companies than for large ones. However, Figure 8 indicates that the variability in production is indifferent to the average number of employees.

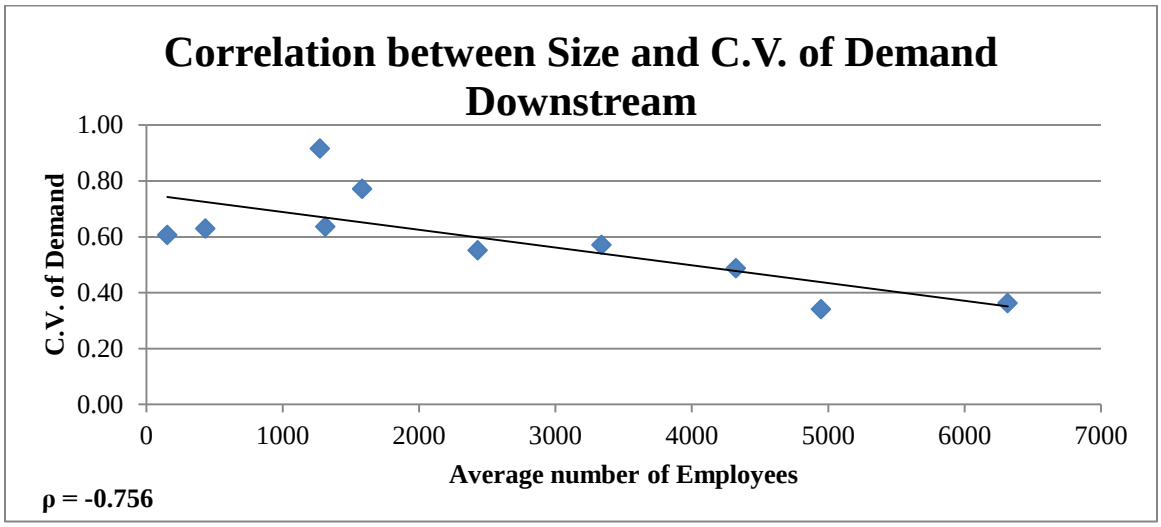


Figure 7. Correlation between Size of Downstream Companies and C.V. of Demand

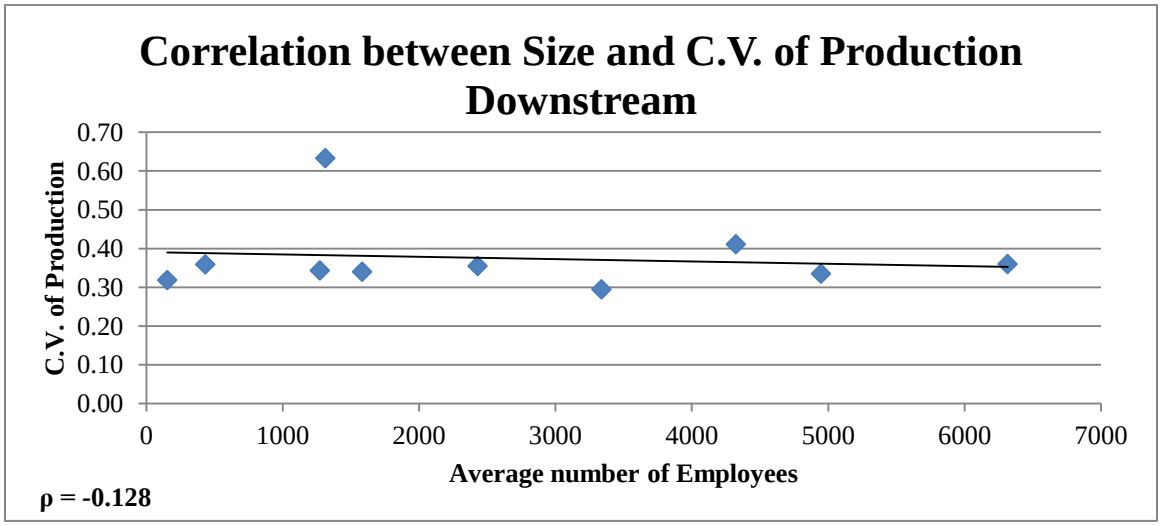


Figure 8. Correlation between Size of Downstream Companies and C.V. of Production

To summarize the analysis of the companies in the downstream level, in general, the bullwhip effect ratio was seen larger in larger sized companies. This can be seen in the increasing trend in Fig. 5. All the companies in this level had relatively low bullwhip effect ratios and most

of them showed cyclic production and demand patterns. The smaller companies were more susceptible to the oil crisis in 2008.

3.3.2 Midstream

Sixteen companies were categorized in the midstream level. The categorization of the companies in this level can be seen in Table 8.

Table 8. Data on Companies in the Midstream Level

Name of Company	Avg. Number of Employees	Size	BE Ratio	C.V. of Demand	Plotted Production and Demand Pattern
Sempra Energy	14,563	Large	1.40	0.31	Non-cyclic
Kinder Morgan, Inc.	8,159	Large	0.59	0.88	Non-cyclic
UGI Corporation	6,317	Large	1.72	0.36	Cyclic
Enbridge Energy Partners, LP	5,922	Large	1.14	0.28	Non-cyclic
Williams Companies, Inc.	4,407	Large	2.59	0.28	Non-cyclic
TransCanada Corporation	3,581	Large	1.77	0.20	Non-cyclic
Enterprise Products Partners, LP	3,248	Large	1.16	0.55	Non-cyclic
Plains All American Pipeline, LP	3,184	Large	1.11	0.29	Non-cyclic
Inergy, LP	2,492	Large	1.64	0.44	Cyclic
ONEOK Partners, LP	1,856	Large	1.12	0.62	Non-cyclic
Magellan Midstream Partners, LP	1,167	Small	2.50	0.31	Non-cyclic
Buckeye Partners, LP	899	Small	1.09	0.98	Non-cyclic
Martin Midstream Partners, LP	585	Small	1.47	0.53	Non-cyclic
Crosstex Energy. LP	563	Small	1.02	0.51	Non-cyclic
Atlas Pipeline Partners, LP	316	Small	1.69	0.59	Non-cyclic
PVR Partners, LP	165	Small	1.05	0.56	Non-cyclic

Magellan Midstream Partners, a small company, appeared to have the second largest bullwhip effect ratio, 2.50. In contrast, the second largest company, Kinder Morgan, did not exhibit the bullwhip effect. It is not representative enough to answer the third research question, based on these two companies alone, since the largest company, which almost twice the size in number of employees, has a bullwhip effect of 1.40.

With one of the lowest BE ratios, Kinder Morgan showed one of the highest variability of demand. Based on data, it appears that Kinder Morgan has been able to keep up with demand despite its high volatility. Magellan Midstream Partners, exhibited one of the largest BE ratios but showed low coefficient of variation of demand compared to the others. This provides evidence that they have volatile production and have not sufficiently kept up with demand.

Cyclicality of production and demand is only seen when plotting UGI Corporation and Inergy. In relation to their bullwhip effect ratios, UGI Corporation exhibited a ratio of 1.72 whereas Inergy showed a ratio of 1.64. Figure 9 shows the level of cyclicality experienced by UGI Corporation. It is shown that production would peak along with its demand, almost consistently, every first quarter and reach its low point every third quarter.

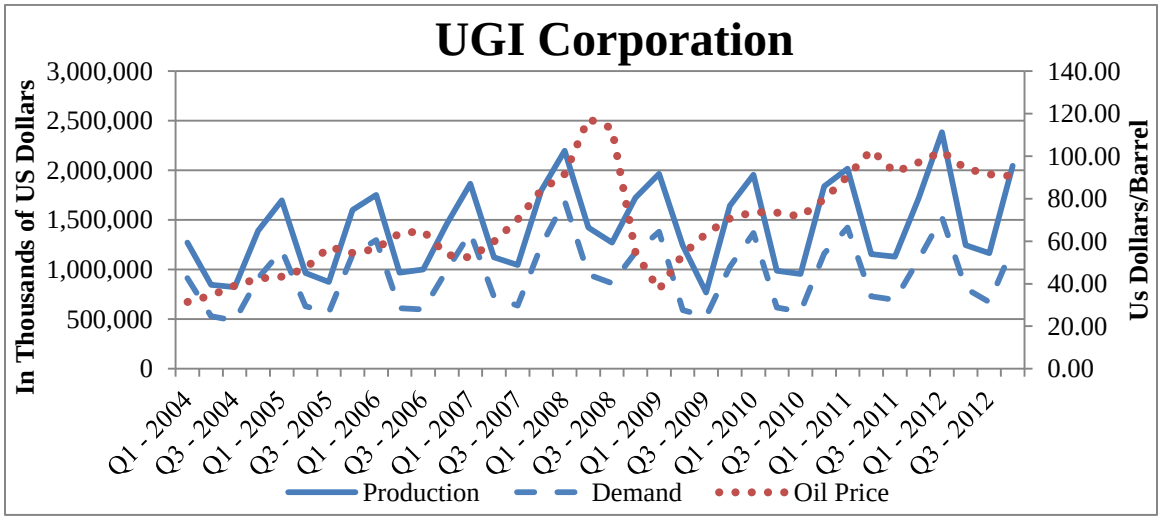


Figure 9. UGI Corporation Plotted Production and Demand

Looking at plotted production and demand at the midstream level, five companies were seen to have large deviations during the crisis. These include Magellan Midstream Partners, Buckeye Partners, Sempra Energy, UGI Corporation and TransCanada Corporation. The plotted graphs for each company in the downstream level can be seen in Appendix 2.

Table 9 indicates a steady pattern, a decreasing trending pattern, and a low and a high bullwhip effect value around the oil crisis. Enbridge Energy Partners, Plains All American, and ONEOK Partners had a BE that was stable around 1.00 before, during, and after the crisis. Despite the data indicating that they had a bullwhip effect present, with a value over 1, they had been able to keep the value consistent, and were not affected by the crisis. There were two companies that showed to have a decreasing trend from 2004 ending with no bullwhip effect in 2012. They are Buckeye Partners and PVR Partners. Buckeye Partners showed high amplification leading up to the crisis; however, it decreased during the crisis. PVR Partners does not show it was largely affected during the crisis since the amplification decreased only by 0.01 but then decreased by 0.64 afterwards. The strategy used by these companies may provide insight on how to handle the crisis.

Table 9. Bullwhip Effect Values Before and After the Oil Crisis in the Midstream Level

Company	2004-2006 BE	2007-2009 BE	2010-2012 BE
Sempra Energy	2.36	1.33	2.07
Kinder Morgan, Inc.	1.19	0.18	2.87
UGI Corporation	1.47	1.37	2.04
Enbridge Energy Partners, LP	0.99	1.03	1.03
Williams Companies, Inc.	1.44	6.32	1.41
TransCanada Corporation	1.62	1.21	3.73
Enterprise Products Partners, LP	1.27	1.13	1.10
Plains All American Pipeline, LP	1.02	1.09	1.11
Inergy, LP	1.49	1.56	1.37
ONEOK Partners, LP	1.15	1.14	1.16
Magellan Midstream Partners, LP	1.35	1.20	3.25
Buckeye Partners, LP	4.27	1.40	0.88
Martin Midstream Partners, LP	1.27	1.48	1.20
Crosstex Energy. LP	1.15	1.05	1.01
Atlas Pipeline Partners, LP	1.46	2.43	1.42
PVR Partners, LP	1.25	1.24	0.60

Kinder Morgan, UGI Corp., TransCanada Corporation and Magellan Midstream show low bullwhip effect ratio during the crisis, while Williams Companies, Inergy and Atlas Pipeline Partners shows high bullwhip effect ratio. Kinder Morgan exhibited a spike in demand within the second and third quarter in 2008. Figure 10 indicates Williams Companies had a large gap between production and demand during the oil crisis, increasing in 2008 then decreasing in 2009. It can be seen that after the crisis the production started to follow demand more smoothly than before.

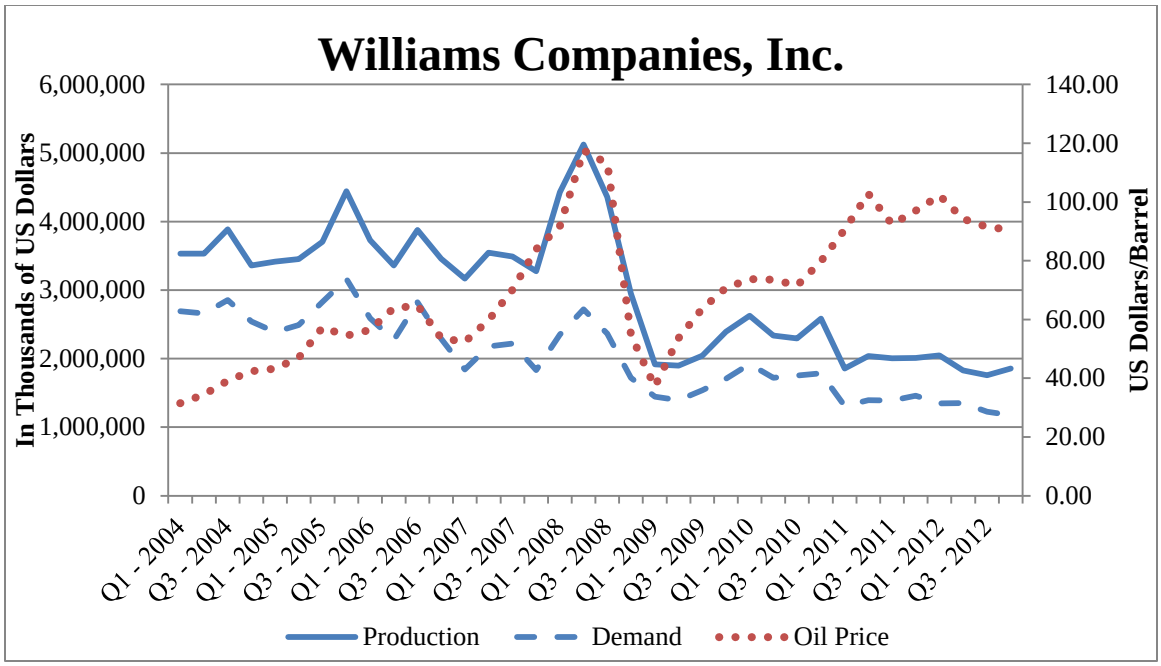


Figure 10. Williams Companies, Inc. Plotted Production and Demand

Relationship between the size of the company, the bullwhip effect it exhibits and the variability of production and demand it experiences is shown in Figures 11 to 14. Figure 11 shows that high bullwhip effect ratios relate to lower demand variability. One cannot conclude from Figure 12 that smaller companies exhibit larger bullwhip effect.

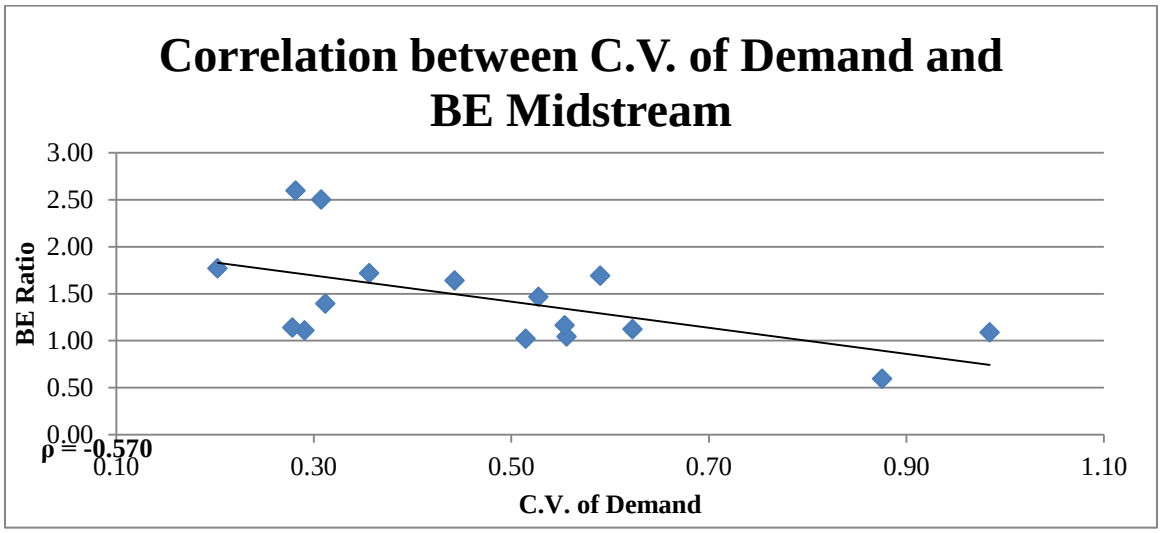


Figure 11. Correlation between C.V. of Demand of Midstream Companies and BE Ratio

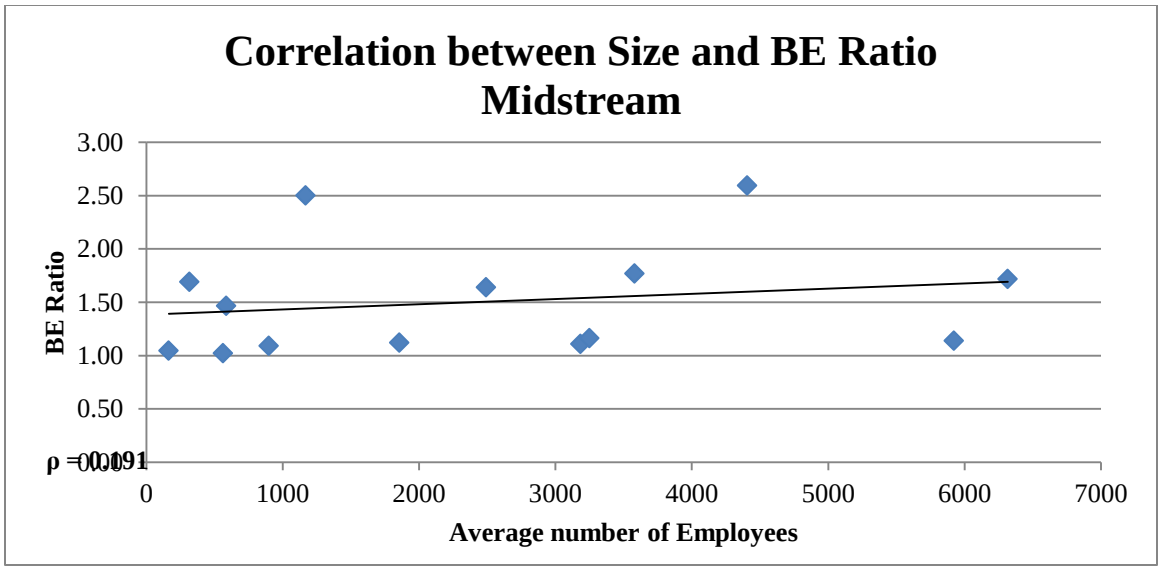


Figure 12. Correlation between Size of Midstream Companies and BE Ratio

Figure 13 and 14, indicates that the smaller companies exhibit higher variability in production and demand. This is because small companies typically have small demand. The same level of variation will result in larger C.V. for small companies than for large ones.

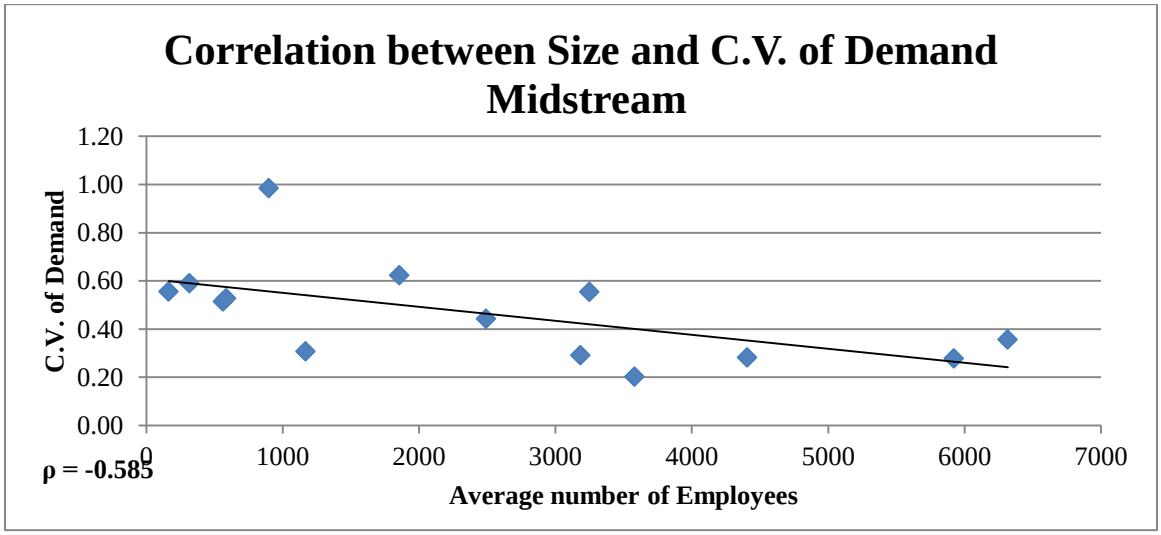


Figure 13. Correlation between Size of Midstream Companies and C.V. of Demand

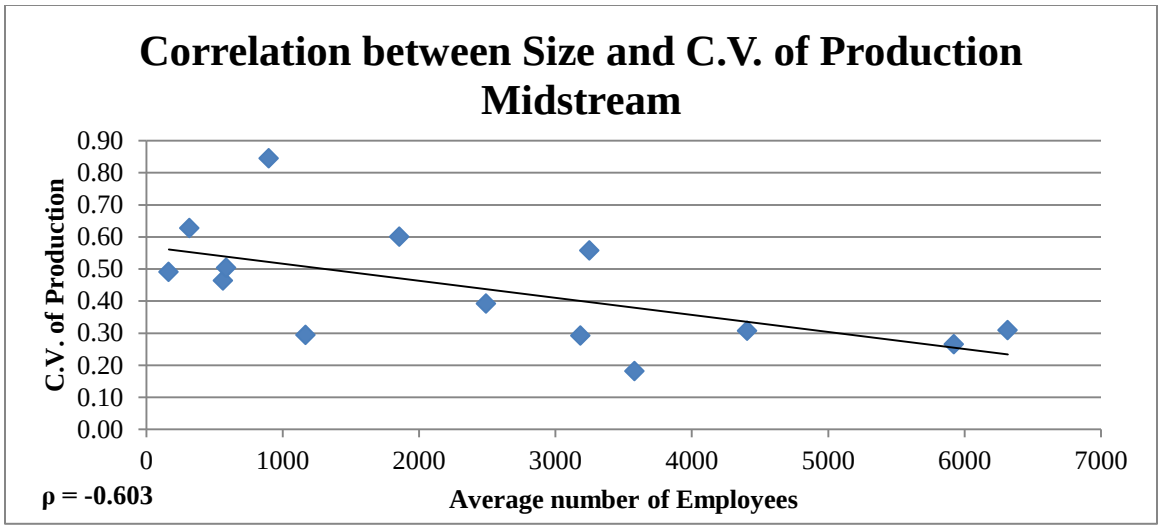


Figure 14. Correlation between Size of Midstream Companies and C.V. of Production

To summarize the analysis of the companies in the midstream level, there was not much that could be concluded from the bullwhip effect, in terms of the size of the company. Both the largest and smallest BE ratios were seen in the group of large companies. In dealing with the oil crisis, the BE ratio appeared to increase during the crisis both in small and large companies. Cyclicality in production and demand were seen only in the large companies.

3.3.3 Upstream

For the upstream level, 51 companies were analyzed. The categorization of the companies along with relevant data is listed in Table 10. Based on the NAICS standards, there are 28 small companies and 23 large companies in the upstream sample.

Table 10. Data on Companies in the Upstream Level

Name of Company	Avg. Number of Employees	Size	BE Ratio	C.V. of Demand	Plotted Production and Demand Pattern
Occidental Petroleum	9,814	Large	4.70	0.24	Non-cyclic
Chesapeake Energy	7,345	Large	164.75	0.47	Non-cyclic
Ecopetrol	6,301	Large	3.34	0.73	Cyclic
Devon Energy	4,931	Large	44.72	0.20	Cyclic

Encana Corporation	4,565	Large	3.27	0.64	Non-cyclic
Andarko Petroleum Corporation	4,311	Large	6.77	0.52	Non-cyclic
Canadian Natural Resources	3,894	Large	3.09	0.42	Non-cyclic
Apache Corporation	3,882	Large	0.74	0.68	Non-cyclic
Pioneer Natural Resources	2,167	Large	2.05	0.45	Non-cyclic
Unit Corporation	2,101	Large	6.02	0.28	Non-cyclic
EOG Resources	1,968	Large	3.63	0.84	Non-cyclic
EQT Corporation	1,610	Large	0.75	0.55	Cyclic
Southwestern Energy	1,561	Large	10.38	0.51	Non-cyclic
Energen Resources Corporation	1,527	Large	2.79	0.31	Cyclic
Noble Energy, Inc.	1,490	Large	16.59	0.33	Non-cyclic
Newfield Exploration Company	1,129	Large	5.23	0.47	Non-cyclic
Denbury Resources	854	Large	10.41	0.60	Non-cyclic
QEP Resources, Inc.	761	Large	2.02	0.57	Cyclic
Cimarex Energy	731	Large	56.80	0.25	Non-cyclic
Range Resources Corporation	710	Large	50.11	0.32	Non-cyclic
Exco Resources	710	Large	24.67	0.59	Non-cyclic
Enerplus	675	Large	48.53	0.19	Non-cyclic
SM Energy	489	Small	11.07	0.36	Non-cyclic
Whiting Petroleum Corporation	476	Small	18.20	0.51	Non-cyclic
Quicksilver Resources	473	Small	4.97	0.59	Non-cyclic
Markwest Energy Partners	469	Small	7.29	0.33	Non-cyclic
Cabot Oil and Gas Corporation	431	Small	22.71	0.22	Non-cyclic
Swift Energy Company	317	Small	46.59	0.33	Non-cyclic
Stone Energy Corporation	294	Small	7.94	0.32	Non-cyclic
Vermillion Energy, Inc.	290	Small	34.41	0.34	Non-cyclic
PDC Energy, Inc	279	Small	3.36	0.29	Non-cyclic
Clayton Williams Energy, Inc.	275	Small	4.57	0.51	Non-cyclic
Berry Petroleum Company	264	Small	14.29	0.38	Non-cyclic
Penn Virginia Corporation	245	Small	0.18	0.69	Non-cyclic
EPL Oil & Gas, Inc.	145	Small	7.17	0.41	Non-cyclic
Baytex Energy Corporation	138	Small	4.16	0.5	Non-cyclic
Comstock Resources	118	Small	7.45	0.52	Cyclic
Carrizo Oil & Gas, Inc.	106	Small	86.40	0.45	Non-cyclic
Goodrich Petroleum	97	Small	8.84	0.44	Non-cyclic
McMoran Exploration	92	Small	8.60	0.28	Non-cyclic

PetroQuest Energy	89	Small	35.19	0.32	Non-cyclic
Callon Petroleum	84	Small	84.47	0.22	Non-cyclic
Ultra Petroleum	84	Small	11.66	0.47	Non-cyclic
Gulfport Energy Corporation	69	Small	130.73	0.43	Non-cyclic
Abraxas Petroleum Corporation	69	Small	8.15	0.40	Non-cyclic
Endeavour International Corporation	63	Small	24.04	0.80	Non-cyclic
Crimson Exploration, Inc.	57	Small	26.72	0.73	Non-cyclic
Warren Resources, Inc.	56	Small	21.68	0.35	Non-cyclic
Tengasco, Inc.	27	Small	13.35	0.31	Non-cyclic
Apco Oil & Gas International, Inc.	19	Small	6.42	0.60	Non-cyclic
Contango Oil & Gas Company	7	Small	5.52	1.40	Cyclic

The last fourteen companies in the list were companies with number of employees less than 110. It was seen that from this small group, a combined average bullwhip effect of 33.71 was obtained. This is considerably larger compared to the 14 largest companies in the level which had an average BE ratio of 18.36. In fact, the largest three bullwhip effect values in the upstream sample were seen in this group. Gulfport Energy Corporation, Carrizo Oil and Gas and Callon Petroleum had bullwhip effect values of 130.73, 86.4, and 84.47, respectively.

Examining the larger sized companies of the sample, 12 out of 14 companies had bullwhip effect values smaller than seven. This is considerably small compared to the values of the rest of the sample. Chesapeake Energy exhibited the largest bullwhip effect from the top 14 largest companies with a value of 164.75. When looking at Devon Energy, the second largest bullwhip effect in the first largest 14 companies, its coefficient of variation in demand was 0.2. This provided evidence that they generated more variability than the demand they receive. This can be corroborated with the high production seen in their plotted production and demand seen in Figure 15.

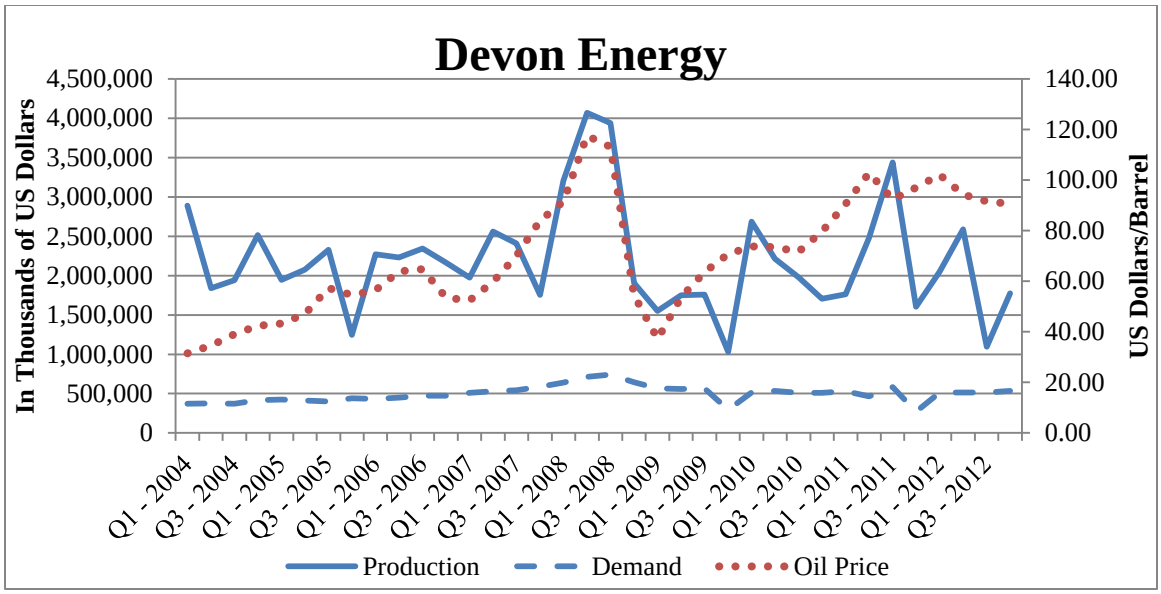


Figure 15. Devon Energy Plotted Production and Demand

At this level, production and demand were not as cyclical when looking at the individual companies. The large companies tend to be more cyclical, this was seen from two small companies and four large companies who had cyclical production and demand. When comparing the largest cyclic company, Ecopetrol, with the smallest cyclic company, Contango Oil & Gas Company, it is obvious that the larger company would be able to handle the more predictable production and demand. Contango became cyclical after the oil crisis but in unforeseeable fashion. Plotted production and demand can be seen in Figures 16 and 17, below.

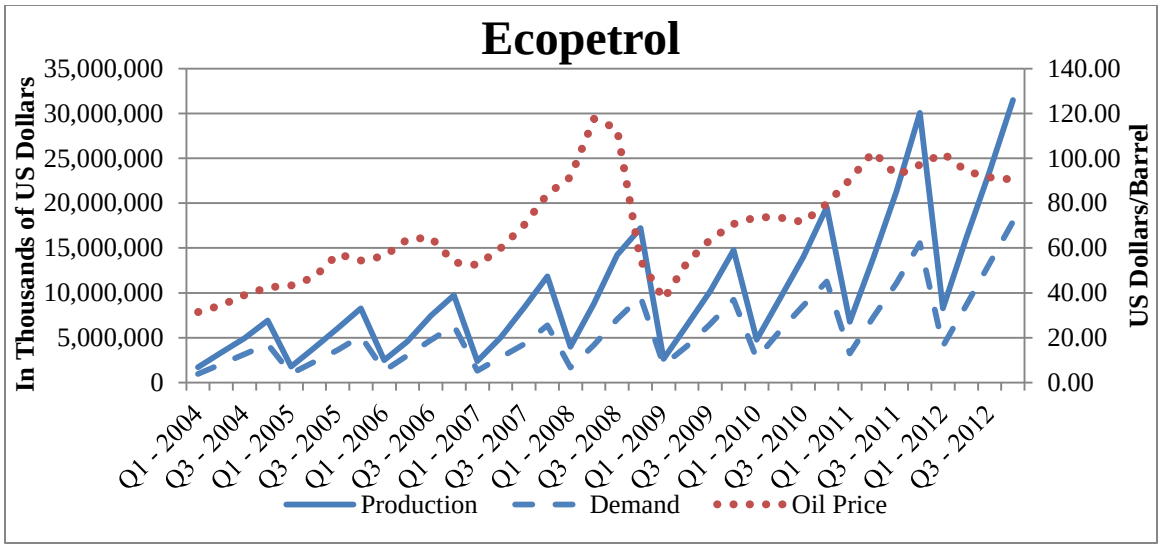


Figure 16. Ecopetrol Plotted Production and Demand

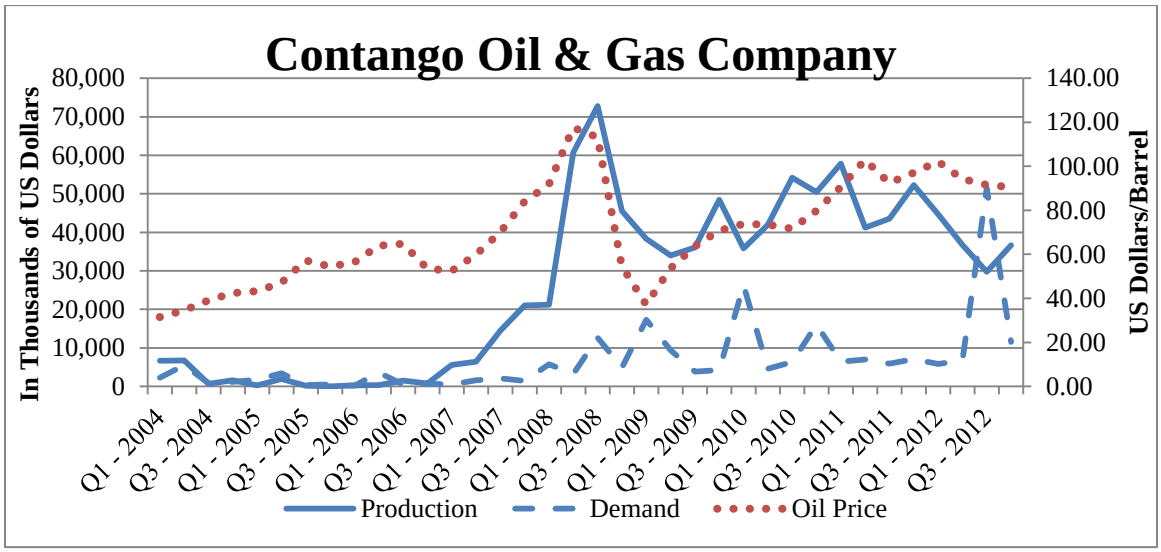


Figure 17. Contango Oil & Gas Company Plotted Production and Demand

Looking at the bullwhip effect values of the companies in the upstream level before, during and after the oil crisis in Table 11, multiple noteworthy occurrences were shown. Twenty two companies showed a considerably large increase of the bullwhip effect during the oil crisis, 10 companies continuously exhibit increasing bullwhip effect in each time period; 12 showed decreasing bullwhip effect ratio; and six had lower bullwhip effect ratios during the oil crisis but then increased considerably afterwards.

Table 11. Bullwhip Effect Values Before and After the Oil Crisis in the Upstream Level

Company	2004-2006 BE	2007-2009 BE	2010-2012 BE
Occidental Petroleum	1.84	18.52	3.42
Chesapeake Energy	196.81	2933.16	123.86
Ecopetrol	2.29	3.06	3.26
Devon Energy	123.66	70.28	64.39
Encana Corporation	7.92	5.04	171.93
Andarko Petroleum Corporation	19.74	40.55	1.89
Canadian Natural Resources	2.28	32.67	7.23
Apache Corporation	4.03	0.15	1.16
Pioneer Natural Resources	5.26	4.86	1.08
Unit Corporation	7.79	7.03	4.13
EOG Resources	36.47	25.79	3.75
EQT Corporation	0.24	0.55	1.92
Southwestern Energy	3.99	8.00	9.07
Energen Resources Corporation	2.07	1.56	2.99
Noble Energy, Inc.	18.79	72.31	11.69
Newfield Exploration Company	3.84	83.16	3.42
Denbury Resources	8.58	48.83	12.05
QEP Resources, Inc.	3.43	1.97	1.03
Cimarex Energy	34.77	294.49	14.33
Range Resources Corporation	19.60	69.80	233.24
Exco Resources	19.14	30.76	24.14
Enerplus	55.81	212.08	8.41
SM Energy	10.66	63.52	10.75
Whiting Petroleum Corporation	11.12	64.75	6.31
Quicksilver Resources	25.33	24.46	3.12
Markwest Energy Partners	2.37	3.77	3.44
Cabot Oil and Gas Corporation	11.10	15.07	14.95
Swift Energy Company	179.06	171.88	24.31
Stone Energy Corporation	3.08	6.95	13.03
Vermillion Energy, Inc.	37.80	84.74	150.44
PDC Energy, Inc	1.22	5.04	4.22
Clayton Williams Energy, Inc.	5.60	3.35	3.11
Berry Petroleum Company	31.92	23.69	10.46
Penn Virginia Corporation	0.09	1.09	1.21
EPL Oil & Gas, Inc.	4.14	7.53	11.12
Baytex Energy Corporation	38.25	8.39	2.63

Comstock Resources	7.26	19.20	0.77
Carrizo Oil & Gas, Inc.	15.34	66.68	320.24
Goodrich Petroleum	3.07	29.77	2.28
McMoran Exploration	4.01	19.53	1.32
PetroQuest Energy	16.87	39.24	10.47
Callon Petroleum	121.90	117.64	13.80
Ultra Petroleum	31.65	20.06	101.32
Gulfport Energy Corporation	68.18	23.74	294.09
Abraxas Petroleum Corporation	36.63	15.21	3.90
Endeavour International Corporation	21.38	81.67	10.46
Crimson Exploration, Inc.	8.53	14.92	8.40
Warren Resources, Inc.	6.58	21.98	12.26
Tengasco, Inc.	20.41	28.94	31.56
Apco Oil & Gas International, Inc.	39.12	1.79	5.45
Contango Oil & Gas Company	2.09	17.14	0.39

The six companies that had lower bullwhip effect ratios during the oil crisis but then increased considerably afterwards behaved in a similar way in their respective plotted production and demand graphs. The dip of the ratio during the crisis was due to a peak reaction in both production and demand. However, after the crisis was over, the companies had an increase in their production. The increase was steep and volatile while demand was relatively stable. Chesapeake Energy exhibited the largest bullwhip effect during the crisis. This can be explained from their stable demand throughout that period; however, production was volatile. In 2008, specifically, the second quarter exhibited a negative production of around 1.6 billion and would have 6.5 billion in production by the third quarter.

Based on Table 11, it appeared to show that there were companies that were more commendable than others in achieving a reduction the presence of the bullwhip effect after the crisis. These companies were Comstock Resources and Contango Oil and Gas. This was notable since Comstock and Contango were some of the smallest companies in the sample. The strategies

used by these companies to reduce the bullwhip effect would be a good example for both small and large companies in the upstream level.

The most common pattern seen in this level was the large surge of the bullwhip effect value during the crisis. When comparing the plotted production and demand of the 22 companies that exhibited these patterns, the same behavior was seen. All increased their production steeply at the beginning of the crisis and then plunged after the crisis was over, even though demand was not exhibiting the same behavior in the same level. The behavior was not different when compared in relation to the size of the companies.

Relationship between the size of the company, the bullwhip effect it exhibits and the variability of production and demand it experiences is shown in Figures 18 to 21. Figures 18 and 19 showed that larger companies exhibit higher bullwhip effect and face lower demand variability. They have a more stable demand yet they pass on their variability of production, resulting in a large bullwhip effect up the chain.

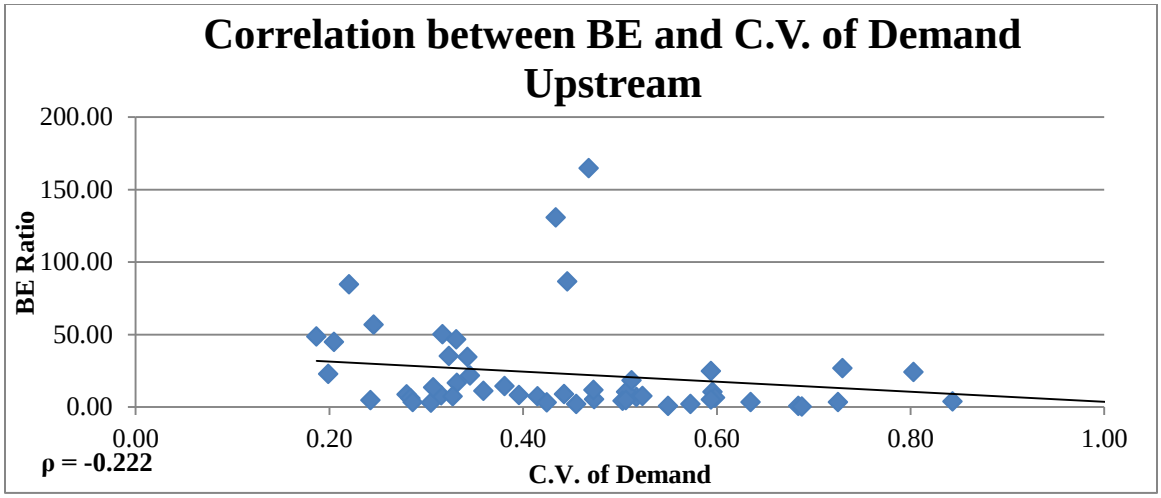


Figure 18. Correlation between C.V. of Demand of Upstream Companies and BE Ratio

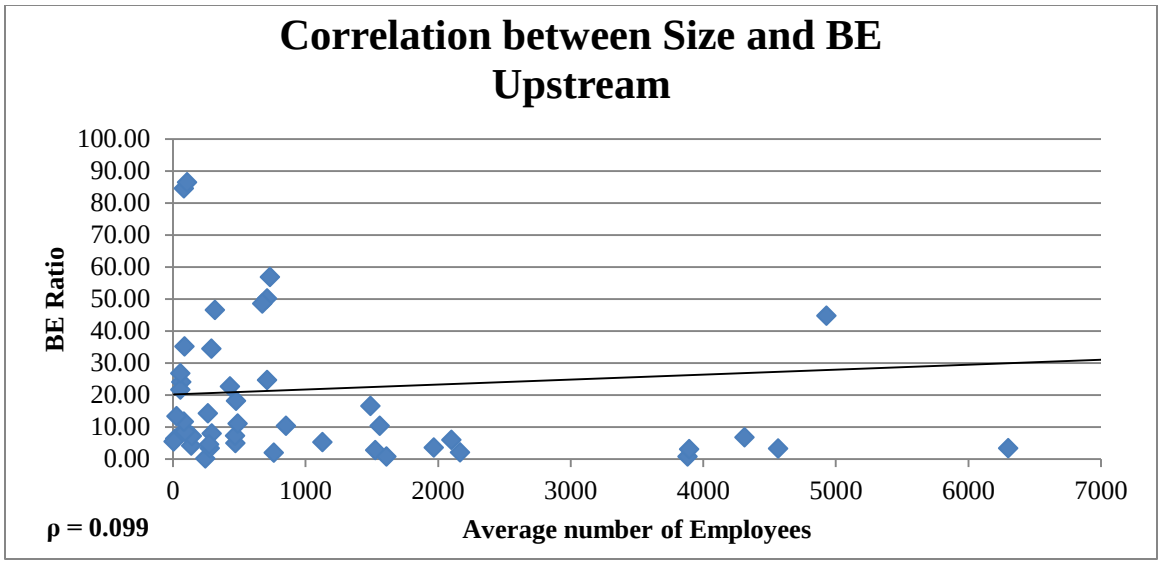


Figure 19. Correlation between Size of Upstream Companies and BE Ratio

Based on Figures 20 and 21 it cannot be concluded that the size of the company relates to the amount variability in demand and production.

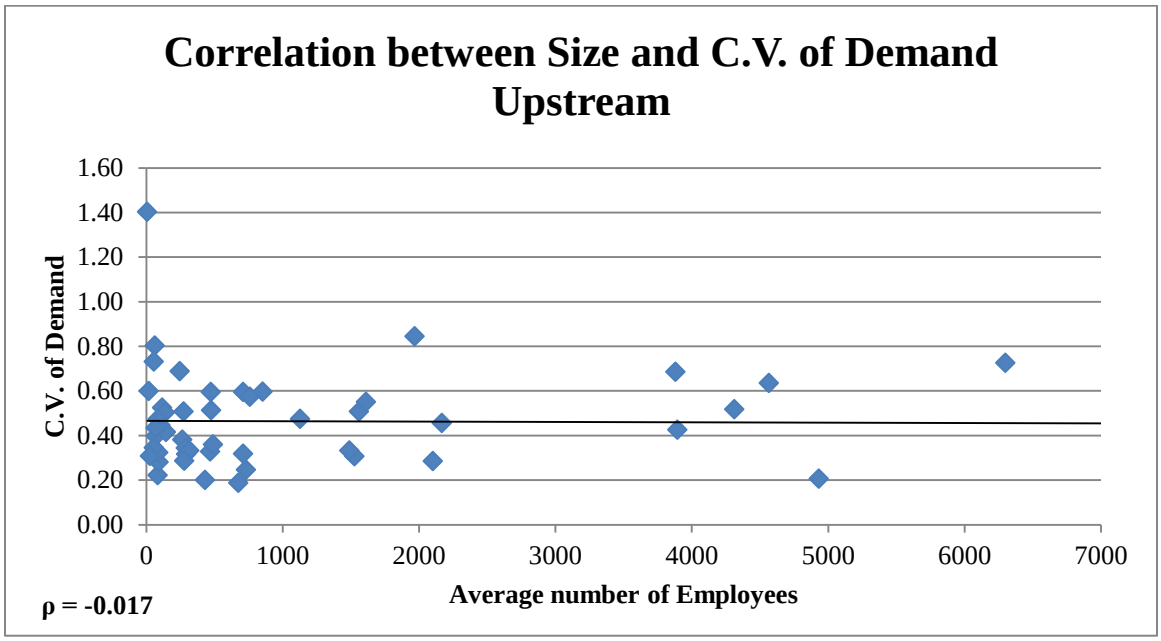


Figure 20. Correlation between Size of Upstream Companies and C.V. of Demand

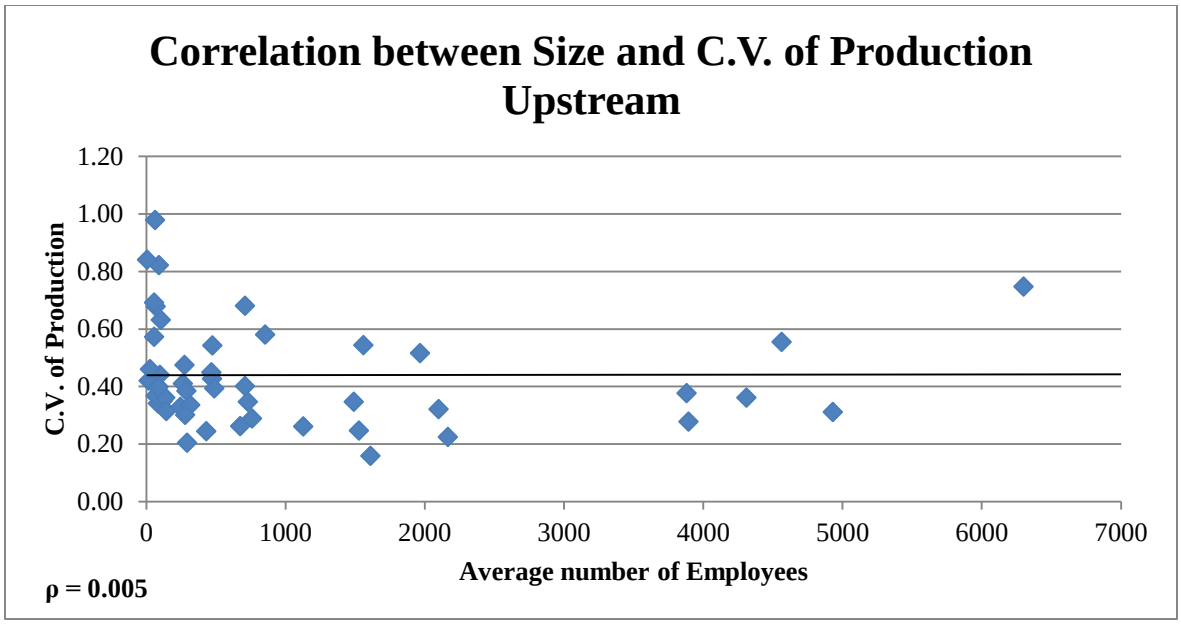


Figure 21. Correlation between Size of Upstream Companies and C.V. of Production

To summarize the analysis of the companies in the upstream level in terms of the bullwhip effect, the smallest companies were seen to have larger bullwhip effect ratios with one exception, Penn Virigina, but it had relatively high C.V. of demand. Larger companies were seen to have smaller ratios with one exception, Devon Energy, which had a relatively low C.V. of demand. This provides evidence that in the upstream level, smaller companies are more susceptible to the bullwhip effect compared to the larger companies, helping answer the third research question.

3.3.4 Drilling

Six companies were observed in the drilling level. The categorization of the companies in this level along with the relevant data is shown in Table 12. All the companies in the sample were considered large based on the NAICS standards. In this level, the bullwhip effect is present in all the companies.

Table 12. Data on Companies in the Drilling Level

Name of Company	Avg. Number of Employees	Size	BE Ratio	C.V. of Demand	Plotted Production and Demand Pattern
Nabors Industries, Inc.	23,761	Large	2.45	0.34	Non-cyclic
Transocean Ltd.	16,228	Large	2.69	0.49	Non-cyclic
Patterson-UTI Energy, Inc.	7,311	Large	3.33	0.38	Non-cyclic
Noble Corporation	5,778	Large	6.15	0.34	Non-cyclic
Helmerich & Payne, Inc.	5,405	Large	3.41	0.46	Non-cyclic
Ensco plc	4,840	Large	3.95	0.60	Non-cyclic
Rowan Companies	4,646	Large	4.60	0.32	Non-cyclic

It can be seen that the largest company in the sample does have the smallest bullwhip effect value. However, nothing conclusive could be obtained from the data in relation to the size of the company with the amount of bullwhip effect a company would exhibit.

No plotted graph showed obvious cyclicality. As noted in Figure 22 Helmerich & Payne appeared to experience cyclicality during the crisis. However, when comparing this graph to Table 13, the bullwhip effect during the crisis was much lower than before and after. Again, as in previous levels, the magnitude of the bullwhip effect cannot be determined through cyclicality. The plotted production and demand of all the companies in the drilling level is shown in Appendix 4.

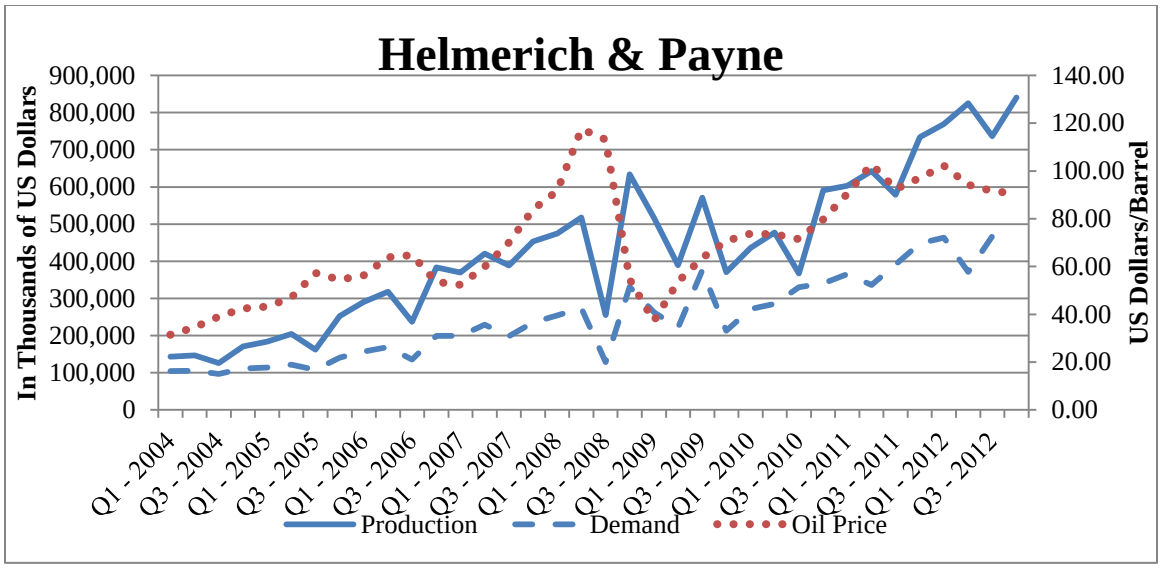


Figure 22. Helmerich & Payne, Inc. Plotted Production and Demand

Examining Table 13, Noble Corporation, Transocean Ltd., Nabors Industries, Ensco plc and Patterson-UTI appeared to have reduced the bullwhip effect continuously from 2004 to 2012. The other two companies experienced a dip in the bullwhip effect during the crisis but it increased again afterwards. This can be seen due to the steep increase in production during the crisis.

Table 13. Bullwhip Effect Values Before and After the Oil Crisis in the Drilling Level

Company	2004-2006 BE	2007-2009 BE	2010-2012 BE
Nabors Industries, Inc.	5.95	3.09	1.96
Transocean Ltd.	8.72	3.41	0.68
Patterson-UTI Energy, Inc.	7.76	3.37	2.71
Noble Corporation	29.59	27.88	2.96
Helmerich & Payne, Inc.	6.51	2.57	3.37
Ensco plc	45.31	16.55	4.17
Rowan Companies	6.56	4.55	4.57

Relationship between the size of the company, the bullwhip effect it exhibits and the variability of production and demand it experiences is shown in Figures 23 to 26. Figure 24 and

26 showed that smaller companies tend to exhibit larger bullwhip effect. Small companies have more of a fixed capacity and they do not have as steady of a demand compared to larger companies. When there is a considerably large change in demand, their inventory is not enough to buffer and they must adjust the production accordingly, resulting in larger variability in production. Larger companies would have a larger amount of inventory, meaning larger buffers to adapt to any change in demand variability. If smaller companies are causing the variability to go up the chain, that means that the large companies in this level are able to keep the production variability low enough that it does not affect its suppliers as much as the small companies.

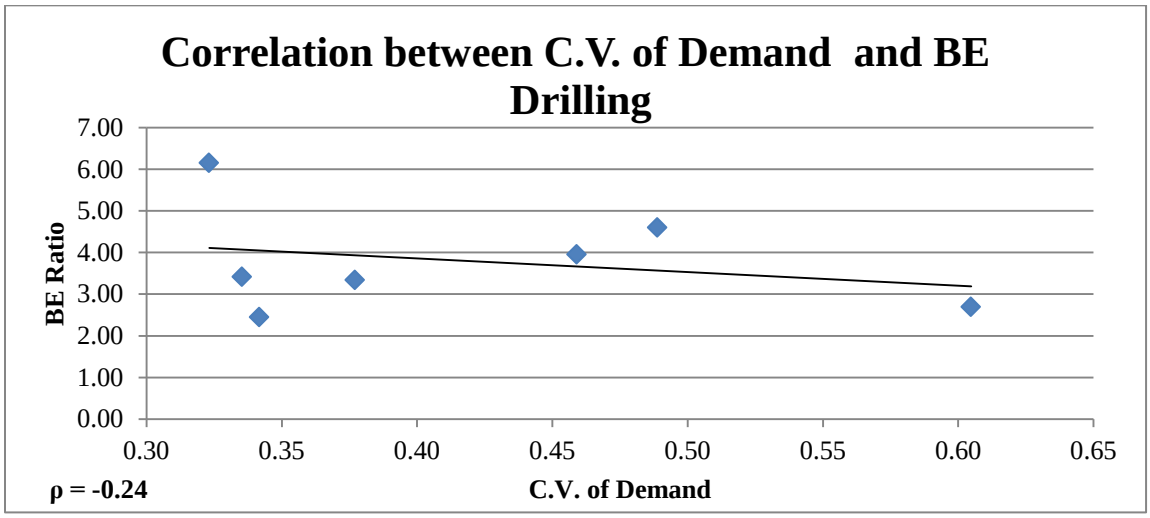


Figure 23. Correlation between C.V. of Demand of Drilling Companies and BE Ratio

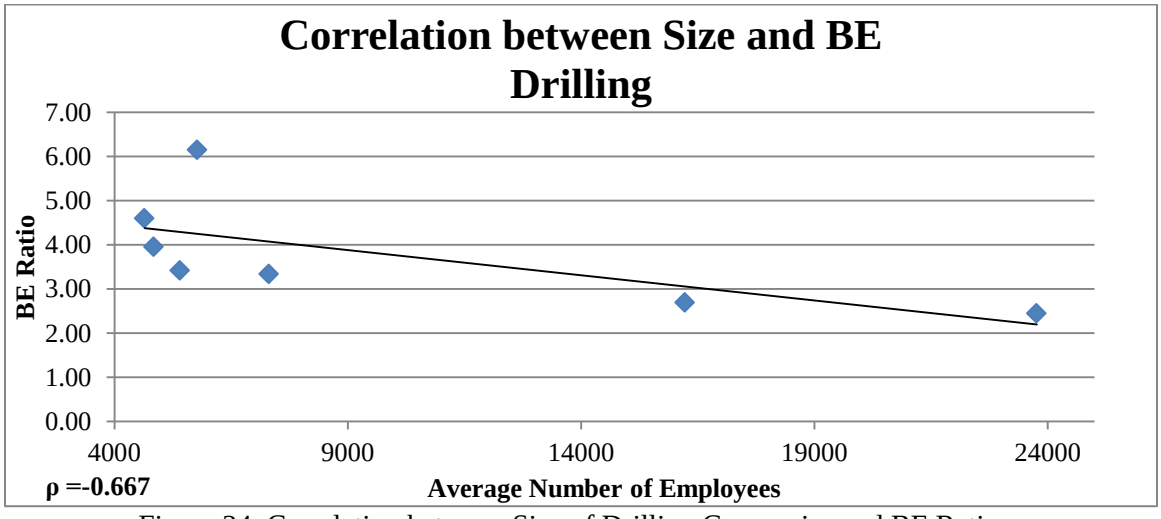


Figure 24. Correlation between Size of Drilling Companies and BE Ratio

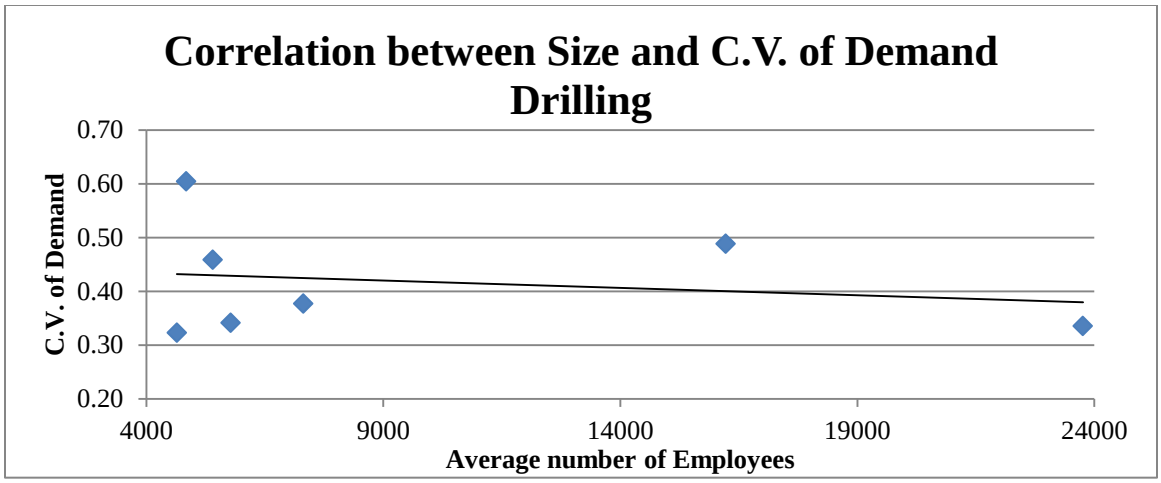


Figure 25. Correlation between Size of Drilling Companies and C.V. of Demand

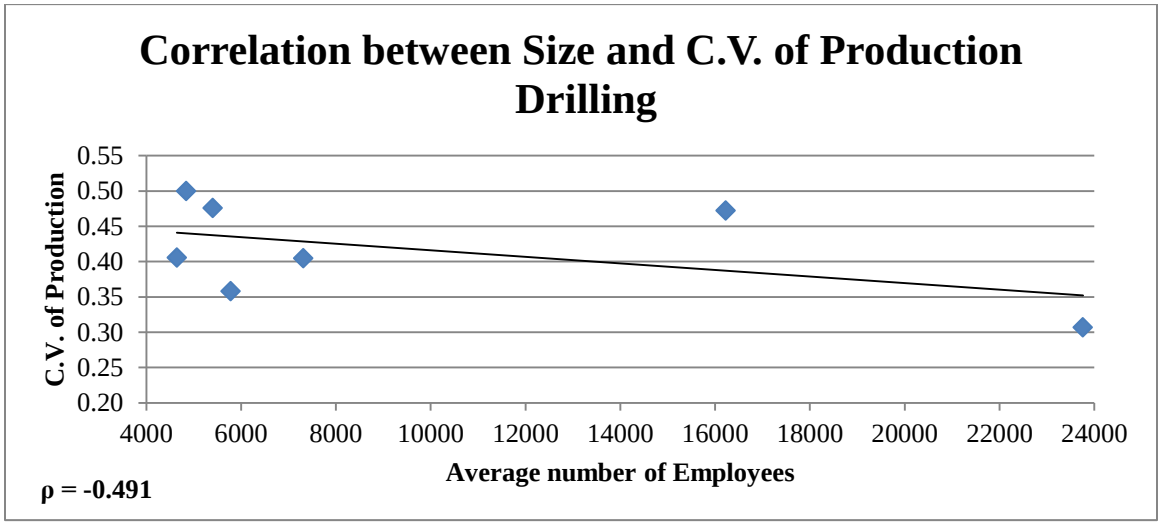


Figure 26. Correlation between Size of Drilling Companies and C.V. of Production

Summarizing the drilling level, the bullwhip effect was exhibited in all the companies but no obvious cyclicality patterns were seen in any of the companies. A comparison of the small and large companies were not possible in this level since all the companies were categorized as large, but the largest company in the group did have the smallest bullwhip effect ratio which supports answering the third research question.

3.3.5 Service and Equipment

Eighteen companies were considered in this sample with two small companies and 16 large companies. Similar to the drilling level, all the companies in this level have a bullwhip effect present. Looking at Table 14, an increasing bullwhip effect value can be seen as the size of the company becomes smaller. Starting with Schlumberger as the largest company with a bullwhip effect of 1.55 and ending with Bolt Technology was the smallest company with 3.92.

Table 14. Data on Companies in the Service and Equipment Level

Name of Company	Avg. Number of Employees	Size	BE Ratio	C.V. of Demand	Plotted Production and Demand Pattern
Schlumberger	80,125	Large	1.55	0.44	Non-cyclic
Halliburton	73,889	Large	1.25	0.25	Non-cyclic
Weatherford International	44,722	Large	1.63	0.49	Non-cyclic
Baker Hughes	41,133	Large	1.44	0.51	Non-cyclic
National Oilwell Varco	35,051	Large	2.28	0.49	Non-cyclic
FMC Technologies	11,922	Large	1.84	0.25	Non-cyclic
Oceaneering International, Inc.	7,678	Large	1.86	0.34	Non-cyclic
Oil States International, Inc	6,229	Large	1.95	0.41	Non-cyclic
Superior Energy Services	5,761	Large	2.77	0.76	Non-cyclic
Core Laboratories	4,822	Large	3.77	0.20	Non-cyclic
RPC, Inc	2,397	Large	3.34	0.61	Non-cyclic
Helix Energy Solutions Group	2,051	Large	1.32	0.48	Non-cyclic
Dril-Quip, Inc.	1,928	Large	3.90	0.29	Non-cyclic
GulfMark Offshore, Inc.	1,499	Large	4.81	0.35	Non-cyclic
Dawson Geophysical Company	1,138	Large	1.49	0.41	Non-cyclic
CARBO Ceramics	721	Large	2.79	0.39	Non-cyclic
Natural Gas Services Group, Inc.	243	Small	3.46	0.40	Non-cyclic
Bolt Technology	136	Small	3.92	0.37	Non-cyclic

When looking at the plotted graphs, many companies had many sudden ups and downs but since it was non-consistently occurring, none was categorized as cyclic. When the plotted production and demand patterns were compared with Table 14, Schlumberger, as shown in Figure 27, showed a decreasing bullwhip effect continuously from 2004 to 2012.

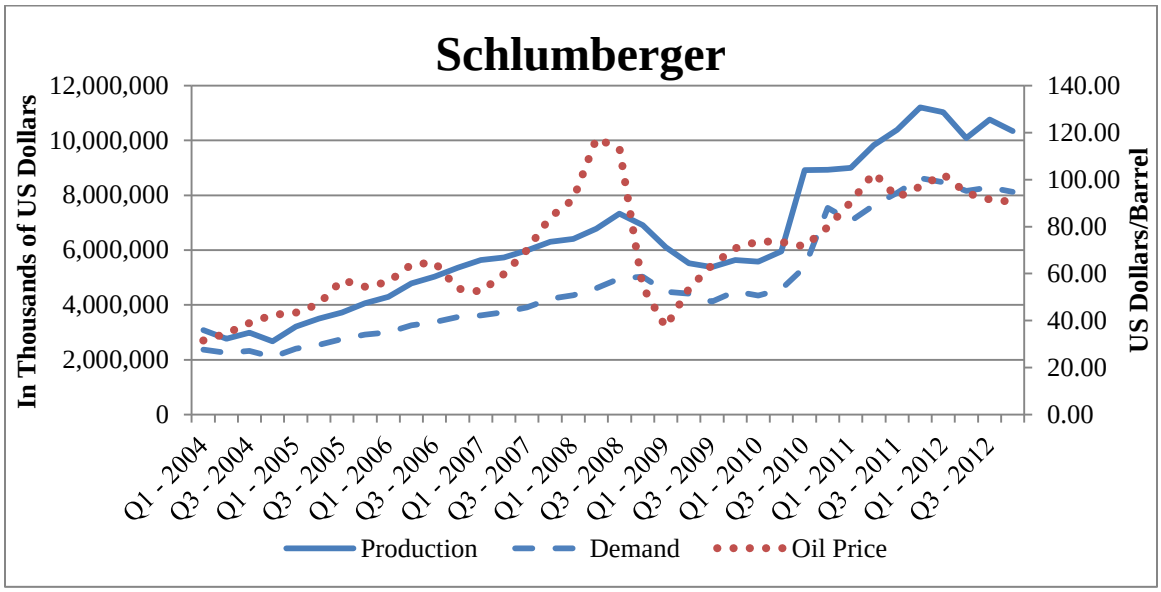


Figure 27. Schlumberger Plotted Production and Demand

However, Natural Gas Services as shown in Figure 28 had a considerably larger bullwhip effect during that period and it can be seen from the large spikes it generated in 2008-2009. Bolt Technology, the smallest company, also had a large increase in production from 2007-2009. Since they were in a smoother flow with their demand in that period compared to Natural Gas Services, the bullwhip effect they exhibited in that period was not as high and continuously decreased afterwards. The plotted production and demand graphs from the downstream level can be seen in Appendix 5.

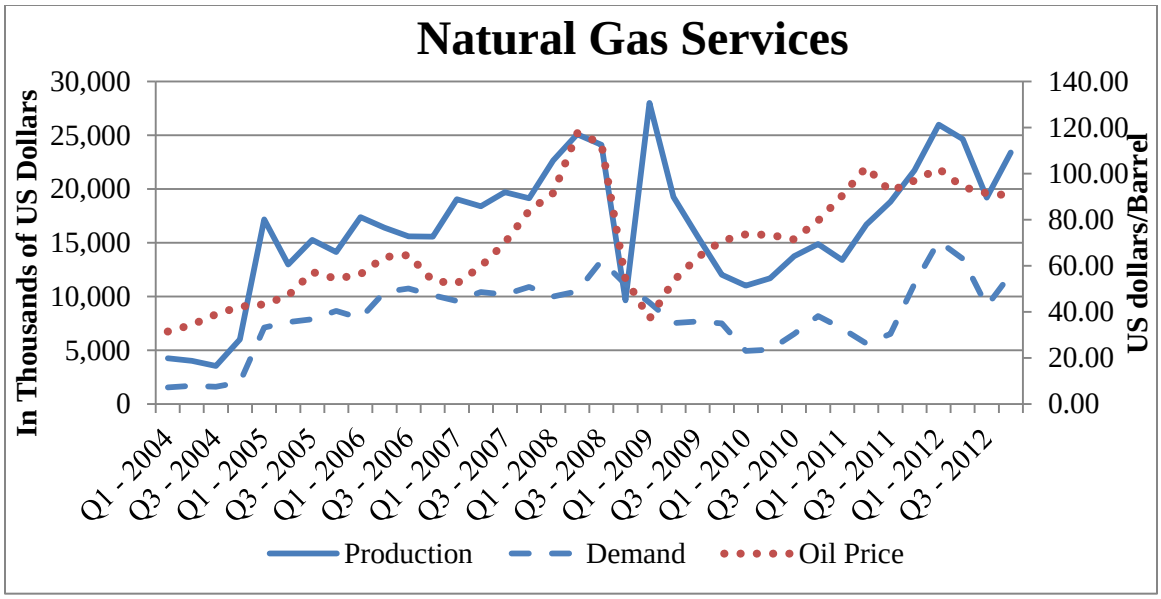


Figure 28. Natural Gas Services Plotted Production and Demand

In Table 15 Natural Gas Services, Superior Energy Services and Dril-Quip, Inc had substantially larger bullwhip effect values during the crisis. Similar to previous levels, it appears that they had a sudden reaction to the crisis by increasing or implementing sudden changes to their production whereas their demand is not behaving as extreme as they expected it to be.

Table 15. BE Ratios Before and After the Oil Crisis in the Service & Equipment Level

Company	2004-2006 BE	2007-2009 BE	2010-2012 BE
Schlumberger	3.61	1.96	1.43
Halliburton	1.84	2.39	1.16
Weatherford International	3.18	1.37	1.43
Baker Hughes	7.53	2.25	1.35
National Oilwell Varco	2.19	2.67	2.15
FMC Technologies	1.65	2.06	1.54
Oceaneering International, Inc.	2.80	1.06	1.98
Oil States International, Inc	1.29	3.22	1.93
Superior Energy Services	7.78	18.70	2.61
Core Laboratories	4.56	2.86	2.93
RPC, Inc	7.69	4.78	3.32

Helix Energy Solutions Group	2.85	1.28	1.13
Dril-Quip, Inc.	4.49	6.72	3.60
GulfMark Offshore, Inc.	30.66	5.76	6.85
Dawson Geophysical Company	1.77	2.90	1.62
CARBO Ceramics	2.48	2.45	2.93
Natural Gas Services Group, Inc.	2.34	9.61	2.22
Bolt Technology	4.8	3.52	2.89

The companies that were seen to continuously decrease were Schlumberger, Helix Energy Solutions and Bolt Technology. Since both the largest and the smallest companies were able to reduce the bullwhip effect from 2004 to 2012, it would be advantageous to learn from the strategies they used.

Relationship between the size of the company, the bullwhip effect it exhibits and the variability of production and demand it experiences is shown in Figures 29 to 32. It cannot be concluded the amount of demand variability increases or decreases based on the size of the company, meaning that both large and small companies face the same amount of demand variability. However, Figure 30 and 32 showed that the smaller companies exhibit higher variability in production and larger bullwhip effect. Small companies have more of a fixed capacity and they do not have as steady of a demand compared to larger companies. So when there is a large change in demand, their inventory is not enough to buffer and they must adjust the production accordingly, resulting in larger variability in production. Larger companies would have a larger amount of inventory, meaning larger buffers to adapt to any change in demand variability. If smaller sized companies are causing the variability to go up the chain, that means that the large companies in this level are able to keep the production variability low enough that it does not affect its suppliers as much as the small companies.

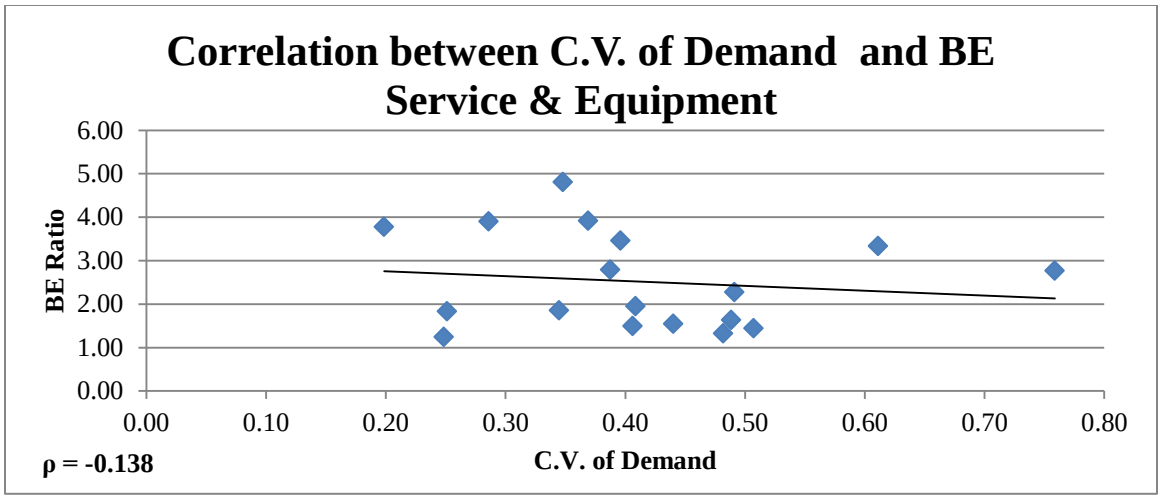


Figure 29. Correlation between C.V. of Demand of S&E Companies and BE Ratio

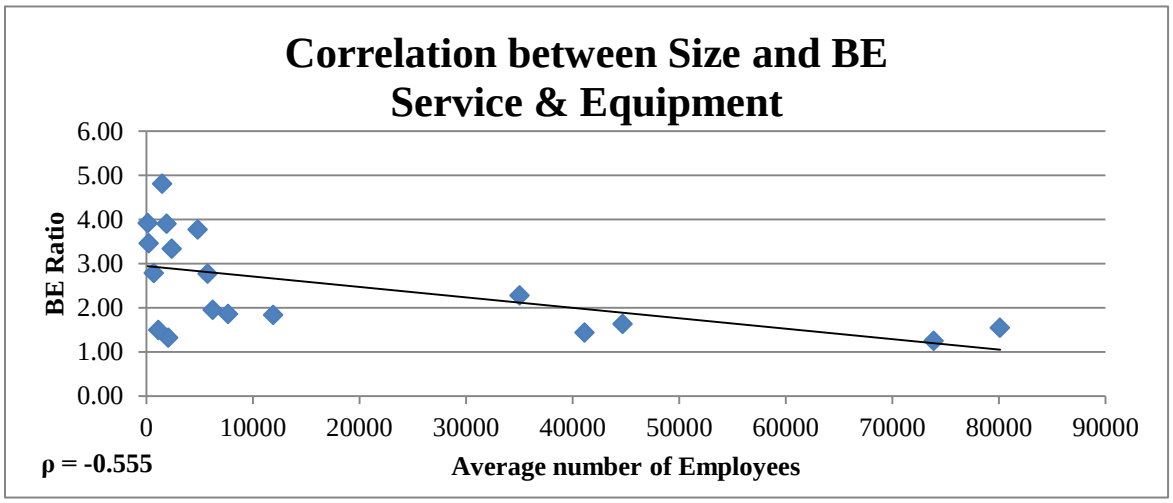


Figure 30. Correlation between Size of S&E Companies and BE Ratio

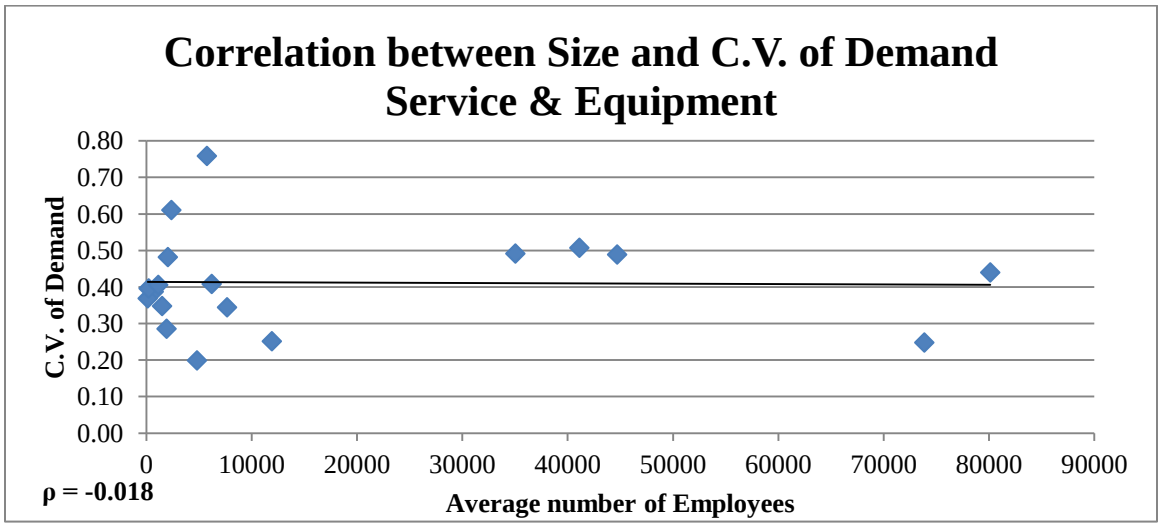


Figure 31. Correlation between Size of S&E Companies and C.V. of Demand

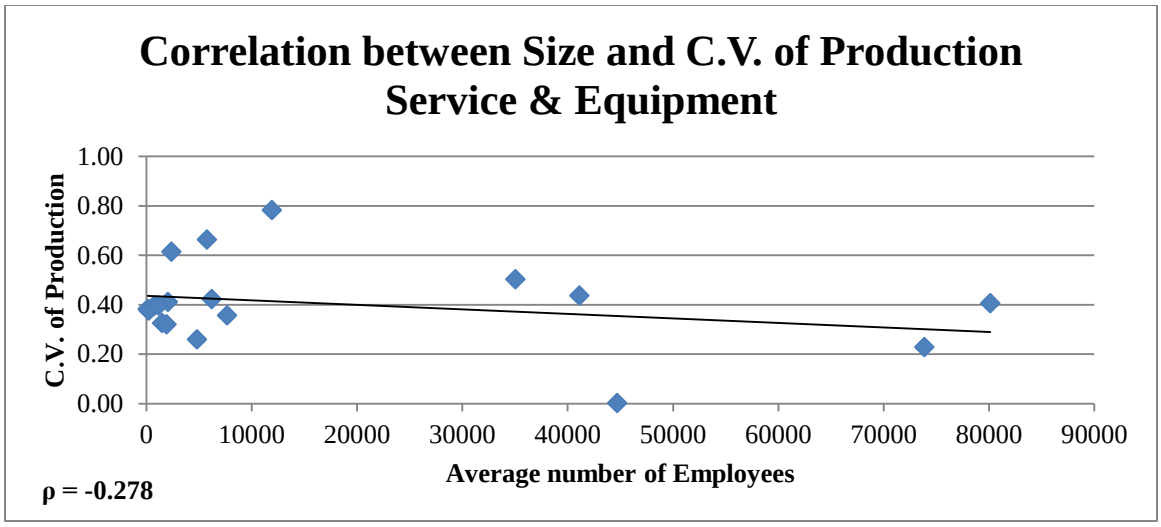


Figure 32. Correlation between Size of S&E Companies and C.V. of Production

Summarizing the service and equipment level, the bullwhip effect ratio was seen to decrease as the size of the company grew; again, this supports answering the third research question. No obvious cyclical patterns were seen in any of the companies. In terms of the crisis, both small and large companies were susceptible to it.

3.4 Aggregate Analysis of Each Level in the Supply Chain

This section examines the behavior of each level in the supply chain. The bullwhip effect values and coefficient of variation of production and demand of each company were compiled and averaged. The same was done for the coefficient of variation of demand. Results are shown in Table 16.

Table 16. Aggregate Data on Each Level

	Service and Equipment	Drilling	Upstream	Midstream	Downstream
Average Bullwhip Effect Ratio	2.52	3.80	22.30	1.44	1.10
C.V. of Demand	0.41	0.41	0.46	0.48	0.56
C.V. of Production	0.40	0.42	0.44	0.43	0.37
Number of Companies	18	6	51	16	11

It provides evidence that that there is a bullwhip effect in the oil and gas industry from downstream to upstream due to the amplified bullwhip effect value. However, the values decrease from upstream to service and equipment. Cachon et al. (2007) concluded that the manufacturing industry tends to have lower bullwhip effect values due to production smoothing. Since the Service and Equipment and Drilling level mainly consist of manufacturing, it is assumed that this decreasing phenomenon is due to smoothing of production.

Table 17 shows that the service and equipment level has a BE ratio much larger than one. The bullwhip effect did not magnify from upstream to the service and equipment level and the variability of demand and production decreases. Even if this decreasing occurrence happens as it goes to the upper suppliers of this level, it would be assumed that the BE ratio is still larger than one. In addition, even though the variability of demand production decreases, the difference between levels are not substantially high, meaning the amount of variability in the supply chain is notable on the small companies.

Table 17. BE Ratio, C.V. of Demand and Production Comparison between Small and Large Companies in Each Level

		Service and Equipment	Drilling	Upstream	Midstream	Downstream
BE	**Small Companies**	3.69	-	22.97	1.47	0.74
	Large Companies	2.37	3.80	21.43	1.42	1.19
C.V. Demand	**Small Companies**	0.38	-	0.47	0.58	0.62
	Large Companies	0.42	0.41	0.45	0.42	0.55
C.V. Production	**Small Companies**	0.38	-	0.47	0.54	0.34
	Large Companies	0.41	0.42	0.41	0.36	0.38

To see the comparison of the bullwhip effect, C.V. of demand and production in the aggregate level, the respective values of the small and the large companies were averaged accordingly. Table 17 shows that in the service and equipment, upstream and midstream level the small companies exhibit a larger bullwhip effect than the large companies. However, demand variability is seen to decrease as it flows up the chain but production variability varies and does not have a noteworthy trend.

When the study analyzed the bullwhip effect, C.V. of demand, and C.V. of production in each level during the crisis, it was apparent that the values are considerably larger in the upper three levels: service and equipment, drilling and upstream. In terms of the bullwhip effect ratio, the upstream level was the only level that performed poorly during the crisis with a much larger bullwhip effect value compared to the other periods, whether a small or a large company (Table 17). The downstream level was the only level to appear to experience higher demand variability during the crisis. Even though service and equipment and drilling had larger bullwhip effect values, they showed improvement from 2004 to 2006. This is mainly due to the decreasing trends exhibited by the large companies.

Referring to Table 18, the midstream and downstream levels had lower bullwhip effect values but their performance was not much better since they experienced a dip in the crisis but it reached its peak after crisis. However, when the midstream level is analyzed further, the small companies showed improvement whereas the large companies' bullwhip increased over time. The opposite was seen in the downstream level. This could be due to factors such as lagging results from their actions during the crisis or increased production after the crisis that does not match the demand pattern.

Table 18. BE Ratio, C.V. of Demand and Production Before, During and After Oil Crisis Comparison of Each Level

			Service and Equipment	Drilling	Upstream	Midstream	Downstream
Bullwhip Effect Ratio	**2004 - 2006**	Small	3.57	-	26.37	1.79	0.61
		Large	5.40	15.77	26.29	1.40	1.33
		Total	**5.20**	**15.77**	**26.34**	**1.47**	**1.20**
	2007 - 2009	Small	6.57	-	34.54	1.47	0.63
		Large	3.90	8.77	180.21	1.64	0.96
		Total	**4.20**	**8.77**	**97.38**	**1.37**	**0.90**
	2010 - 2012	Small	2.56	-	37.10	1.39	1.32
		Large	2.37	2.92	32.20	1.79	1.48
		Total	**2.39**	**2.92**	**34.98**	**2.04**	**1.45**
C.V. of Demand	**2004 - 2006**	Small	0.48	-	0.37	0.43	0.53
		Large	0.22	0.20	0.35	0.47	0.43
		Total	**0.35**	**0.20**	**0.36**	**0.45**	**0.48**
	2007 - 2009	Small	0.25	-	0.25	0.26	0.66
		Large	0.14	0.22	0.30	0.36	0.52
		Total	**0.20**	**0.22**	**0.28**	**0.31**	**0.59**
	2010 - 2012	Small	0.34	-	0.28	0.21	0.61
		Large	0.22	0.29	0.27	0.15	0.47
		Total	**0.28**	**0.29**	**0.28**	**0.18**	**0.54**
C.V. of Production	**2004 - 2006**	Small	0.47	-	0.39	0.38	0.28
		Large	0.27	0.35	0.30	0.41	0.32
		Total	**0.37**	**0.35**	**0.35**	**0.40**	**0.30**
	2007 - 2009	Small	0.31	-	0.38	0.37	0.38
		Large	0.18	0.23	0.40	0.28	0.32
		Total	**0.25**	**0.23**	**0.39**	**0.32**	**0.35**
	2010 - 2012	Small	0.27	-	0.21	0.20	0.37
		Large	0.22	0.28	0.21	0.17	0.32
		Total	**0.24**	**0.28**	**0.21**	**0.18**	**0.35**

Throughout the study, cyclicality was observed for each company. Looking at cyclical patterns, the midstream and downstream level appear to have more cyclical production compared to the upper levels. One reason was that they have a more direct view of the demand and due to the seasonal characteristic of the product; forecasting of having cyclical demand is more common.

This study wanted to confirm cyclicality in each level of the supply chain by summing the demand of all the companies in each level and then averaging them based on the quarters. Seasonality of demand was seen consistently throughout the supply chain. Demand is generally higher during the fourth quarter and lowest in the first quarter, as shown in Table 19. The actual demand values can be seen in Appendix 6.

Table 19. Ranking of Quarterly Demand

Lowest to Highest Demand ↑	Service and Equipment	Drilling	Upstream	Midstream	Downstream
	Q4	Q4	Q4	Q4	Q3
	Q3	Q3	Q3	Q3	Q4
	Q2	Q2	Q2	Q1	Q2
	Q1	Q1	Q1	Q2	Q1

3.4 Comparison to Companies with an Integrated Supply Chain

The supply chain defined thus far is a compilation of multiple companies from pre-defined levels of the supply chain. However, there were large companies that have integrated the multiple levels into one controlled supply chain system. Chen et al. (2000) stated that a supply chain with centralized demand information should demonstrate smaller bullwhip effect. This study compared the decentralized supply chain with three large integrated, centralized, companies: Chevron, ExxonMobil and Questar Corporation. Questar Corporation had an exploration and production segment until 2010, when it was sold to QEP Resources. Only the downstream and midstream levels were analyzed.

Table 20, indicates that the larger integrated companies did substantially better in the upstream level compared to the decentralized companies. The downstream level of the integrated companies exhibited larger bullwhip effects compared to the decentralized supply chain. Questar Corporation was the only company that exhibited a larger bullwhip effect as it went upstream compare to the decentralized supply chain, seen from the midstream BE ratios.

Table 20. Comparison of Integrated Companies with the Decentralized Supply Chain

	Avg. Number of Employees	Upstream	Midstream	Downstream
Decentralized Supply Chain	-	22.30	1.44	1.10
ExxonMobil	81,744	2.56	-	1.39
Chevron	56,813	2.52	-	1.76
Questar Corporation	688	-	2.34	1.20

Referring to the plotted production and demand data of the three companies, it shows that Questar Corporation(Figure 32) had a cyclic pattern compared to the two larger companies, ExxonMobil and Chevron. The plotted production and demand of each integrated company can be seen in Appendix 7.

The three integrated companies exhibited the bullwhip effect. However, the larger companies did not appear to have a large increase as it went up the supply chain and the smaller company did.

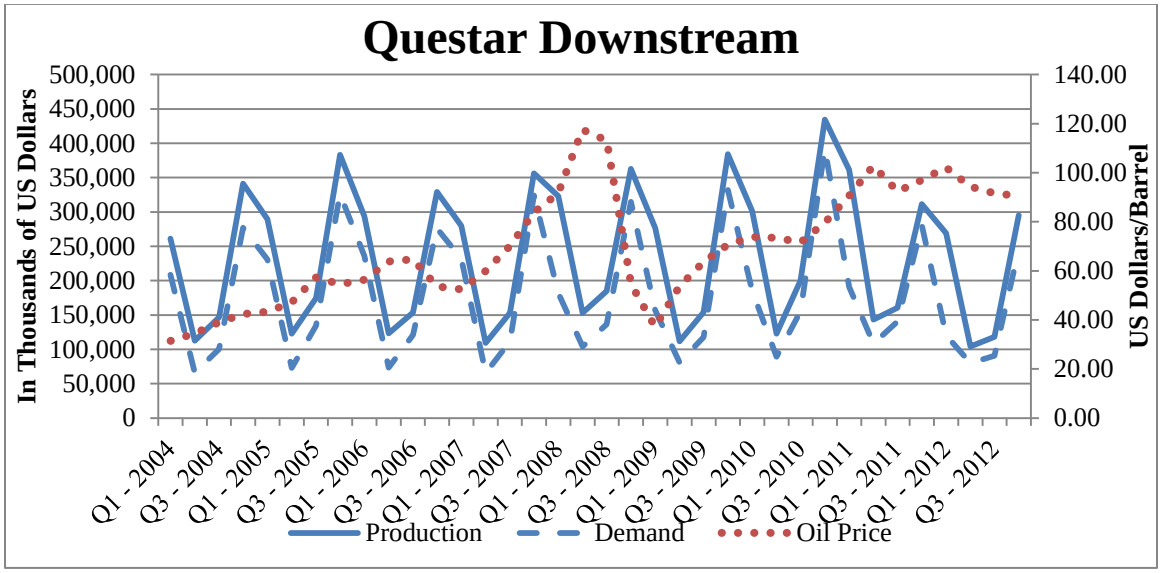


Figure 33. Questar Corporation Downstream Plotted Production and Demand

CHAPTER IV

FINDINGS

4.1 Research Questions

The research questions in this study were answered based on what was concluded from the analyses of the data. The three research questions this thesis tried to answer are the following:

- Research Question 1: Does the bullwhip effect exist in the oil and gas industry?
- Research Question 2: Does the service and equipment level exhibit the highest demand variability in the supply chain?
- Research Question 3: Are smaller sized companies more susceptible to larger demand variability than larger sized companies?

4.1.1. Research Question 1

To answer the first research question, the bullwhip effect was analyzed at three different levels of the industry; at the individual level, the aggregate level and the supply chain as a whole.

When the companies were looked at individually based on the level in which they were categorized, it showed that the number of companies that have the bullwhip effect increased as the level increased. This information is shown in Table 21. With a high percentage of bullwhip effect existence in each level, >99%, it shows that the bullwhip effect is exhibited by the majority of the companies in the oil and gas industry, regardless of which level of the supply chain it belongs to.

Table 21. Summary of companies in Each Level with BE

	Service and Equipment	Drilling	Upstream	Midstream	Downstream
Number of companies that showed BE	100%	100%	99.94%	99.94%	99.64%
	18 out of 18	6 out of 6	48 out of 51	15 out of 16	7 out of 11

At the aggregate level, indicated in Table 22, all the levels of the supply chain have a bullwhip effect ratio larger than 1, meaning that the bullwhip effect exists in each level of the supply chain. It is evident that the bullwhip effect in the midstream and the downstream level are much lower than the others. This can be explained due to the proximity of these two levels to the demand from the market.

Table 22. Average BE of Each Level

	Service and Equipment	Drilling	Upstream	Midstream	Downstream
Average Bullwhip Effect Ratio	2.52	3.80	22.30	1.44	1.10

To see if the bullwhip effect exists in the industry, the variance of production over the variance of demand should amplify as it goes up the supply chain. This shows as the bullwhip amplifies starting from the downstream level (1.10), then larger in the midstream level (1.44) and even larger as it arrives in the upstream level (22.30). However, this amplification did not continue as it goes further up the supply chain. Two reasons were found to explain this; production smoothing and diversification strategy. Production smoothing was mentioned by Cachon et al. (2007) to explain the lack of amplification in the manufacturing industry and this would be applicable in this study since the two levels that show lower amplification are mostly manufacturing type companies. The other reason was diversification strategy; this would be applicable for the service and equipment industry since they provide multiple products and

service for multiple levels of the supply chain. This shows that they are not tied to the demand of the level ahead of them. However, the diversification would not be relevant for the drilling level since they directly supply services and products to the upstream level.

Based on these results, the study was able to answer the first research question; the data provides evidence that bullwhip effect exists in the oil and gas industry up to the upstream level.

4.1.2. Research Question 2

The second research question states that the service and equipment level has the highest demand variability. The aim of this research question was to see if the problems experienced by the small suppliers in Oklahoma that supplied the service and equipment level were the result of a widespread effect of the bullwhip across the industry. To answer this research question, the bullwhip effect of the service and equipment level should be larger when compared to the other levels of the supply chain.

The BE ratios and C.V. of demand of each level is shown in Table 23. Evidently, the bullwhip effect exhibited is not larger than the levels of the supply chain it directly supplies. The C.V. of demand does not seem to increase and the service and equipment level shows the lowest demand variability.

Table 23. BE Ratios and C.V. of Demand of Each Level in the Supply Chain

	Service and Equipment	**Drilling**	**Upstream**	**Midstream**	**Downstream**
BE Ratio	2.52	3.80	22.30	1.44	1.10
C.V. of Demand	0.41	0.42	0.46	0.48	0.56

It was mentioned previously that the companies in the service and equipment level do not tend to focus on supplying to one level. Due to this fact, the service and equipment level was split

based on the main level they supply directly, seen from the majority of the offerings they provide or where most of their revenue comes from. It was found that three mostly serve the drilling companies, three mostly serve the midstream companies, and 12 mostly serve the upstream companies. The companies categorized can be seen in Table 24.

Table 24. List of Split Service and Equipment Level Companies

Drilling	Upstream	Midstream
CARBO Ceramics	RPC, Inc	Oil States International, Inc.
Helix Energy Solutions Group	National Oilwell Varco	Natural Gas Services Group, Inc.
Dril-Quip, Inc.	Core Laboratories	GulfMark Offshore, Inc.
	Superior Energy Services	
	Oceaneering International, Inc.	
	Schlumberger	
	Halliburton	
	Baker Hughes	
	FMC Technologies	
	Weatherford International	
	Bolt Technology	
	Dawson Geophysical Company	

From the companies listed in Table 25, the bullwhip effect and C.V. of demand for each company was calculated and then averaged with the other companies in the group. These values were then compared to the values from the level it directly supplied. The BE ratio of the service and equipment level was only larger when compared to the midstream level. The C.V. of demand of segmented service and equipment level exhibited similar behavior and did not have a C.V. of demand larger than any of the levels it directly supplies. Since the value is not the largest in the supply chain, the data provided evidence that the demand variability was not largest at the service and equipment level.

Table 25. Comparison of Split S&E BE ratios with Their Respective Levels

	S&E Drilling	Drilling	S&E Upstream	Upstream	S&E Midstream	Midstream
BE Ratio	2.67	3.80	2.26	22.30	3.41	1.44
C.V. of Demand	0.38	0.42	0.43	0.46	0.38	0.56

4.1.3. Research Question 3

Since NPDC's mission is to provide support to the small and medium sized manufacturers in Oklahoma, it was of interest to this study to see if smaller companies were more susceptible to the bullwhip effect and demand variability than larger companies in the oil and gas industry. To answer this research question, the study compared the bullwhip effect and the C.V. of demand of the small companies to the large companies in each level. This can be seen in Table 26.

Table 26. BE Ratio, C.V. of Demand Comparison between Small and Large Companies in Each Level and in Total

		Service and Equipment	Drilling	Upstream	Midstream	Downstream	Total Average (independent of level)
BE	**Small Companies**	**3.69**	**-**	**23.51**	**1.47**	**0.74**	**17.53**
	Large Companies	**2.37**	**3.98**	**14.06**	**1.42**	**1.19**	**6.29**
C.V. of Demand	**Small Companies**	**0.38**	**-**	**0.47**	**0.58**	**0.62**	**0.51**
	Large Companies	**0.42**	**0.41**	**0.45**	**0.42**	**0.55**	**0.45**

From the data, evidence showed that small companies tend to have larger bullwhip effect values then their larger counterparts in every level except for drilling and downstream. There

were no small companies in the drilling sample and only two small companies in the downstream level and neither one showed the presence of the bullwhip effect. When all the BE ratios of the small companies in the sample were averaged, it showed that the bullwhip effect was considerably larger in the small companies than in the large ones. Figure 33 emphasized this with higher BE ratios at smaller number of employees.

The same phenomenon is seen when analyzing the C.V. of demand of each level. Only the small companies of the service and equipment did not exhibit higher demand variability when compared with its larger counterparts. However, in general it is seen that the smaller companies exhibit larger demand variability. Thus, the data provides evidence that smaller sized companies are more susceptible to higher demand variability when compare to larger sized companies.

Reasonably, the smaller companies have smaller capital to be flexible in adjusting their labor and production capacities to adapt to sudden changes in demand.

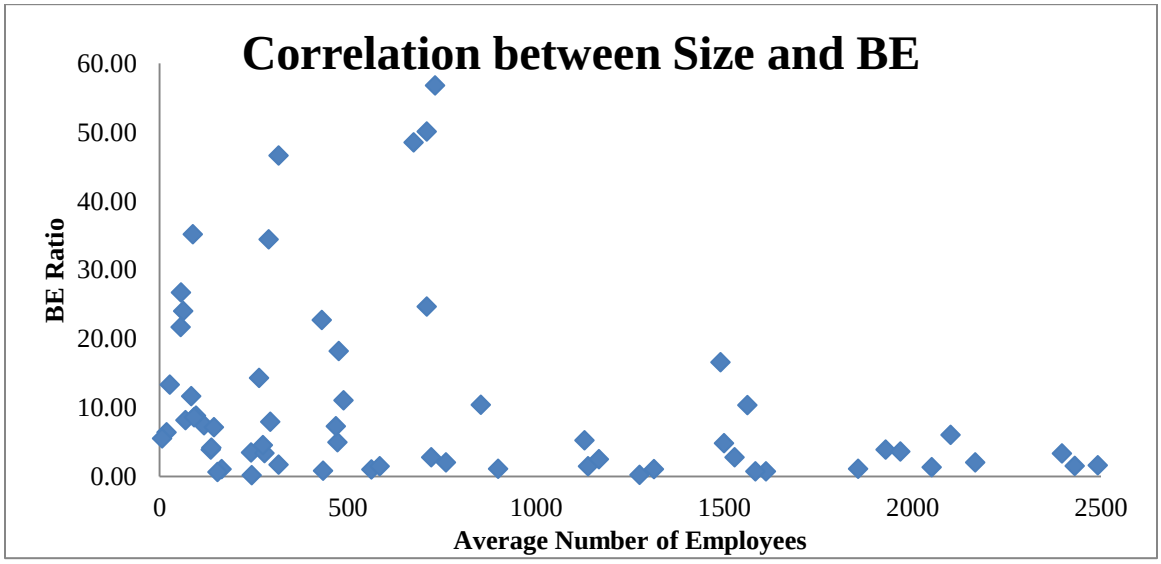


Figure 34. Correlation between Size and BE

CHAPTER V

CONCLUSIONS

This study analyzed data from the New York Stock Exchange (NYSE) on oil and gas companies. A supply chain model was defined for this industry with five sequential levels. The bullwhip effect was evaluated in each company and then aggregated to further investigate its existence in a more aggregate level -- the supply chain of the oil and gas industry. The bullwhip effect was then examined in terms of how it behaved before, during and after the oil crisis in 2008.

The analysis of the bullwhip effect in the individual level showed the behavior of the company in terms of its production and demand, susceptibility to the bullwhip effect and how it dealt with the oil crisis. Exploration in this level showed cyclical pattern of production and demand in certain companies. When compared to the bullwhip effect of the company, each company behaved differently. This led to the conclusion that the magnitude of the bullwhip effect did not determine the existence of cyclicality in production and demand of that company. Cyclicality was also shown to exist in both the large and small companies, which provided evidence that it has no relation to the size of the company.

Cyclicality of the companies was observed through the aggregate level through seasonality of demand. This was determined through ranking of the quarters that experienced the highest demands. It was seen in 4 out of 5 levels that the 4^{th} quarter of the year had the largest demand and the 1^{st} quarter had the lowest demand.

The bullwhip effect for each company varied. A majority of the companies showed that they were dealing with the bullwhip effect. The third research question asked if small companies had larger bullwhip effect and large companies had smaller ones. This was not always the case when each company was analyzed. Some large companies were seen to have high BE ratios and some small companies were found not to have the bullwhip effect. Nevertheless, these were exceptions and were not common to find in the rest of the sample. When all the small companies were analyzed together, it showed that the bullwhip effect they incurred was considerably larger than what the large companies experience.

At each level, the size of the company was correlated with the size of the bullwhip it exhibited and the amount of variability of production and demand it experienced. All levels showed that high bullwhip effect was highly correlated with low demand variability. Most levels showed that smaller companies experienced high variability in demand and production. The upstream and downstream levels showed that both small and large companies had similar amount of variability in production and also showed that the bullwhip effect was exhibited by large companies. The inventory of small companies cannot handle demand variation that is higher or similar to theirs especially when it comes from a large company. The other three levels showed that the bullwhip effect is exhibited by smaller companies. Larger companies would have larger inventory, meaning larger buffers to adapt to any change in demand variability. If the smaller companies are causing the variability to go up the chain, that means that the large companies in this level are able to keep the production variability low enough that it does not affect its suppliers as much as the small companies.

At the aggregate level, it showed how prominent the existence the bullwhip effect was since more than 99% in every level had an amplification ratio larger than 1. In addition, the bullwhip effect amplified as it went from downstream to midstream and through the upstream level. These indicate that the bullwhip effect is especially present in the oil and gas industry.

However, this amplification did not continue through the highest level of the defined supply chain, which was the service and equipment level. It was concluded that the drilling level had a smaller effect in comparison to the upstream level due to production smoothing. Due to the multiple levels to which the S&E level supplies, it was concluded that their smaller value was due to a diversification strategy.

This study also analyzed the supply chain levels in terms of how they did during the oil crisis. The upstream level did the worst since it had the largest bullwhip and was the only level that showed an increase in bullwhip effect at that time. This existed in both the small and large companies. The S&E and drilling level continuously increased their bullwhip by decreasing its levels at each period: before, during and after the crisis. The midstream and downstream, though having the lowest bullwhip effect values, exhibited a substantially large increase of the bullwhip effect after a sudden dip during the crisis. Midstream small companies improved over time whereas the large companies did the exact opposite and downstream did the exact opposite. These represent how the majority of the companies in each level reacted before, during and after the oil crisis in 2008.

To conclude, the data obtained in this thesis, evidence provided that the high variability the oil equipment suppliers experienced were due to their sizes and not due to their position in the supply chain.

5.1 Recommendation for Further Work

Since this study examined the presence of the bullwhip effect, an in-depth study should be conducted on why amplification of the bullwhip effect stopped at the upstream level. Even though some conclusions were made through literature and the characteristics of the product that the company provided, an in-depth survey to the drilling and S&E level would give a more accurate explanation for the phenomenon.

This study shows that some companies did well than others in improving the bullwhip effect: whether it is from continuously declining BE ratios from 2004 to 2012 or from a dampening of the bullwhip effect after oil crisis. Further investigation on what strategies these companies used to achieve these results would be a good guide for those companies who have not been able to accomplish that.

During the study, there was effort to categorize the companies based on their main product being oil or natural gas. It was clear which companies provided which type of product when looking at downstream and midstream levels. However, going up the supply chain and looking at the upstream and higher levels, most companies did a combination of both products and the separation was no longer clear. There was not much that could be concluded just with the separated midstream and downstream. It is deemed more beneficial if further study was conducted tracking the production, processing, storage and distribution of natural gas and oil directly through the supply chain to see how the behavior of the companies differ in relation to the product they deliver.

This study analyzed the behavior of the bullwhip effect before, during and after the oil crisis. Further investigation in how the amplification of demand and production up the oil and gas supply chain in relation to a change in the oil price will provide insight on what each level might expect when a change occurs.

REFERENCES

1. Anderson, Edward G., Charles H. Fine, and Geoffrey G. Parker. "Upstream volatility in the supply chain: The machine tool industry as a case study." *Production and Operations Management* 9, no. 3 (2000): 239-261.

2. Beecham, M. A., and M. Cordey-Hayes. "Partnering and knowledge transfer in the UK motor industry." *Technovation* 18, no. 3 (1998): 191-205.

3. Blanchard, Olivier J. "The production and inventory behavior of the American automobile industry." (1983).

4. Boyd, Dan T. "Oklahoma natural gas: past, present, and future." *Oklahoma Geology* Notes 62, no. 4 (2002): 143-154.

5. Bray, Robert L., and Haim Mendelson. "Information transmission and the bullwhip effect: An empirical investigation." *Management Science* 58, no. 5 (2012): 860-875.

6. Burbidge, John L. "The new approach to production." *Production Engineer* 40, no. 12 (1961): 769-84.

7. Cachon, Gérard P., Taylor Randall, and Glen M. Schmidt. "In search of the bullwhip effect." *Manufacturing & Service Operations Management* 9, no. 4 (2007): 457-479.

8. Carlsson, Christer, and Robert Fullér. "Reducing the bullwhip effect by means of intelligent, soft computing methods." In *System Sciences*, 2001. *Proceedings of the 34th Annual Hawaii International Conference* on, pp. 10-pp. IEEE, 2001.

9. Chen, Frank, Zvi Drezner, Jennifer K. Ryan, and David Simchi-Levi. "Quantifying the bullwhip effect in a simple supply chain: the impact of forecasting, lead times, and information." *Management science* 46, no. 3 (2000): 436-443.

10. Chen, Li, and Hau L. Lee. "Bullwhip effect measurement and its implications." *Operations Research* 60, no. 4 (2012): 771-784.

11. Chima, Christopher M. "Supply-chain management issues in the oil and gas industry." *Journal of Business & Economics Research* (JBER) 5, no. 6 (2011).

12. Davis, Jerome D. *The changing world of oil: an analysis of corporate change and adaptation*. Ashgate Publishing Company, 2006.

13. Dodgson, Mark. *Technological collaboration in industry: strategy, policy, and internationalization in innovation*. LondonNew York: Routledge, 1993.

14. Doz, Yves L. "Technology partnerships between larger and smaller firms: some critical issues." *International Studies of Management & Organization* 17, no. 4 (1987): 31-57.

15. Edmiston, Kelley. "The Role of Small and Large Businesses in Economic Development." *Economic Review* 92.2 (2007): 73-97.

16. Ernst, David, and Andrew MJ Steinhubl. "Alliances in upstream oil and gas."*McKinsey Quarterly* (1997): 144-155.

17. Forrester, Jay. "W., 1958."Industrial Dynamics: A Major Breakthrough for Decision Makers."." *Harvard Business Review* 36, no. 4 (1958): 37-66.

18. Forrester, Jay Wright. *Industrial dynamics*. Vol. 2. Cambridge, MA: MIT press, 1961.

19. Geary, S., Stephen M. Disney, and Dennis R. Towill. "On bullwhip in supply chains—historical review, present practice and expected future impact." *International Journal of Production Economics 101*, no. 1 (2006): 2-18.

20. Ghali, Moheb A. "Seasonality, aggregation and the testing of the production smoothing hypothesis." *The American Economic Review* 77, no. 3 (1987): 464-469.

21. GPO. "eCFR — Code of Federal Regulations." U.S. Government Printing Office. http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&sid=71ac907fad82aecd72ed5415a51b0055&rgn=div5&view=text&node=13:1.0.1.1.17&idno=13#13:1.0.1.1.17.1.267.4. (accessed July 24, 2013).

22. Gray, Andrew, James Hay, Richard Marsh, and Alistair Punt. "Can SMEs survive crine." *Offshore Europe* (1995).

23. Hammond, Janice H. Barilla spa (a). *Harvard Business School*, 1994.

24. Williams, James L.. "History and Analysis -Crude Oil Prices." WTRG Economics. http://www.wtrg.com/prices.htm (accessed June 27, 2013).

25. Holt, Charles C., Franco Modigliani, and John P. Shelton. "The transmission of demand fluctuations through a distribution and production system, the TV-set industry." *The Canadian Journal of Economics/Revue canadienne d'Economique* 1, no. 4 (1968): 718-739.

26. Hope, John B., and Patrick C. Mackin. “The Relationship between Employee Turnover and Employee Compensation in Small Business.” *Small Business Research Summary* 308 (2007): 1-44.

27. Huang, Xiao-Yuan, Ni-Na Yan, and Hai-Feng Guo. "An H∞ control method of the bullwhip effect for a class of supply chain system." International journal of production research 45, no. 1 (2007): 207-226.

28. Jacoby, David. The oil price “bullwhip”: problem, cost, response. *Oil and Gas Journal* 108, no.11 (March 2010): 20-25.

29. Kalchschmidt, Matteo, Giulio Zotteri, and Roberto Verganti. "Inventory management in a multi-echelon spare parts supply chain." *International Journal of Production Economics* 81 (2003): 397-413.

30. Lee, Hau L., Venkata Padmanabhan, and Seungjin Whang. "Information distortion in a supply chain: the bullwhip effect." *Management Science* 43, no. 4 (1997a): 546-558.

31. Lee, Hau L., Venkata Padmanabhan, and Seungjin Whang. "The Bullwhip Effect in Supply Chains." *Sloan Management Review* 38, no. 3 (1997b): 93-102.

32. Mack, Ruth P. "The Process of Capital Formation in Inventories and the Vertical Propagation of Business Cycles." *The Review of Economics and Statistics* 35, no. 3 (1953): 181-198.

33. Mentzer, John T., William DeWitt, James S. Keebler, Soonhong Min, Nancy W. Nix, Carlo D. Smith, and Zach G. Zacharia. "Defining supply chain management." *Journal of Business Logistics* 22, no. 2 (2011): 1-25.

34. Miron, Jeffrey A., and Stephen P. Zeldes. "Seasonality, cost shocks, and the production smoothing model of inventories." *Econometrica: Journal of the Econometric Society* (1988): 877-908.

35. Mitchell, Thomas Warner. "Competitive illusion as a cause of business cycles." *The Quarterly Journal of Economics* 38, no. 4 (1924): 631-652.

36. Shizheng, Guo, Lu Zhen, and Huang Xiaoyuan. "Stochastic Control of Bullwhip Effect in Supply Chain." *In Service Systems and Service Management, 2006 International Conference on*, vol. 2, pp. 1455-1459. IEEE, 2006.

37. Simchi-Levi, David, Philip Kaminsky, and Edith Simchi-Levi. *Designing and managing the supply chain: concepts, strategies, and case studies*. Boston: Irwin/McGraw-Hill, 2000.

38. EconMatters. "The Seasonality of Crude Oil & Gasoline (Guest Post) | EconMatters." EconMatters.com. http://www.econmatters.com/2011/04/seasonality-of-crude-oil-gasoline-guest.html. (accessed May 27, 2013).

39. Terwiesch, Christian, Z. Justin Ren, Teck H. Ho, and Morris A. Cohen. "An empirical analysis of forecast sharing in the semiconductor equipment supply chain." *Management Science* 51, no. 2 (2005): 208-220.

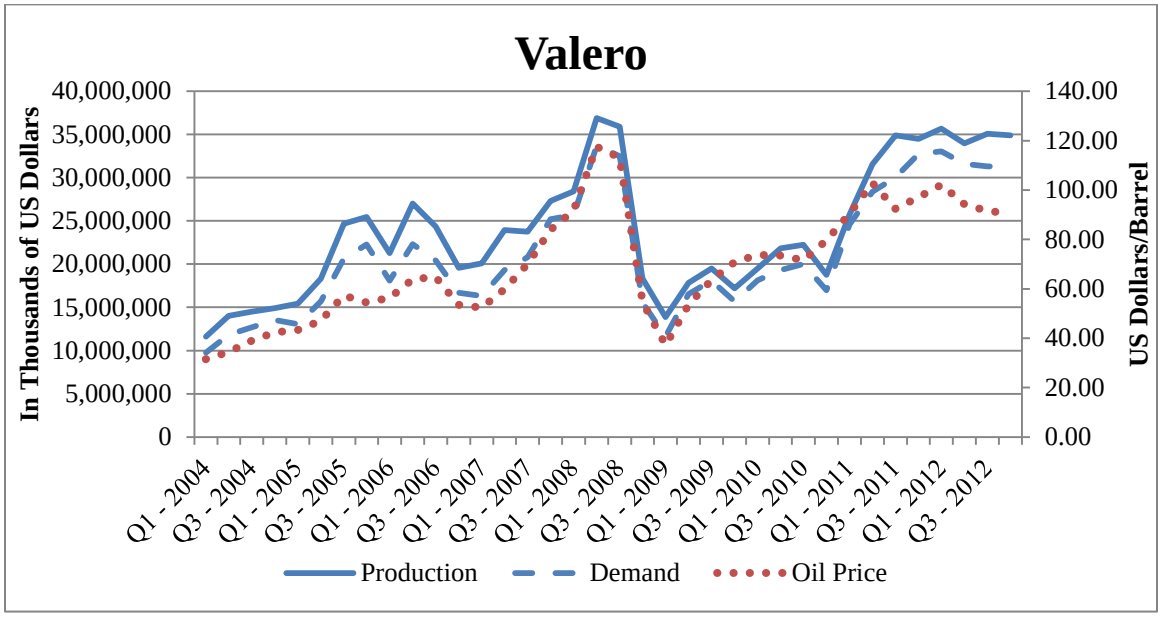
40. Ward, Michael Paul. "Optimal production and inventory decisions: an analysis of firm and industry behavior." PhD diss., University of Chicago, 1978.

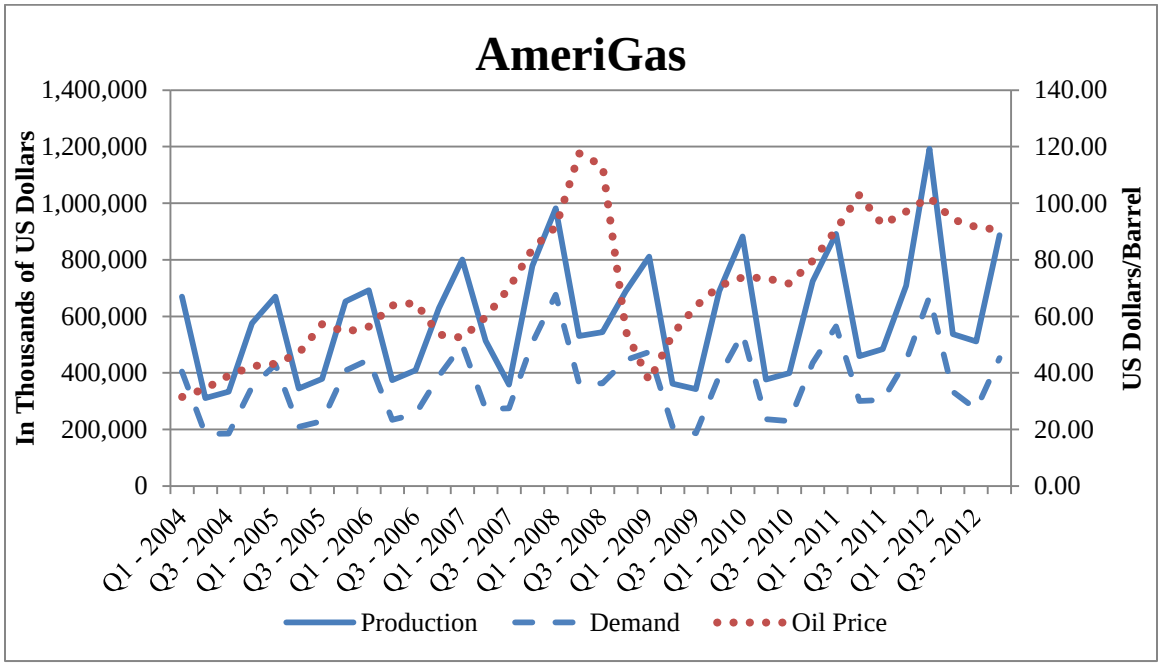
41. Zhang, Jihai, and Quanquan Zhang. "The System Dynamic Analyses of Bullwhip Effect in China Processed Oil Supply Chain." *Applied Mechanics and Materials* 295-298 (2013): 3310-3317.

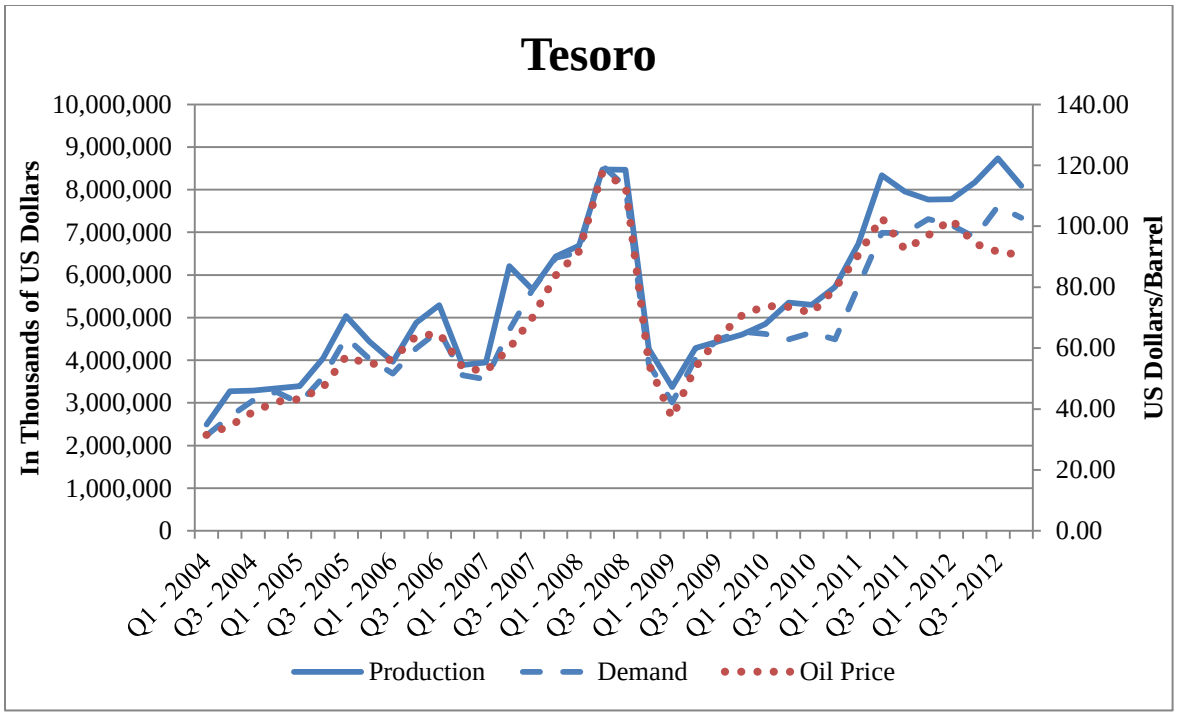
42. Zymelman, Manuel. "A stabilization policy for the cotton textile cycle." *Management Science* (1965): 572-580.

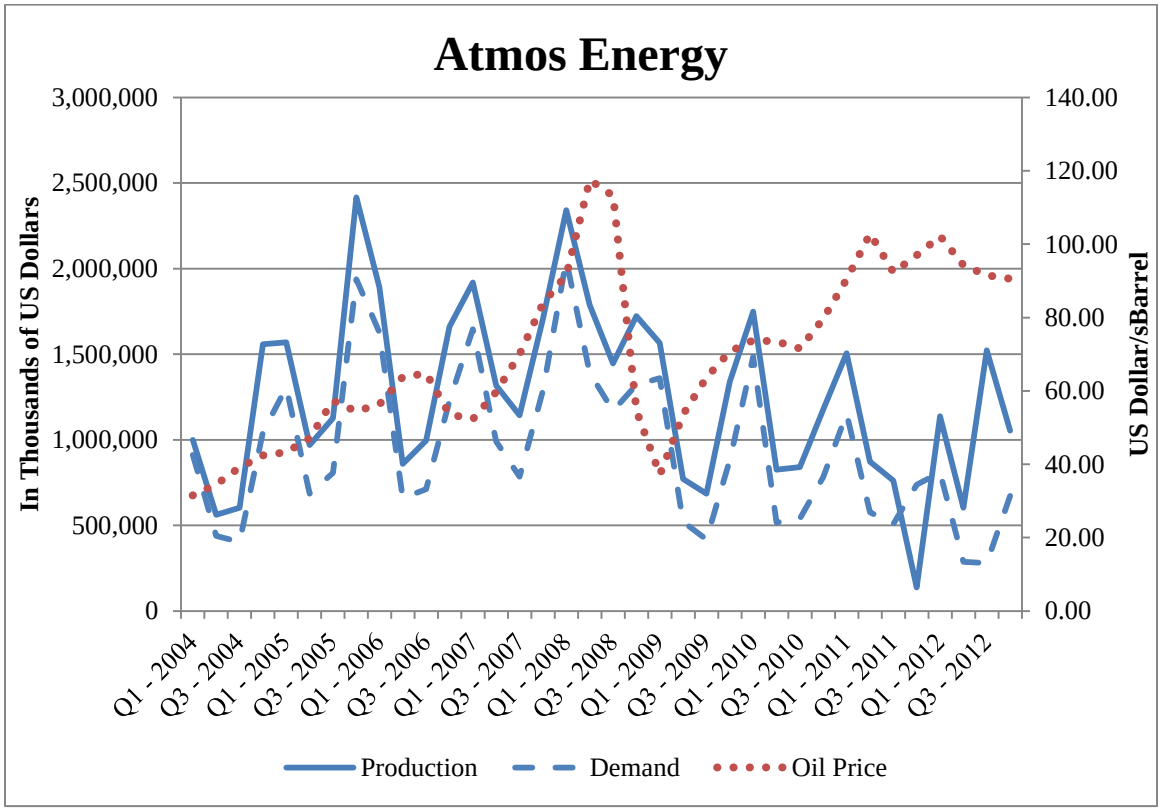
APPENDICES

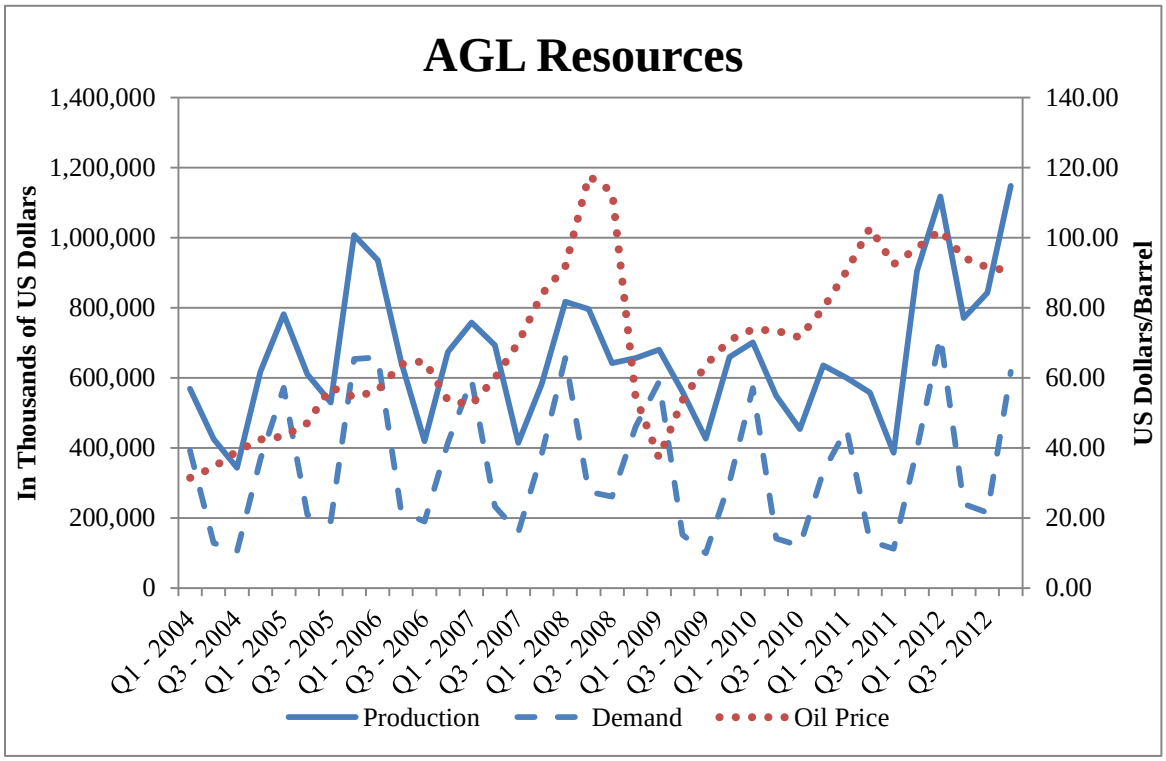
Appendix 1. Plotted Production and Demand Graphs of Each Company in the Downstream Level

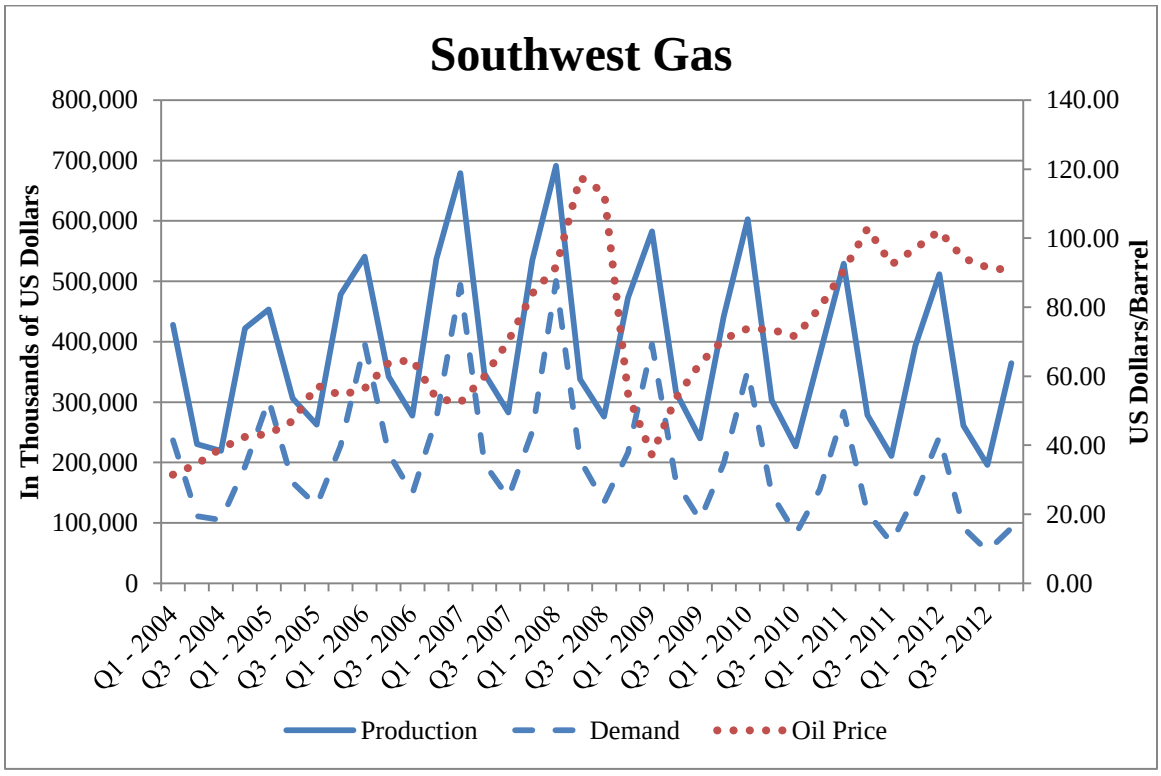


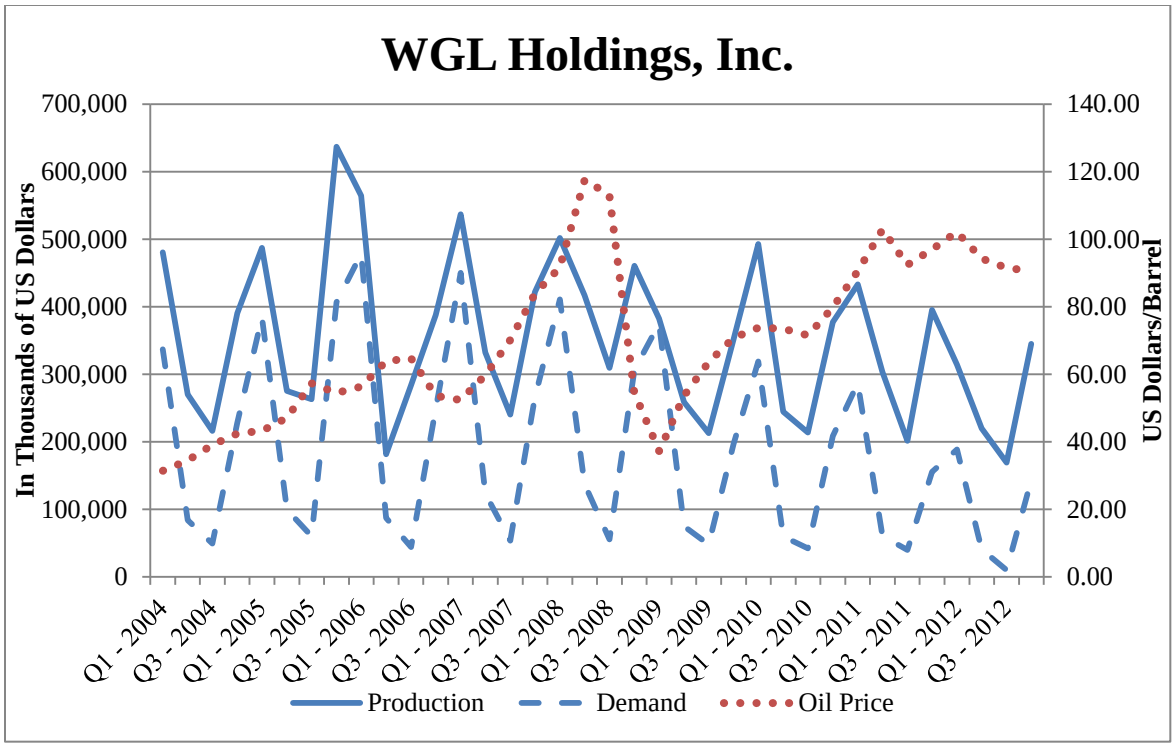


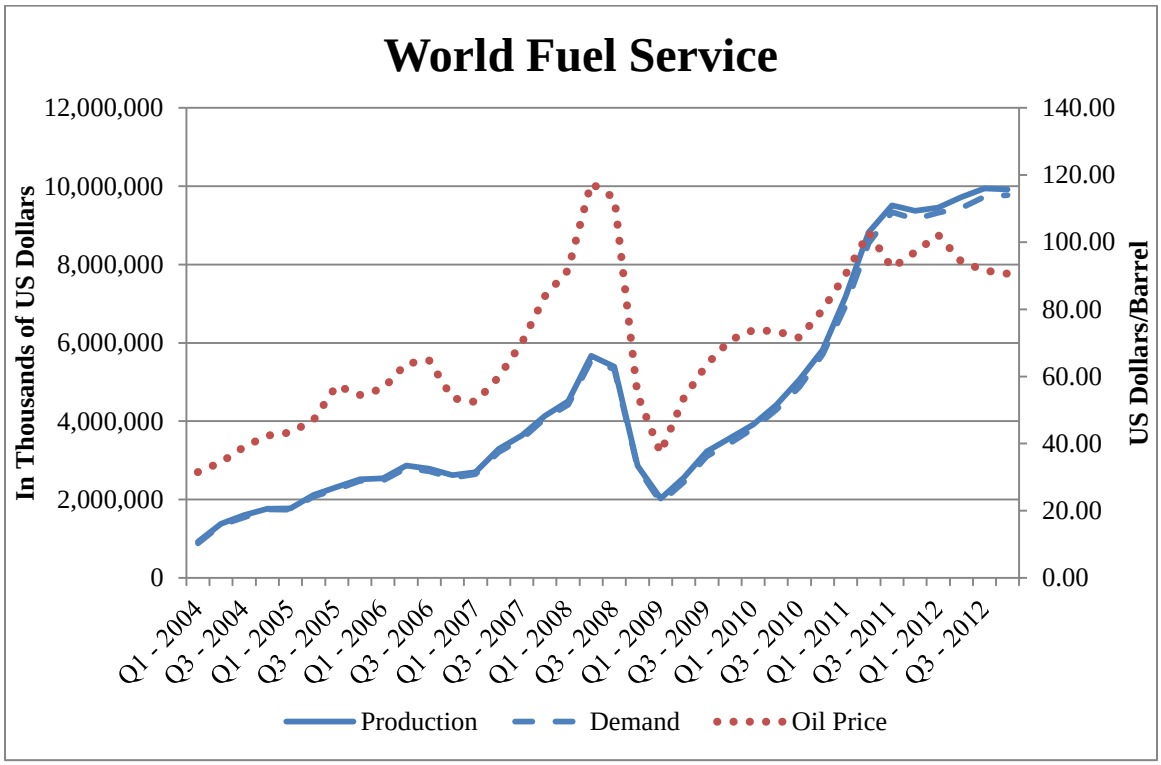

Tesoro
In Thousands of US Dollars
US Dollars/Barrel
10,000,000
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

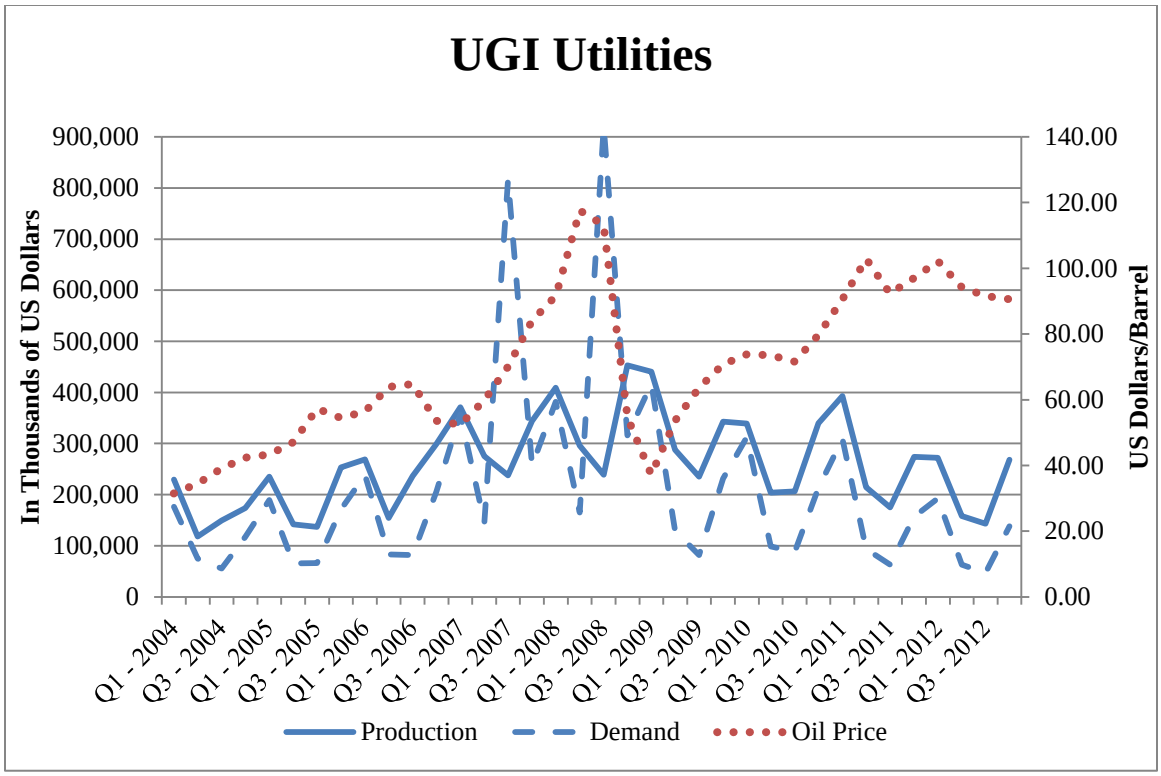

Atmos Energy
In Thousands of US Dollars
US Dollar/sBarrel
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

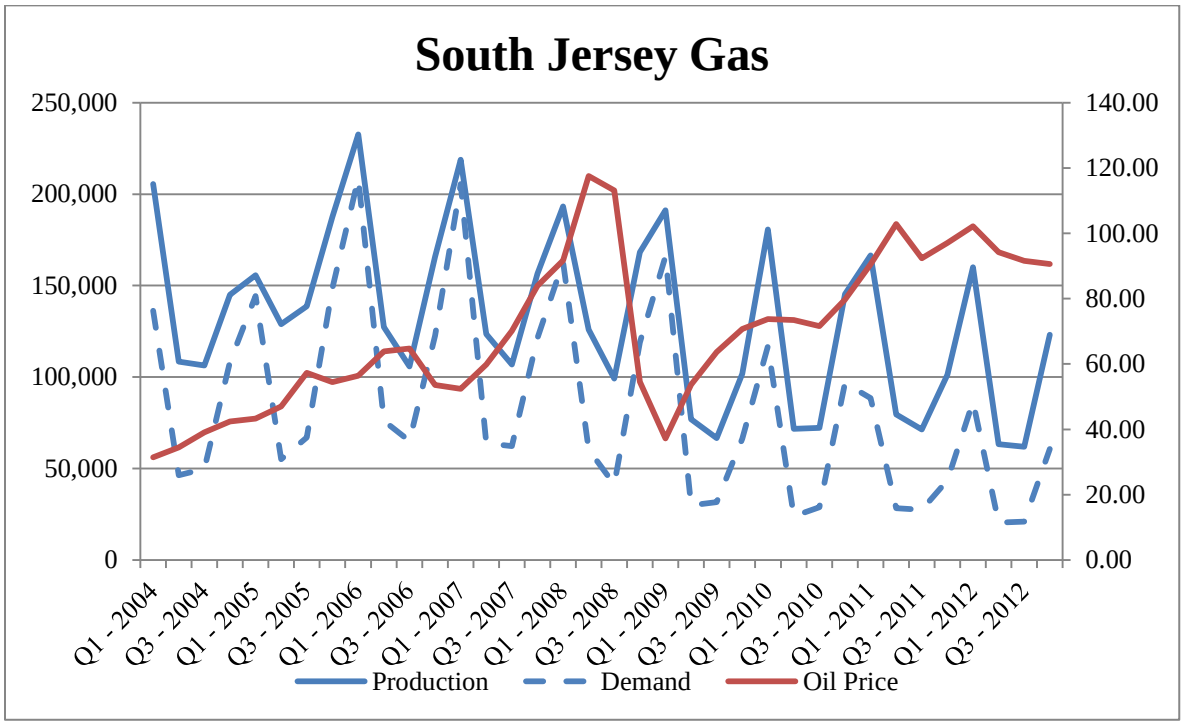

AGL Resources
In Thousands of US Dollars
US Dollars/Barrel
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

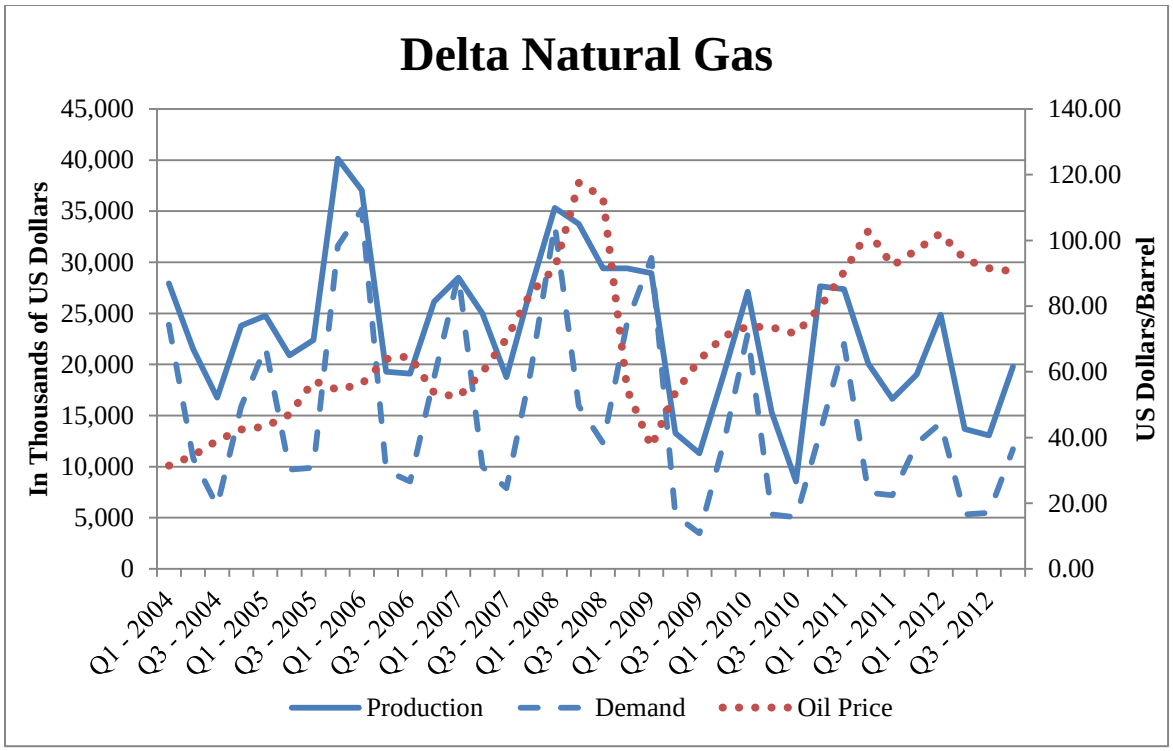

Southwest Gas
In Thousands of US Dollars
US Dollars/Barrel
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price


WGL Holdings, Inc.
In Thousands of US Dollars
US Dollars/Barrel
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

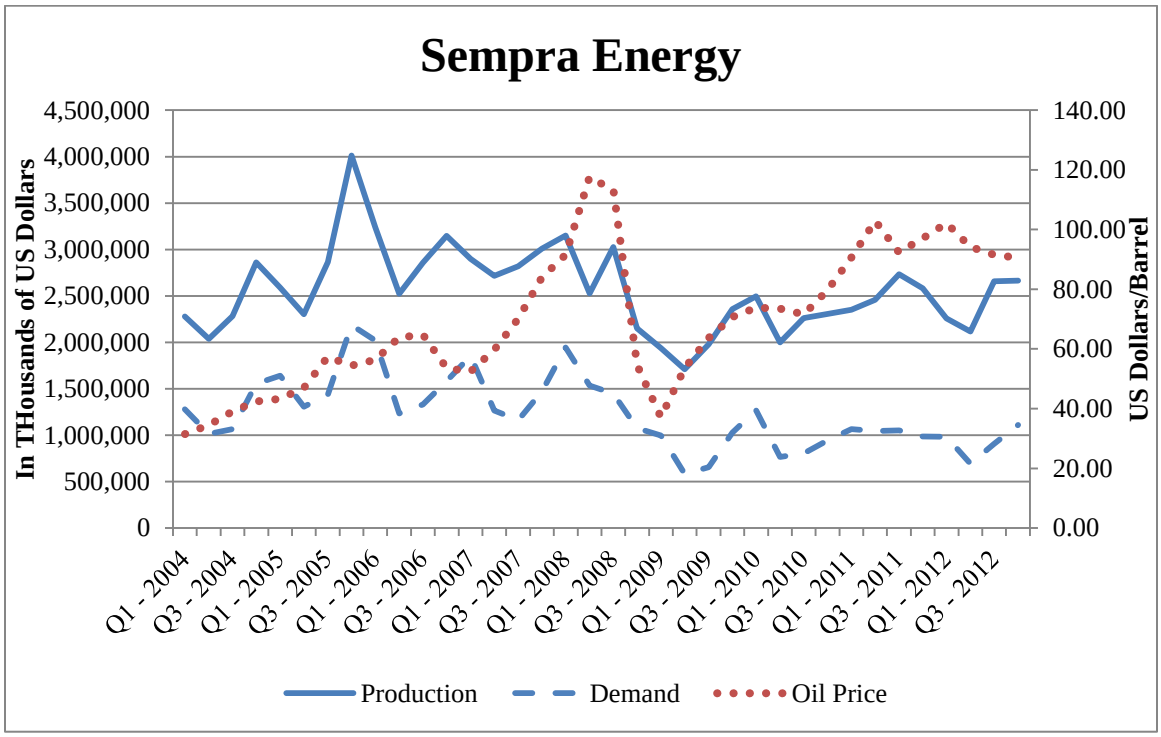

World Fuel Service
In Thousands of US Dollars
US Dollars/Barrel
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

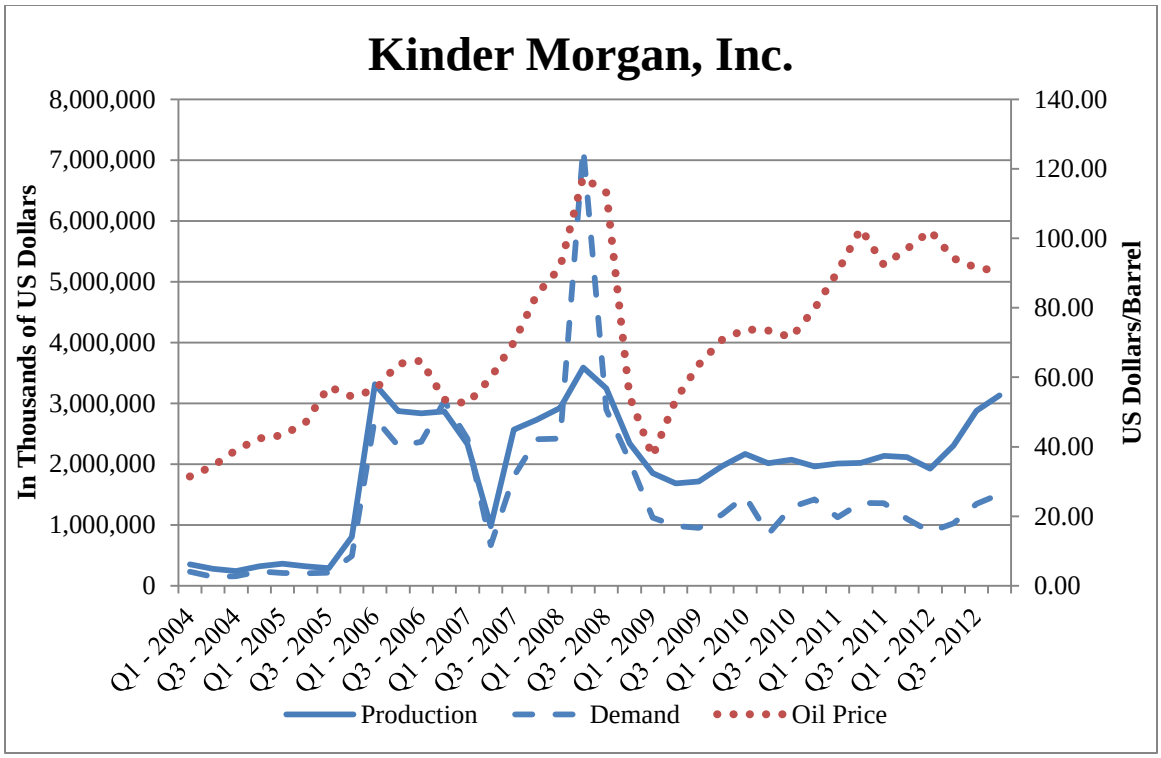

UGI Utilities
In Thousands of US Dollars
US Dollars/Barrel
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

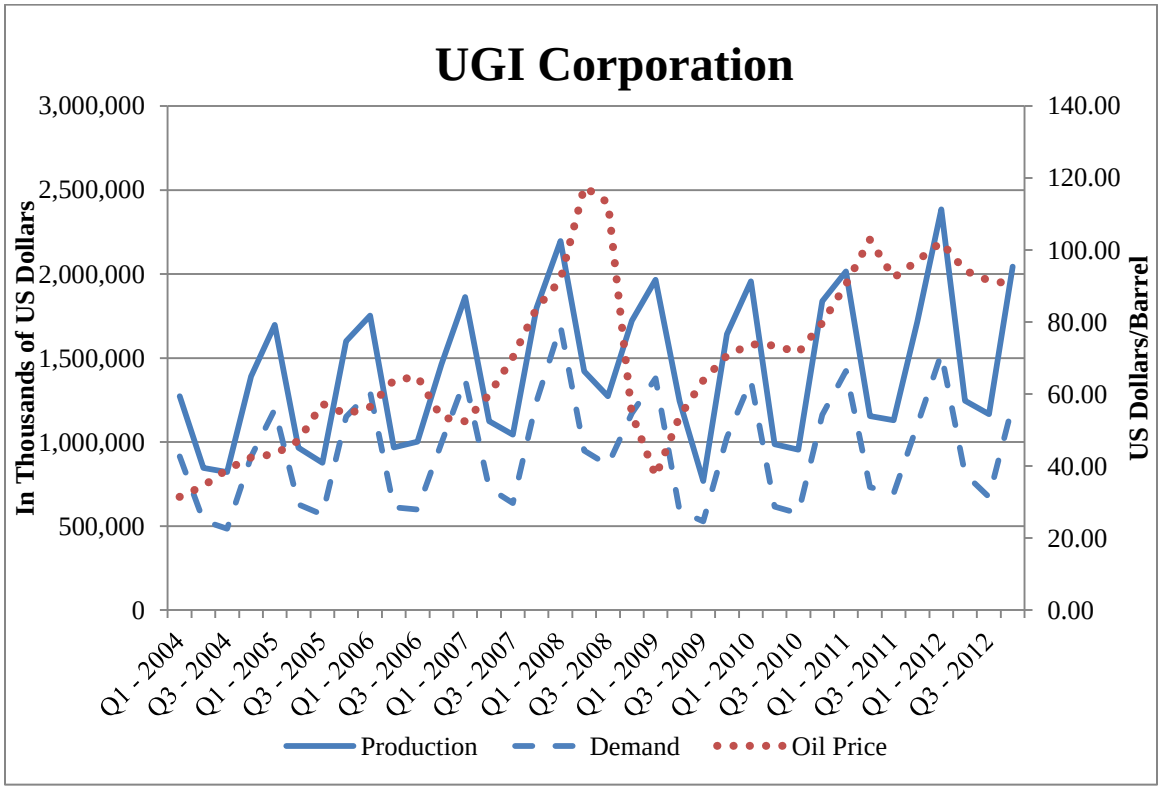

South Jersey Gas
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

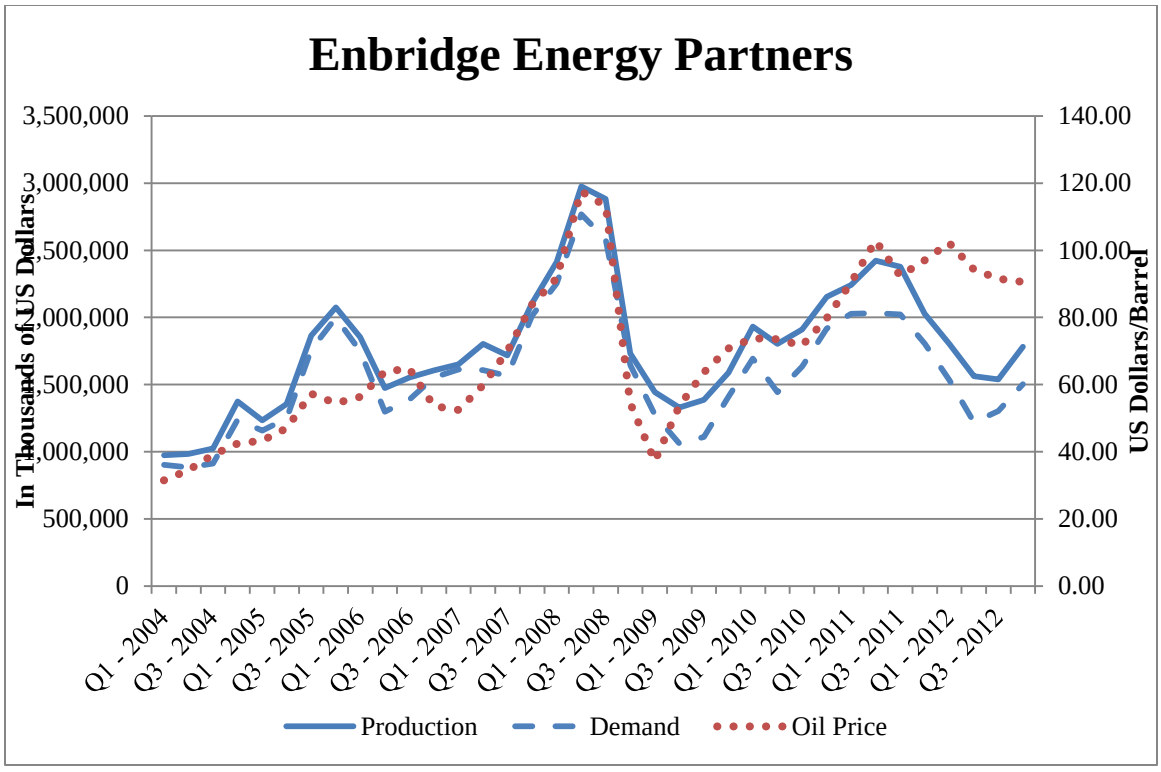


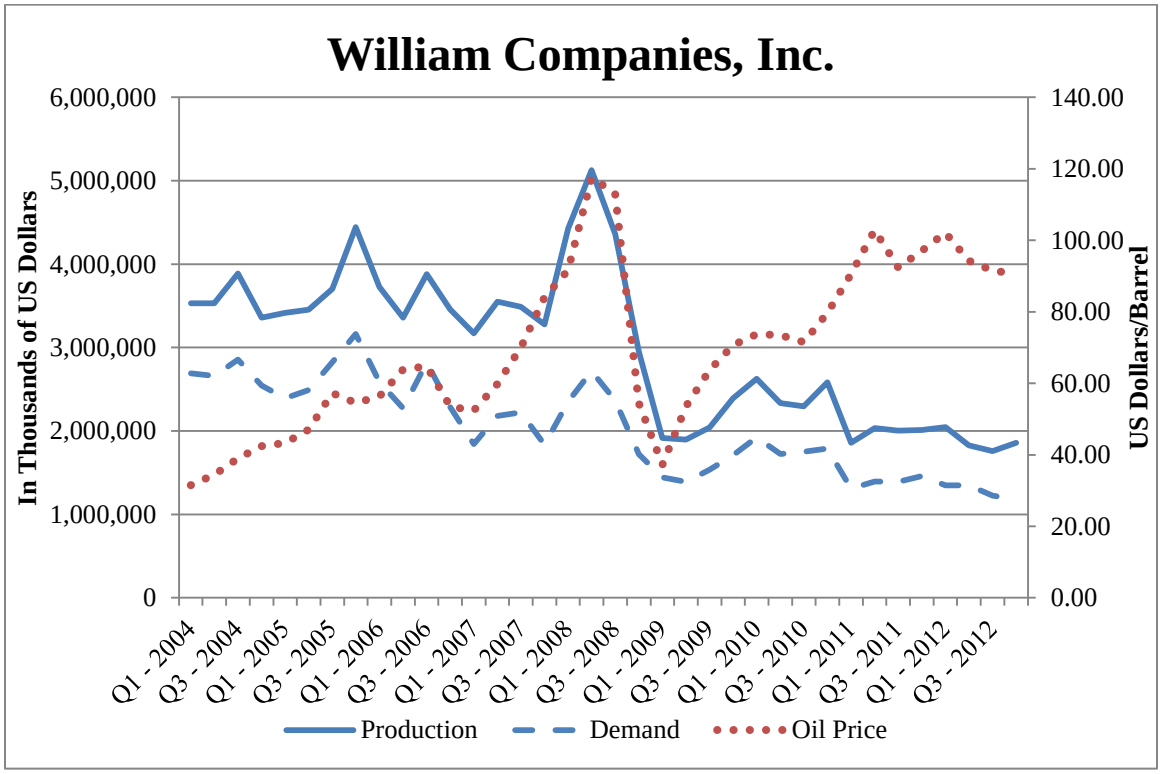
Appendix 2. Plotted Production and Demand Graphs of Each Company in the Midstream Level

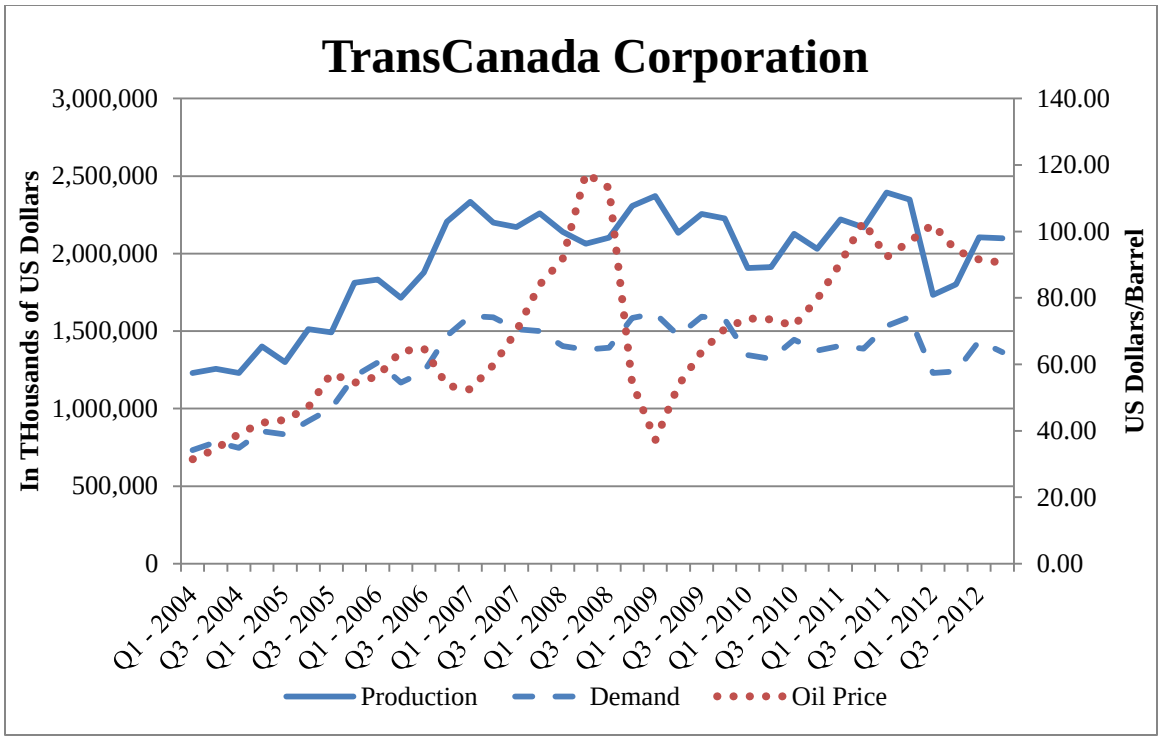


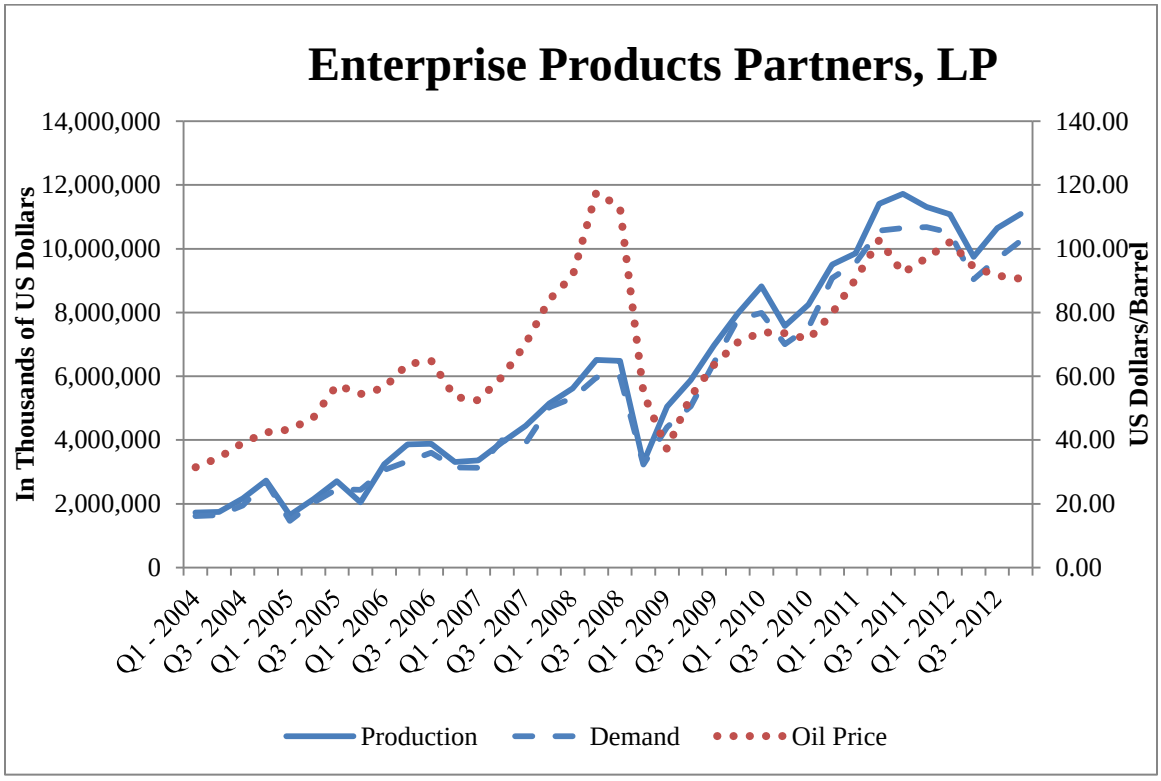

Kinder Morgan, Inc.
In Thousands of US Dollars
US Dollars/Barrel
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

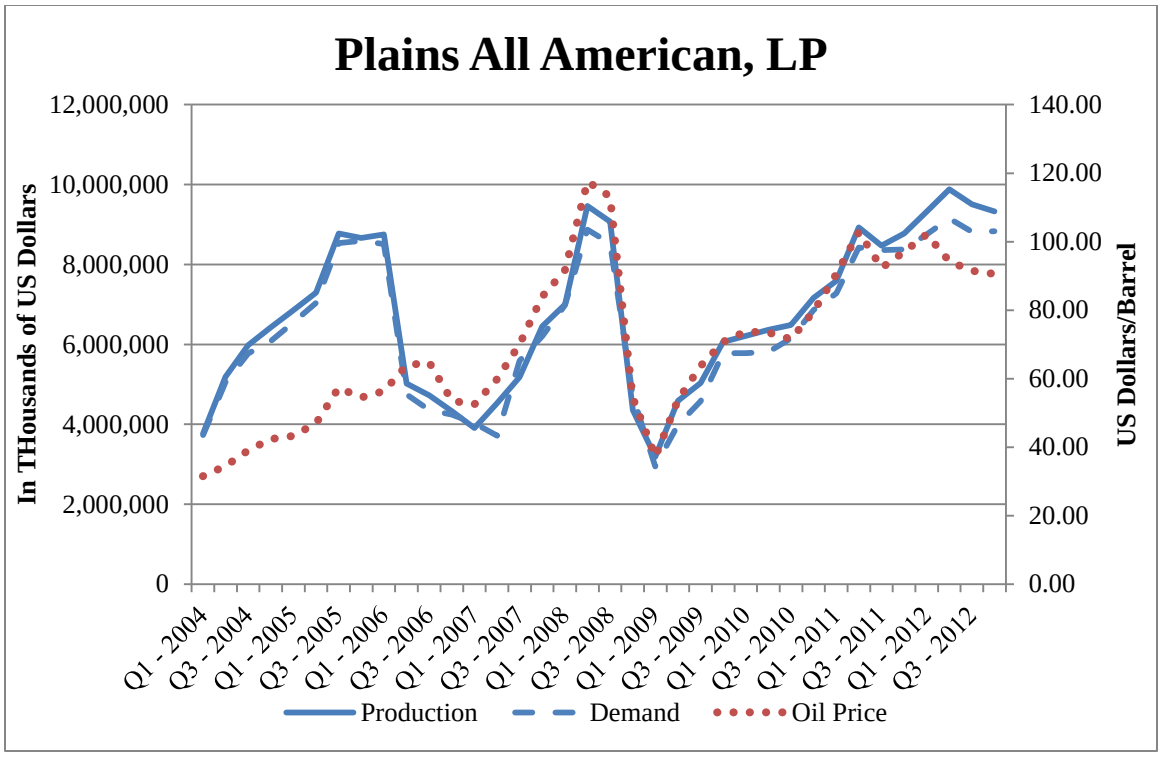

UGI Corporation
In Thousands of US Dollars
US Dollars/Barrel
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

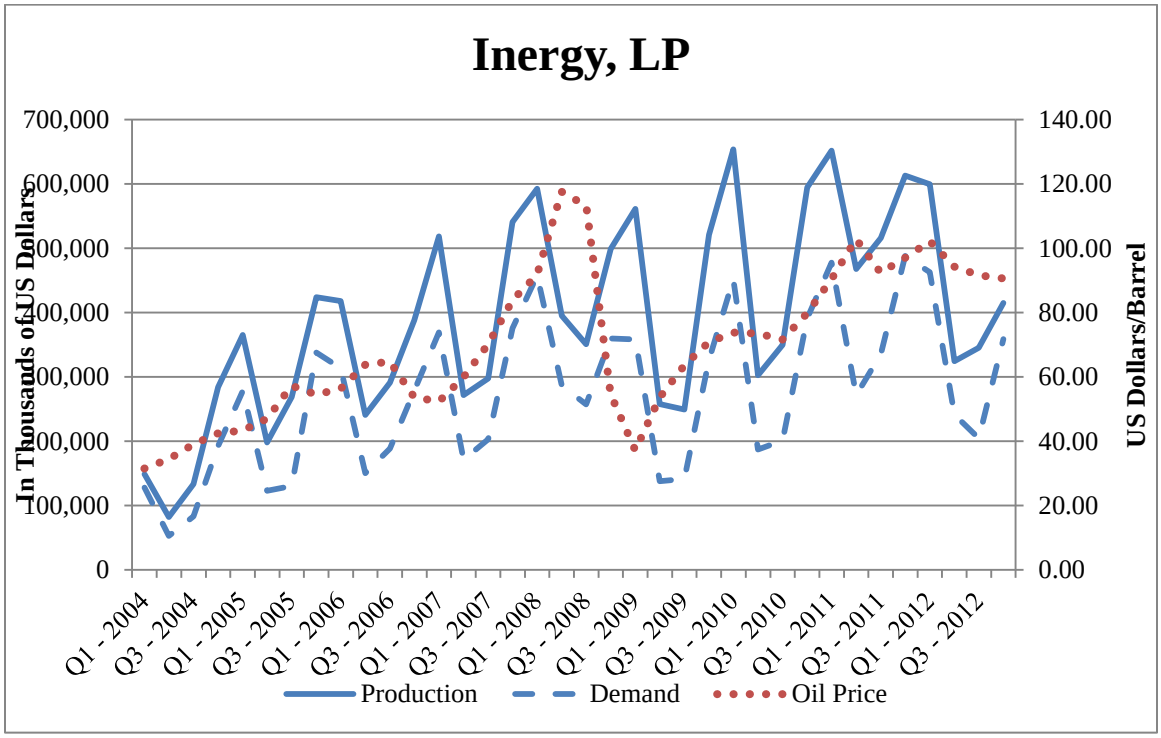

Enbridge Energy Partners
In Thousands of US Dollars
US Dollars/Barrel
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

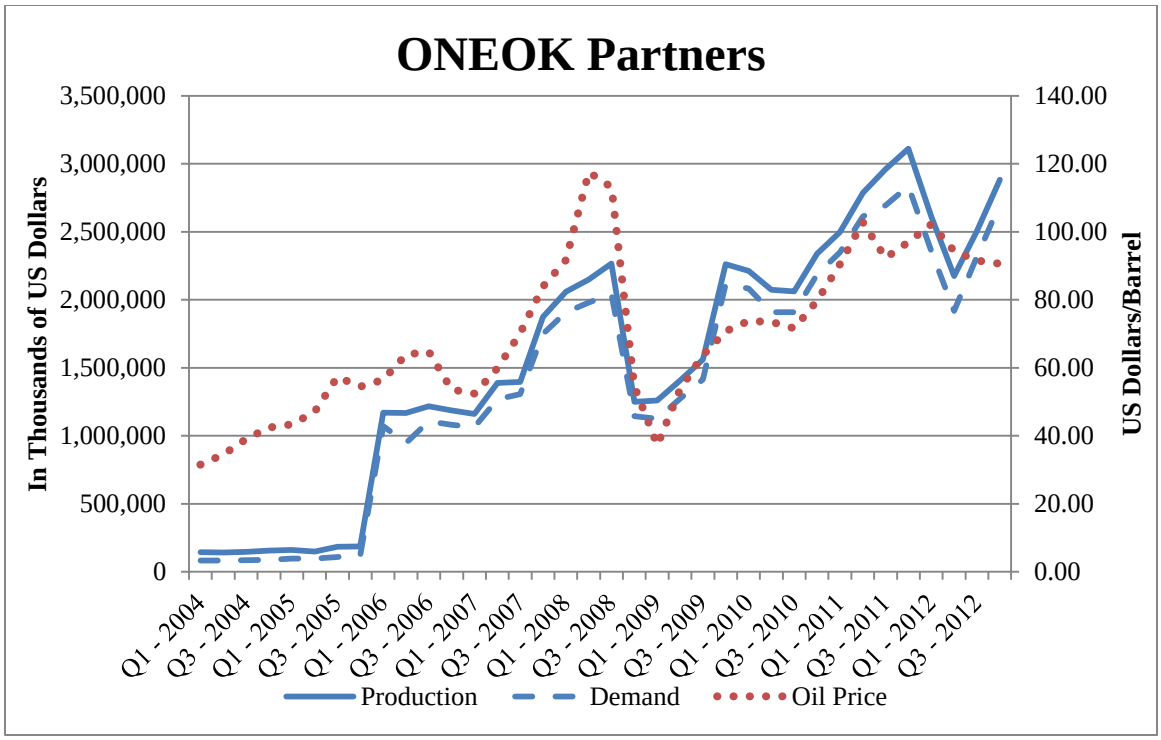

William Companies, Inc.
In Thousands of US Dollars
US Dollars/Barrel
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

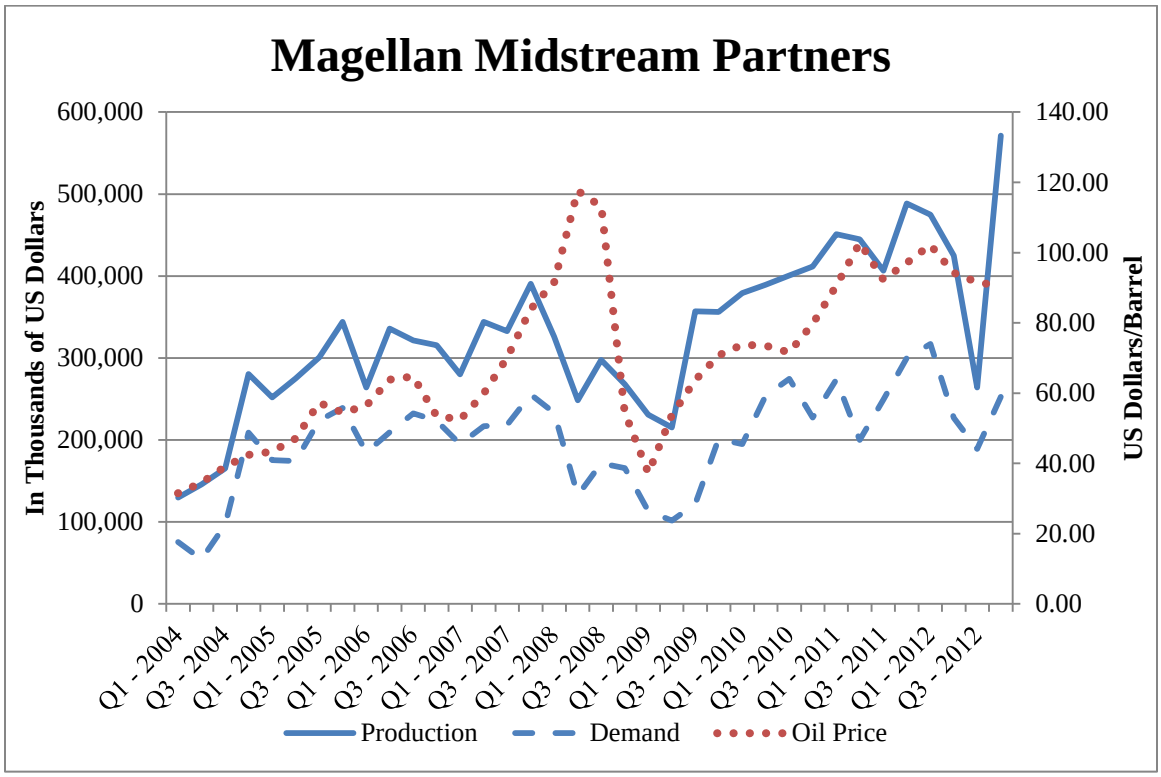

TransCanada Corporation
In THousands of US Dollars
US Dollars/Barrel
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

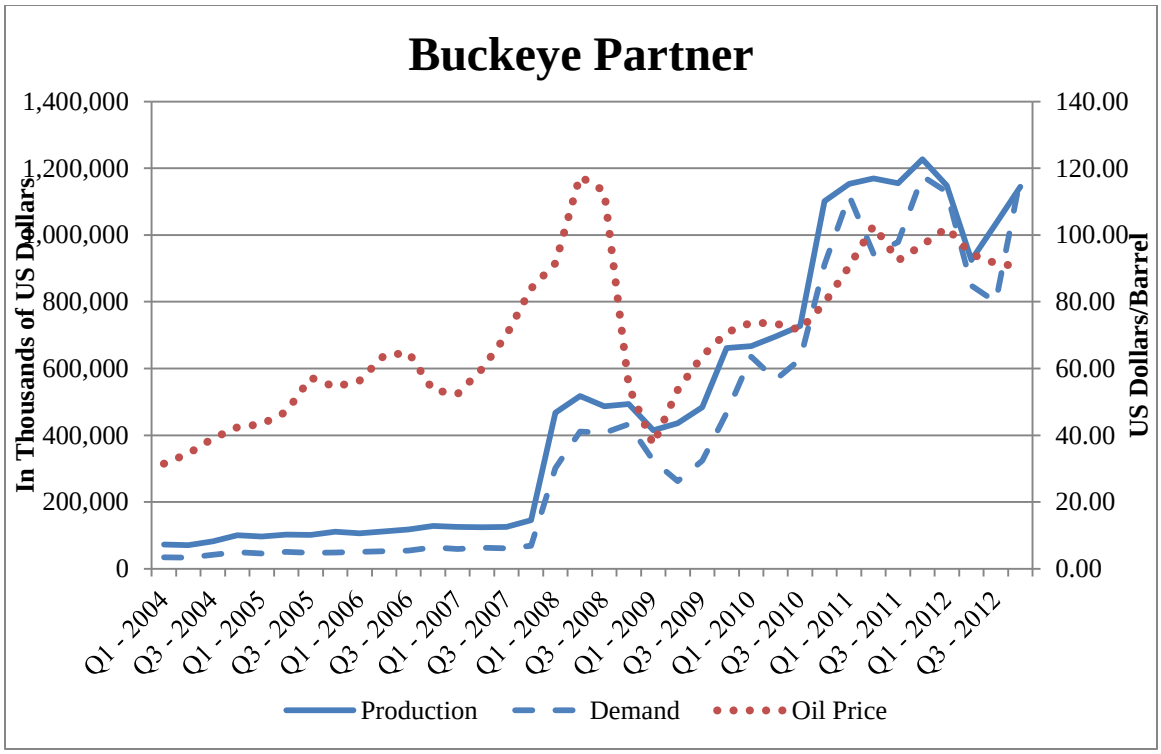

Enterprise Products Partners, LP
In Thousands of US Dollars
US Dollars/Barrel
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

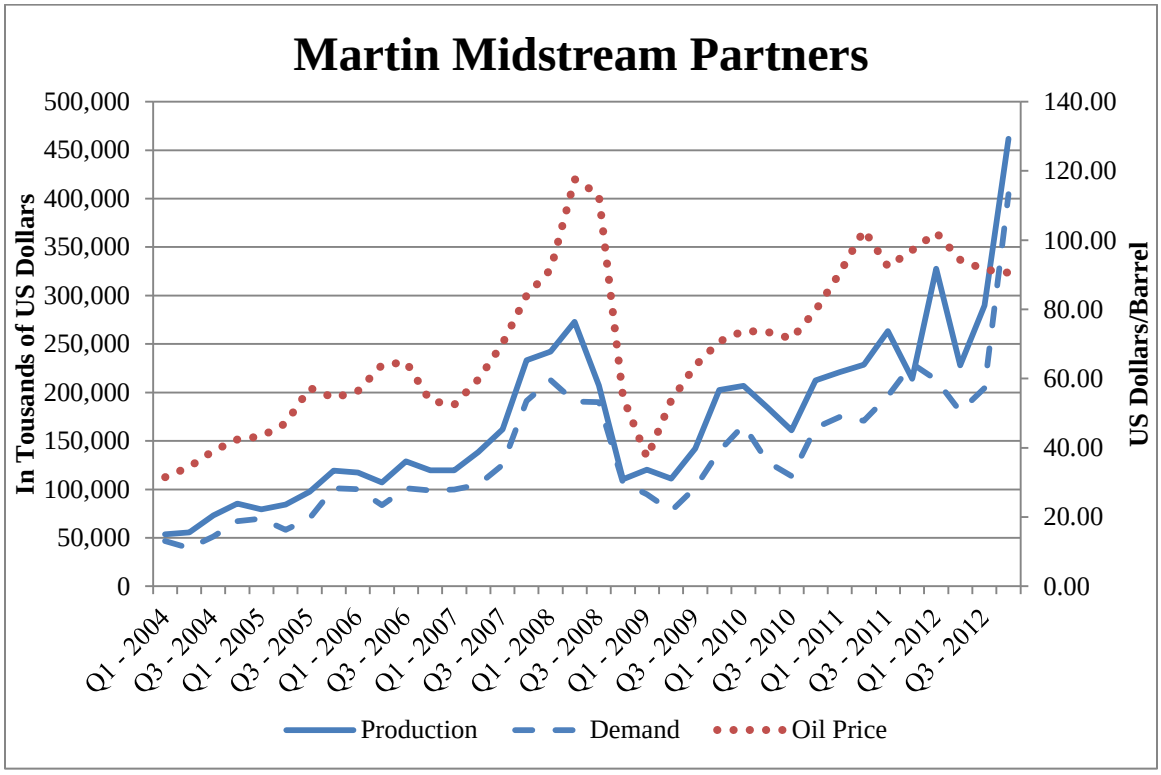

Plains All American, LP
In THousands of US Dollars
US Dollars/Barrel
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

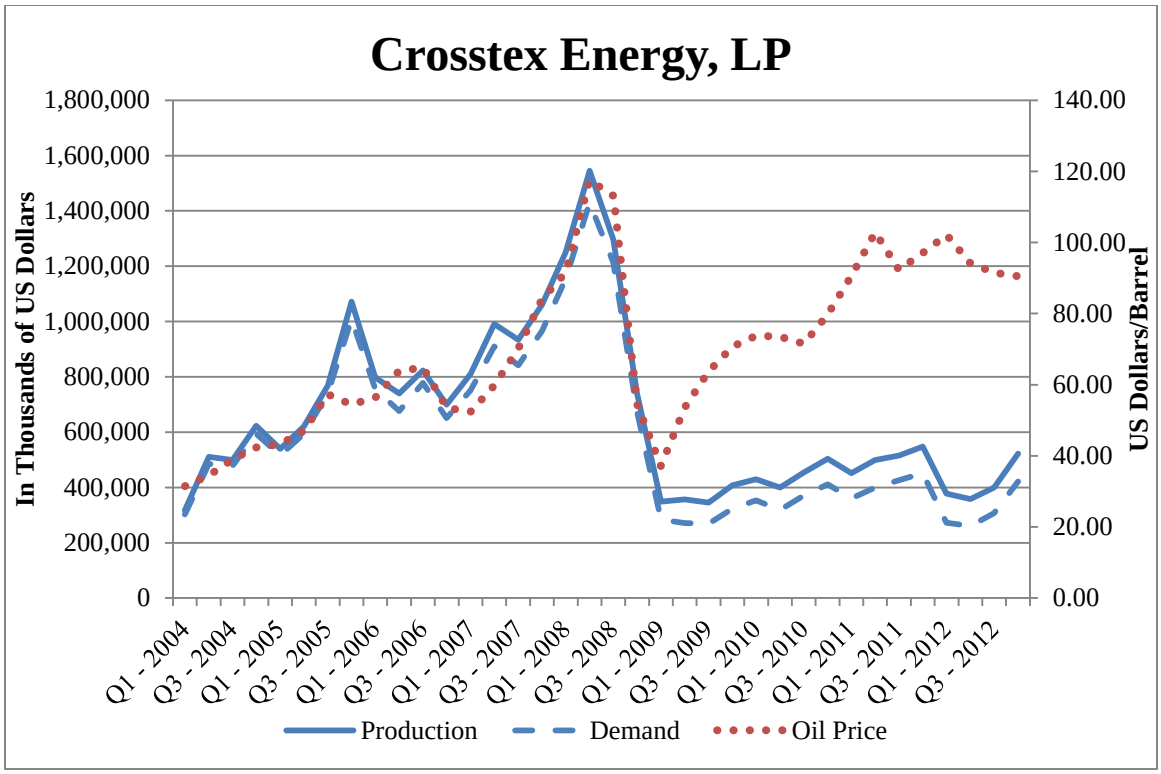

Inergy, LP
In Thousands of US Dollars
US Dollars/Barrel
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

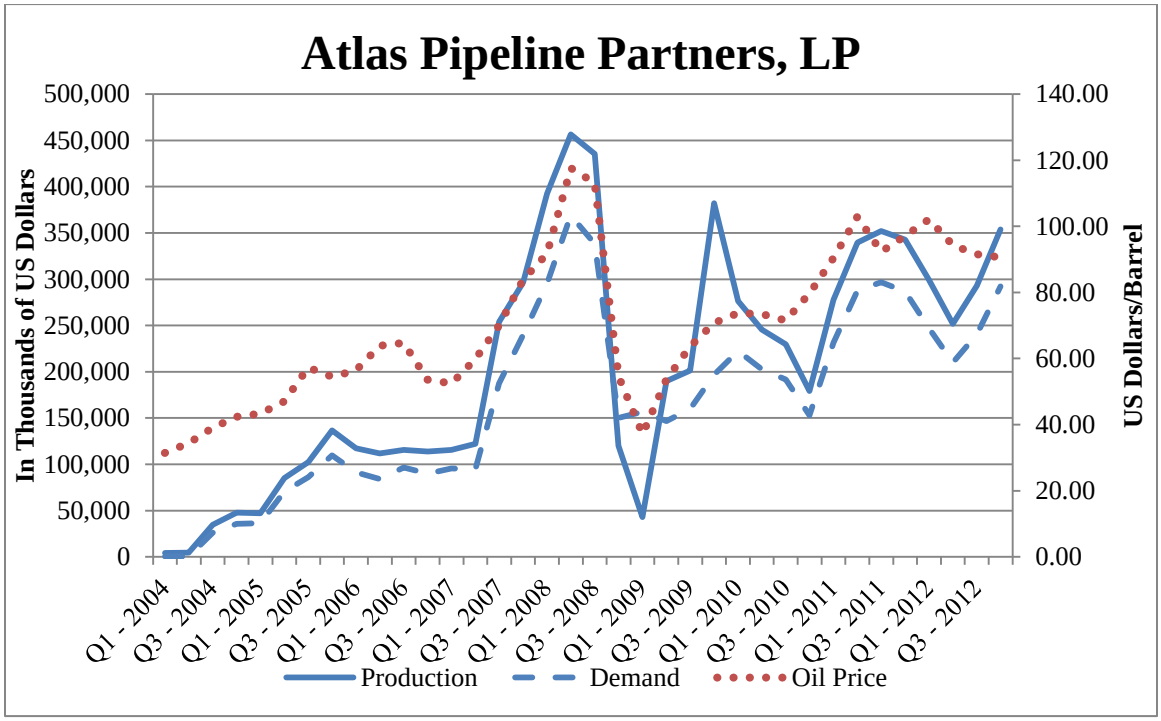

ONEOK Partners
In Thousands of US Dollars
US Dollars/Barrel
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

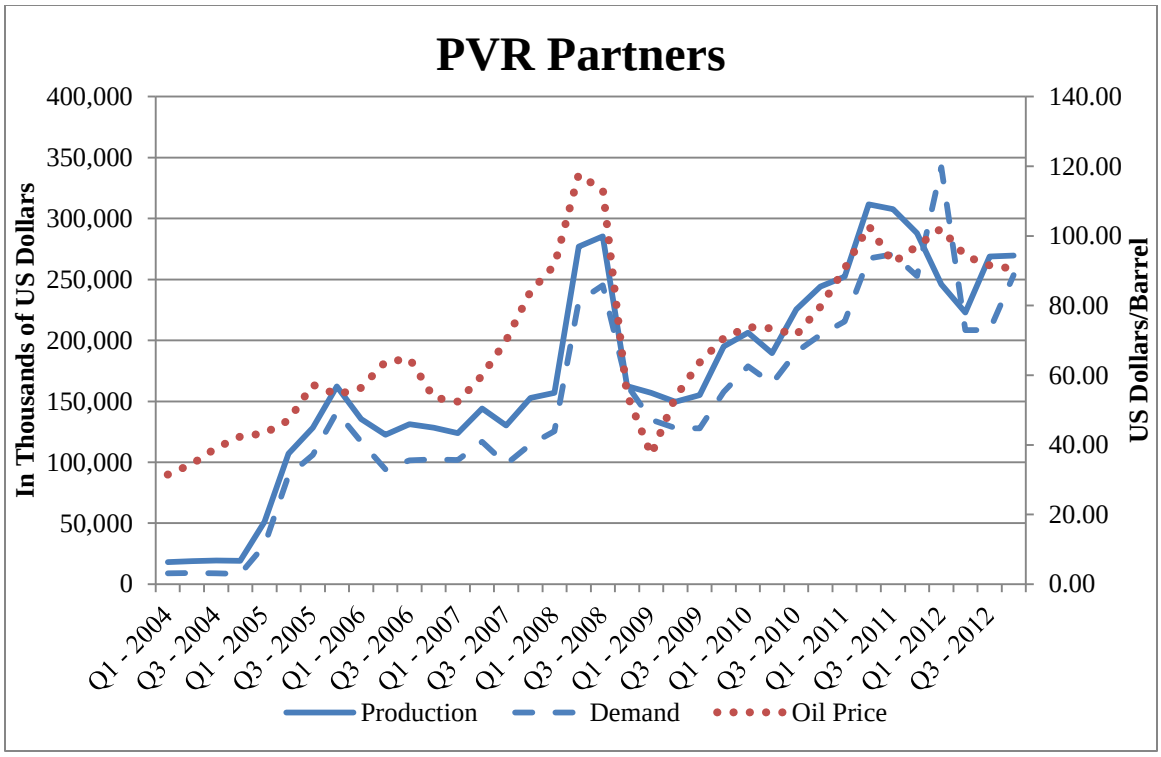

Magellan Midstream Partners
In Thousands of US Dollars
US Dollars/Barrel
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price


Buckeye Partner
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
In Thousands of US Dollars
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
US Dollars/Barrel
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

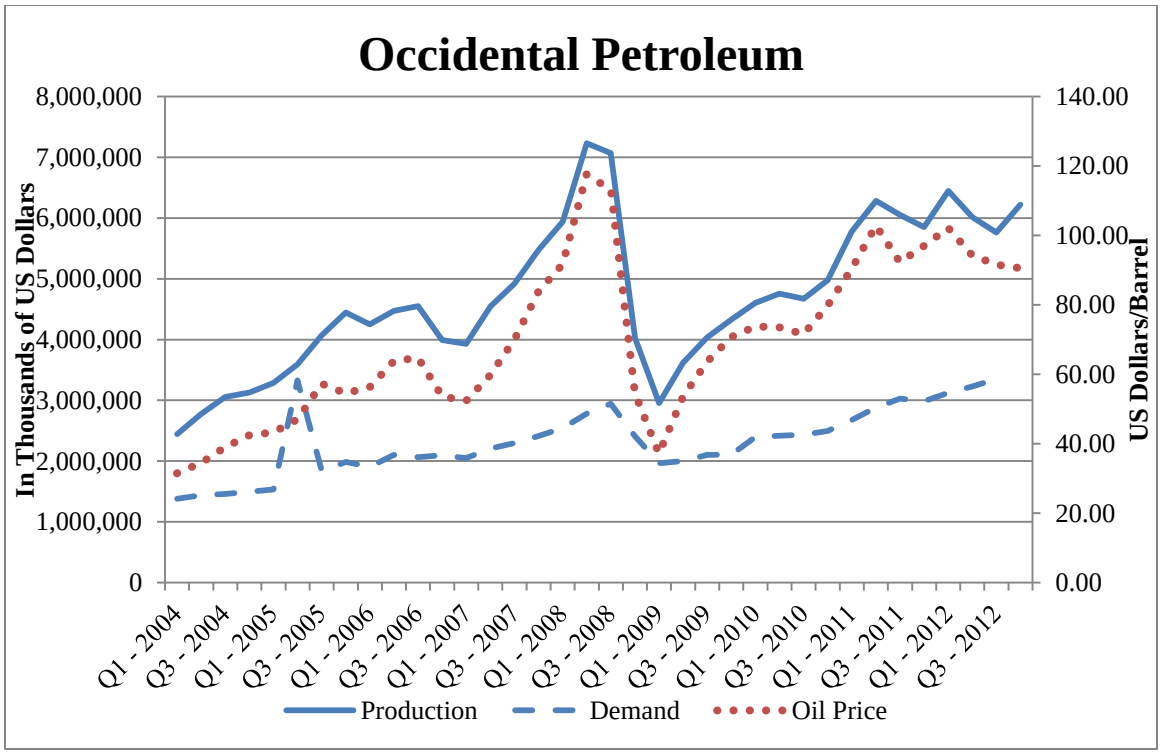

Martin Midstream Partners
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
In Tousands of US Dollars
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
US Dollars/Barrel
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

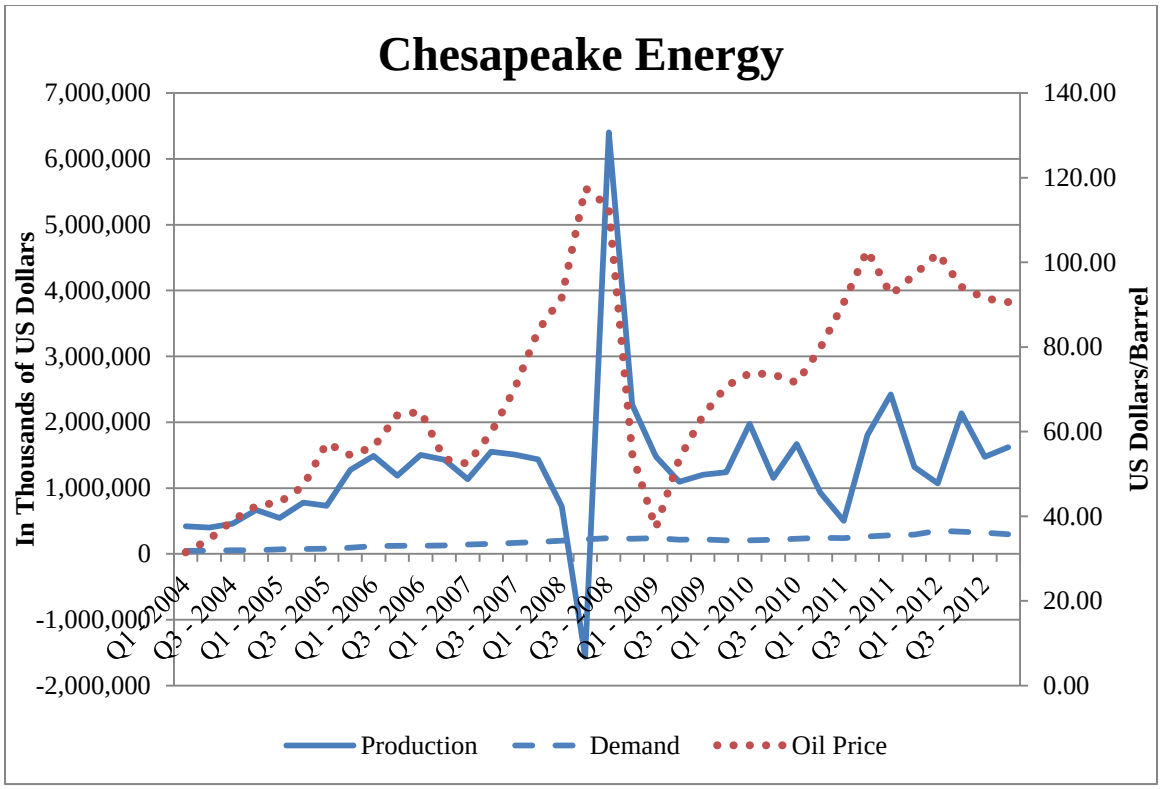

Crosstex Energy, LP
In Thousands of US Dollars
US Dollars/Barrel
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

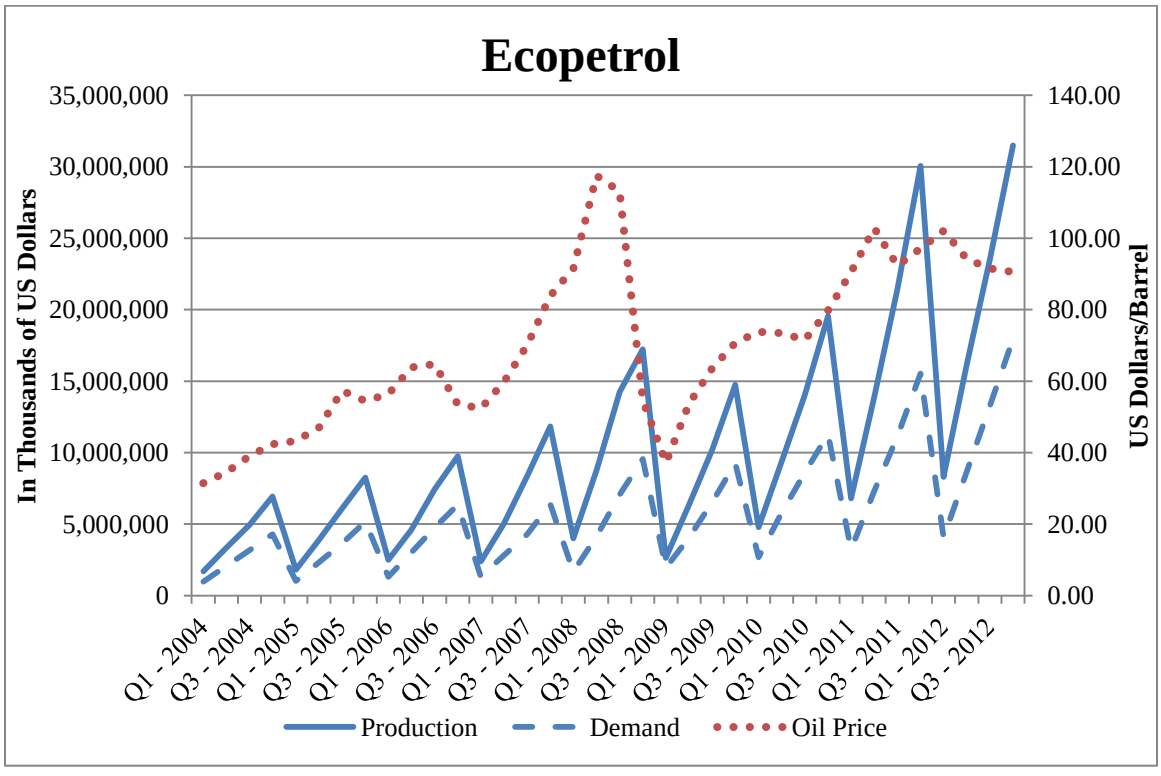

Atlas Pipeline Partners, LP
In Thousands of US Dollars
US Dollars/Barrel
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

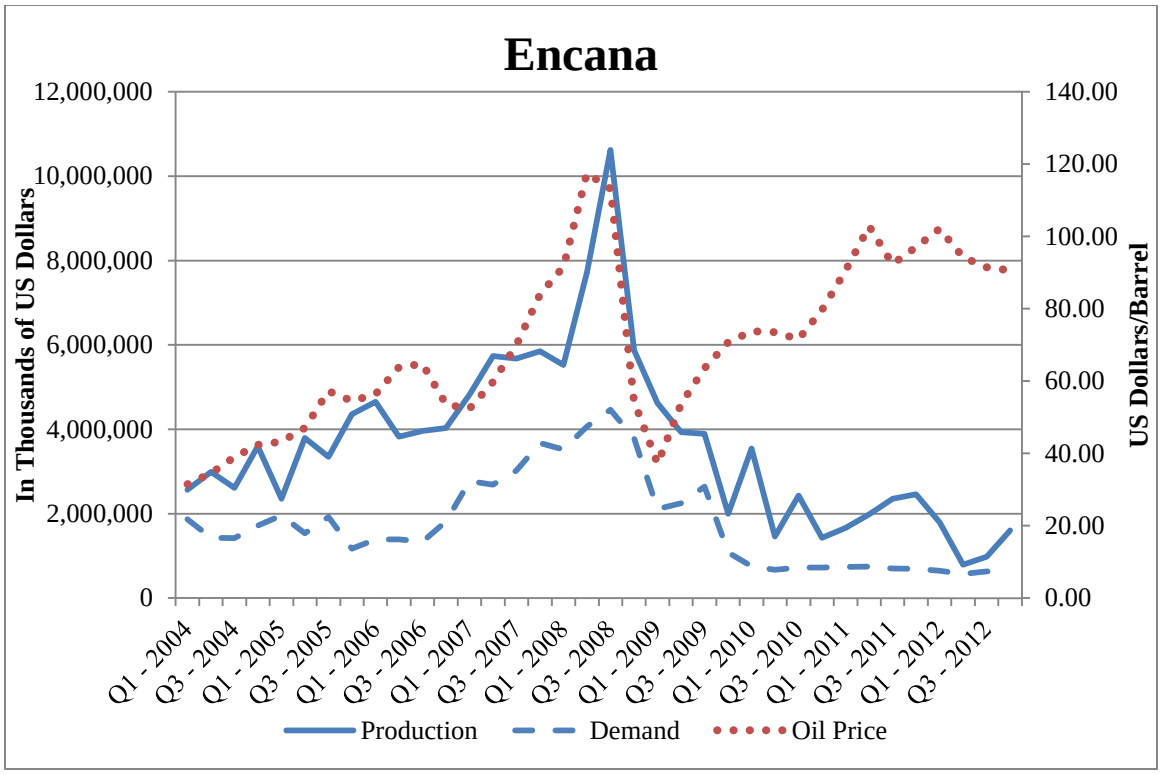


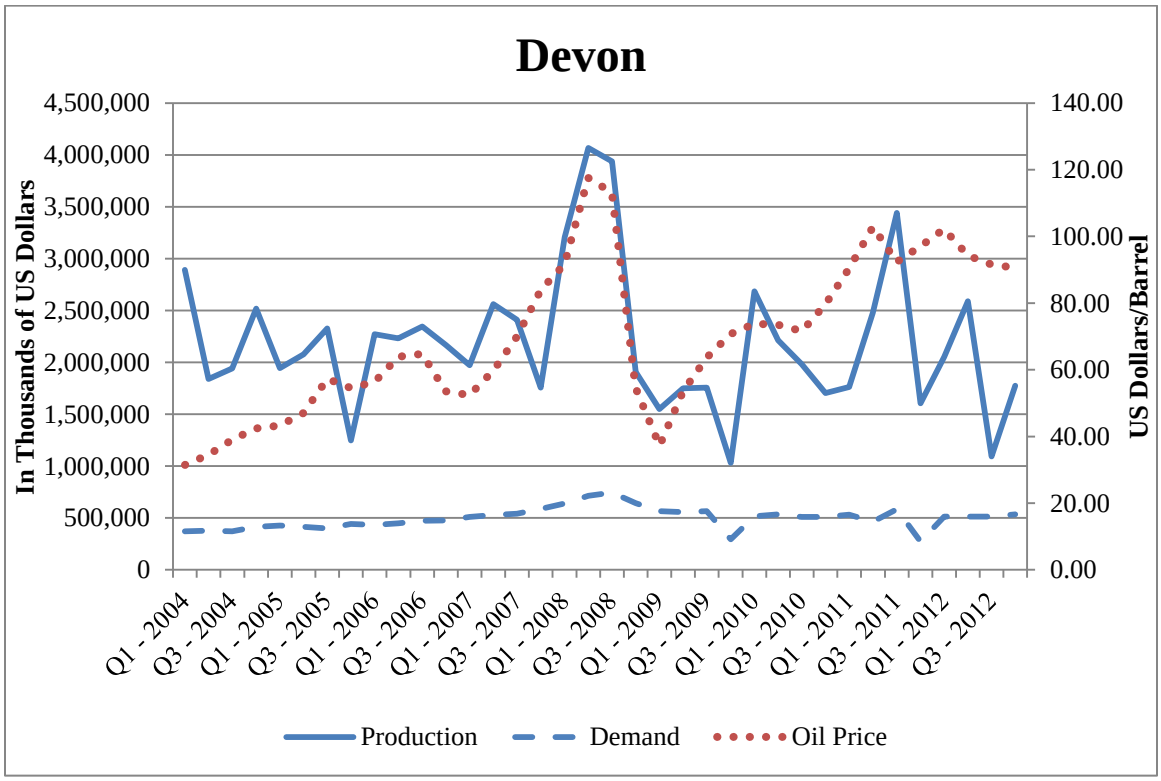
Appendix 3. Plotted Production and Demand Graphs of Each Company in the Upstream Level

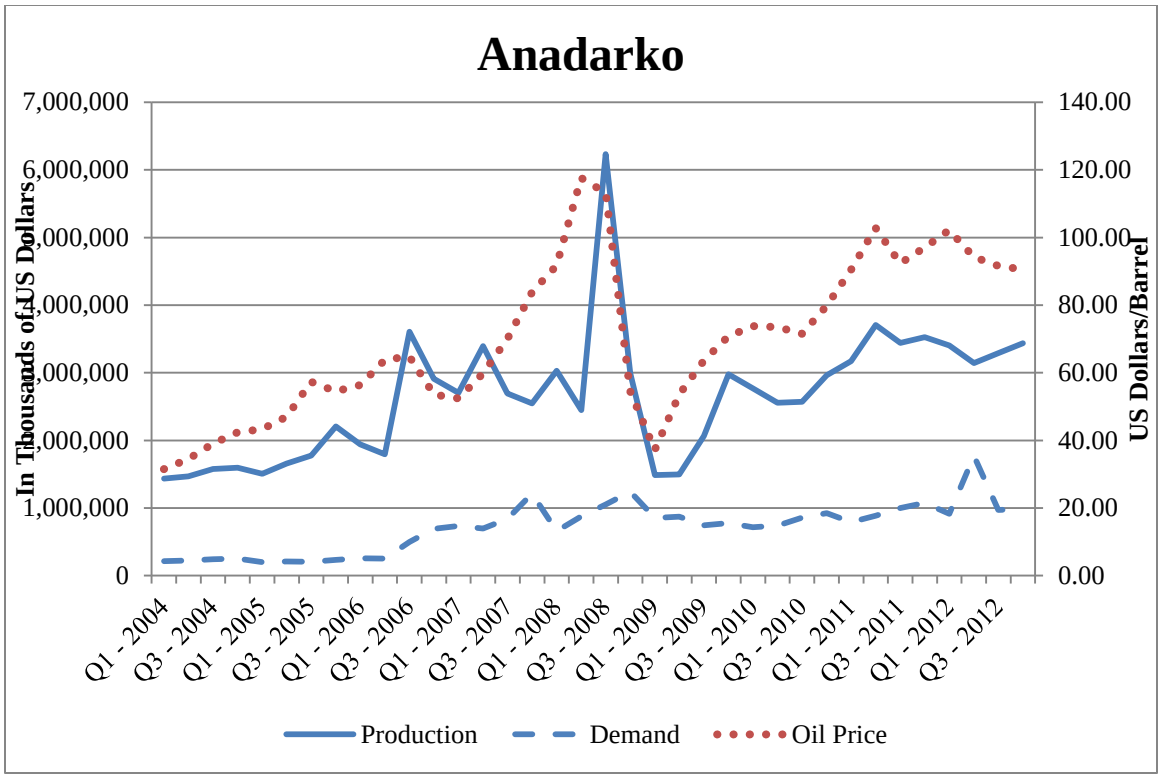


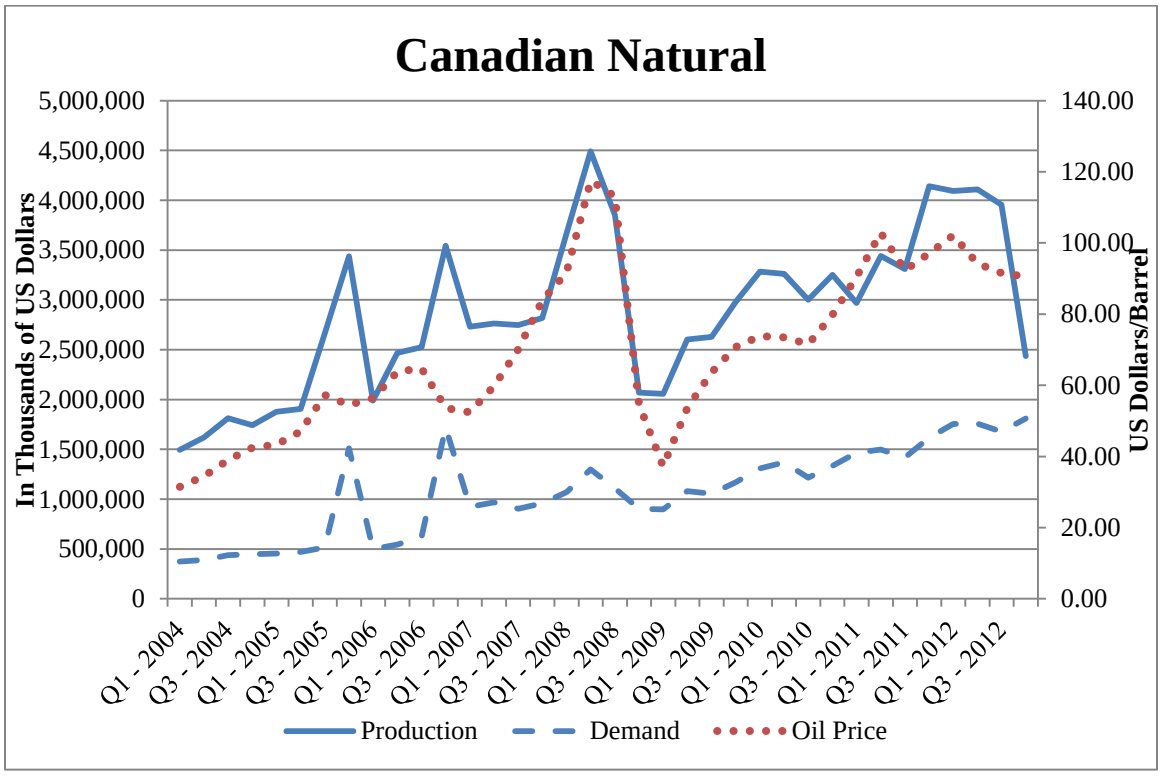

Chesapeake Energy
In Thousands of US Dollars
US Dollars/Barrel
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
-1,000,000
-2,000,000
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

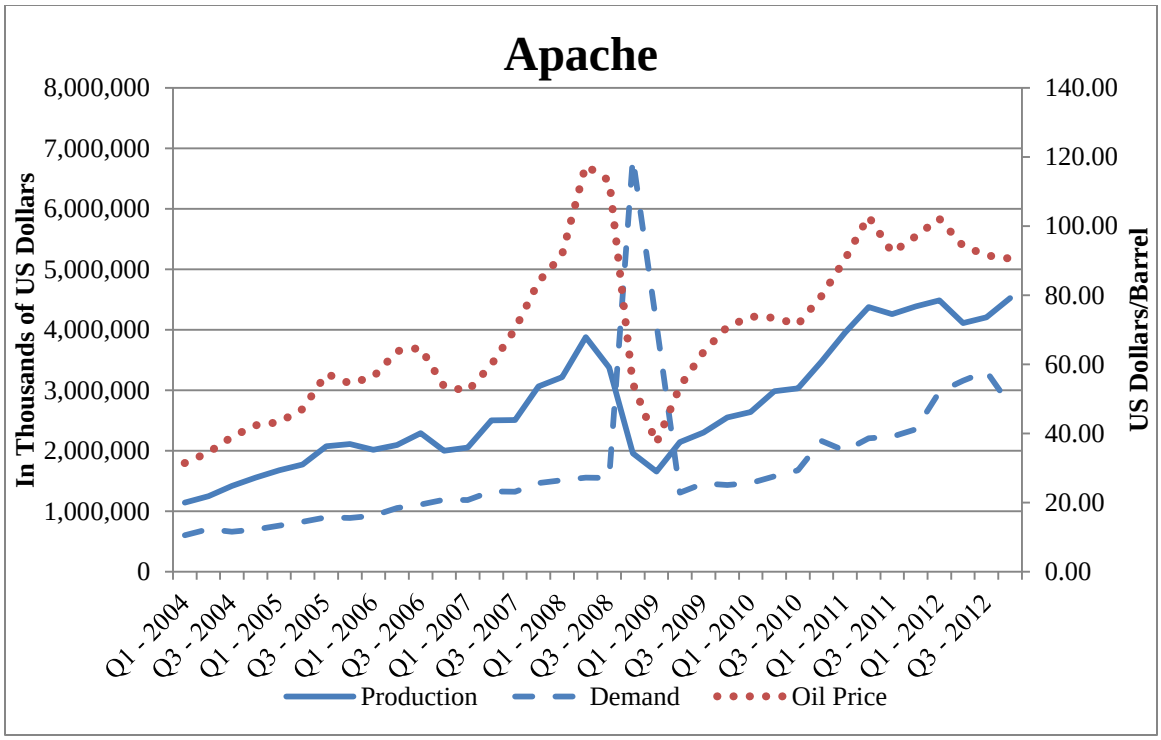

Ecopetrol
In Thousands of US Dollars
US Dollars/Barrel
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

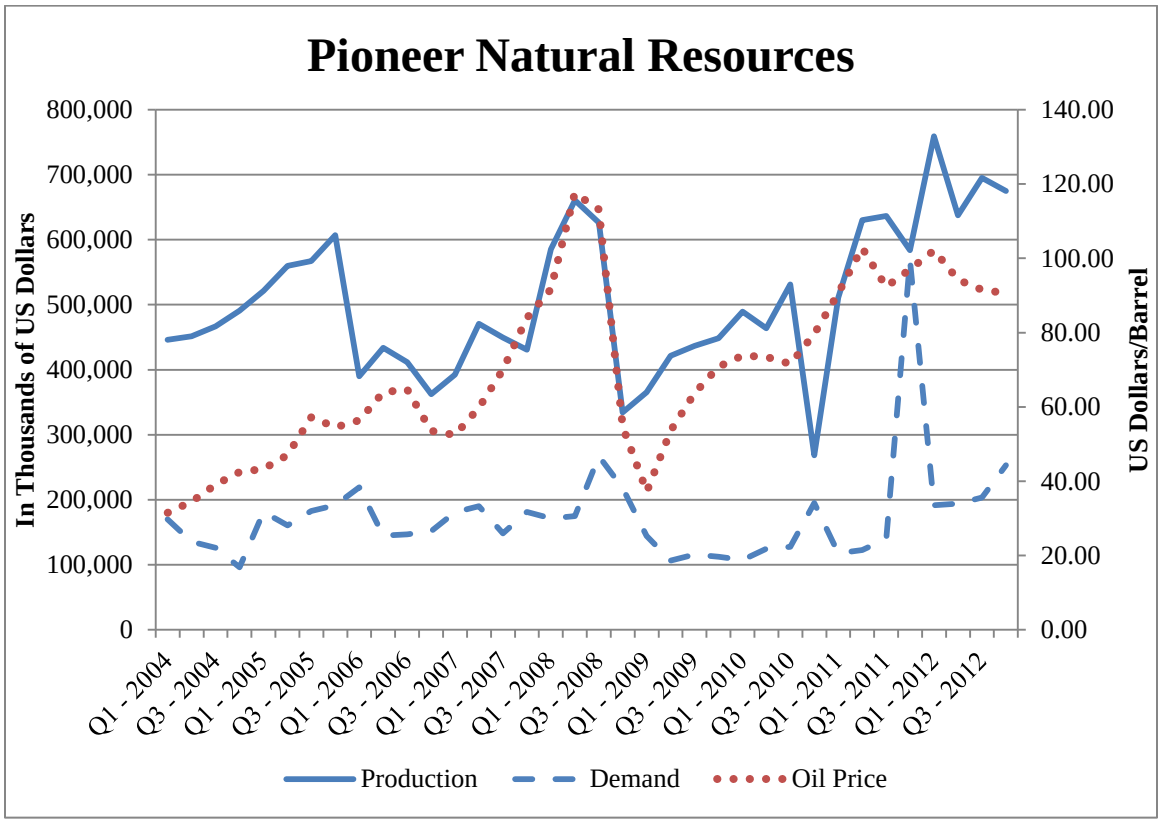

Encana
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
In Thousands of US Dollars
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
US Dollars/Barrel
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

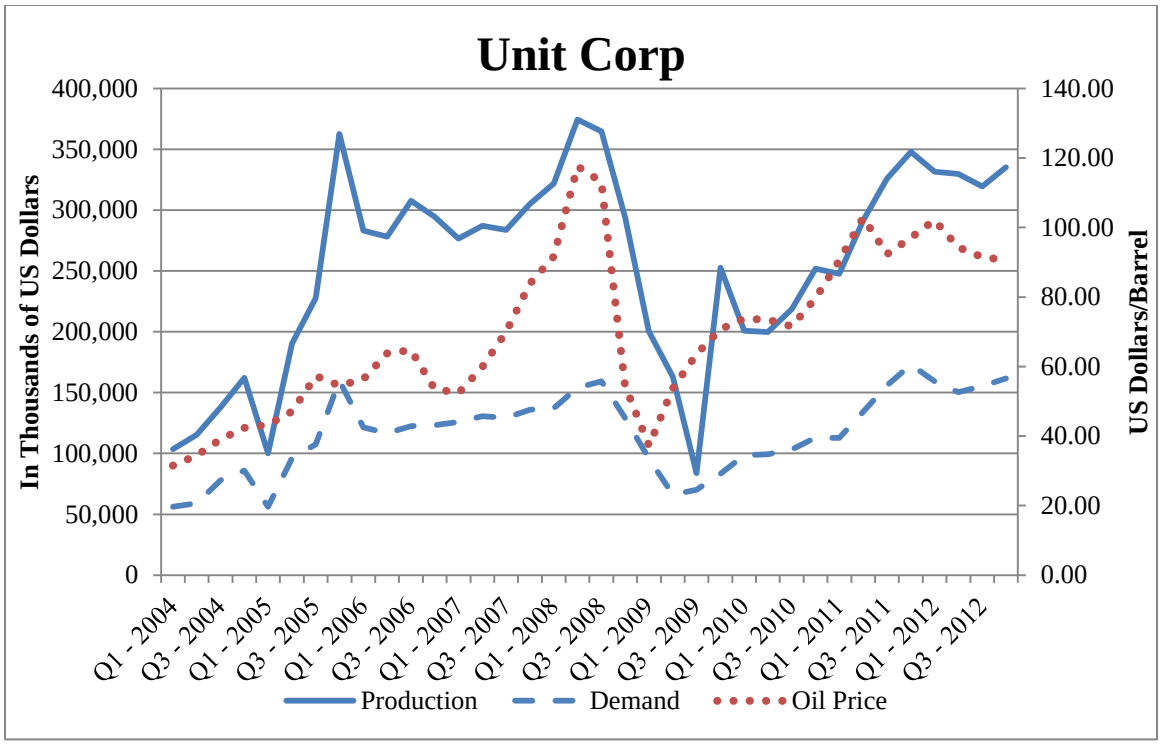

Devon
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
In Thousands of US Dollars
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
US Dollars/Barrel
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

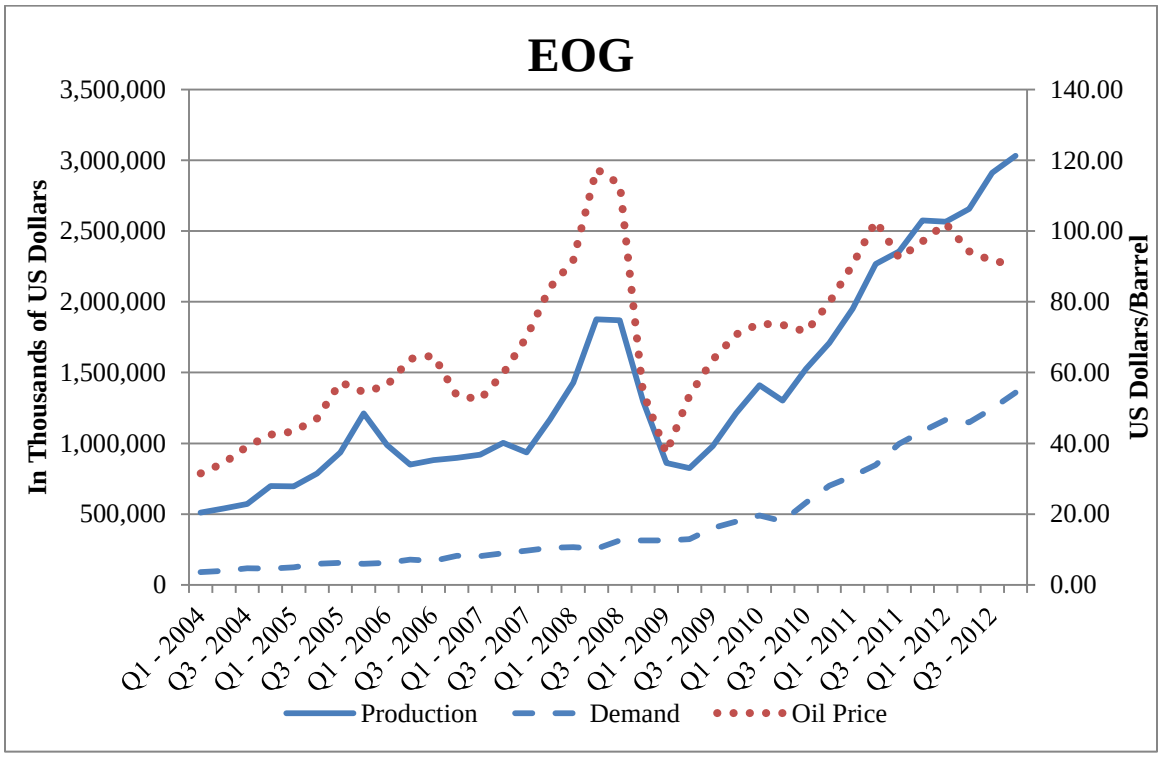

Anadarko
In Thousands of US Dollars
US Dollars/Barrel
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

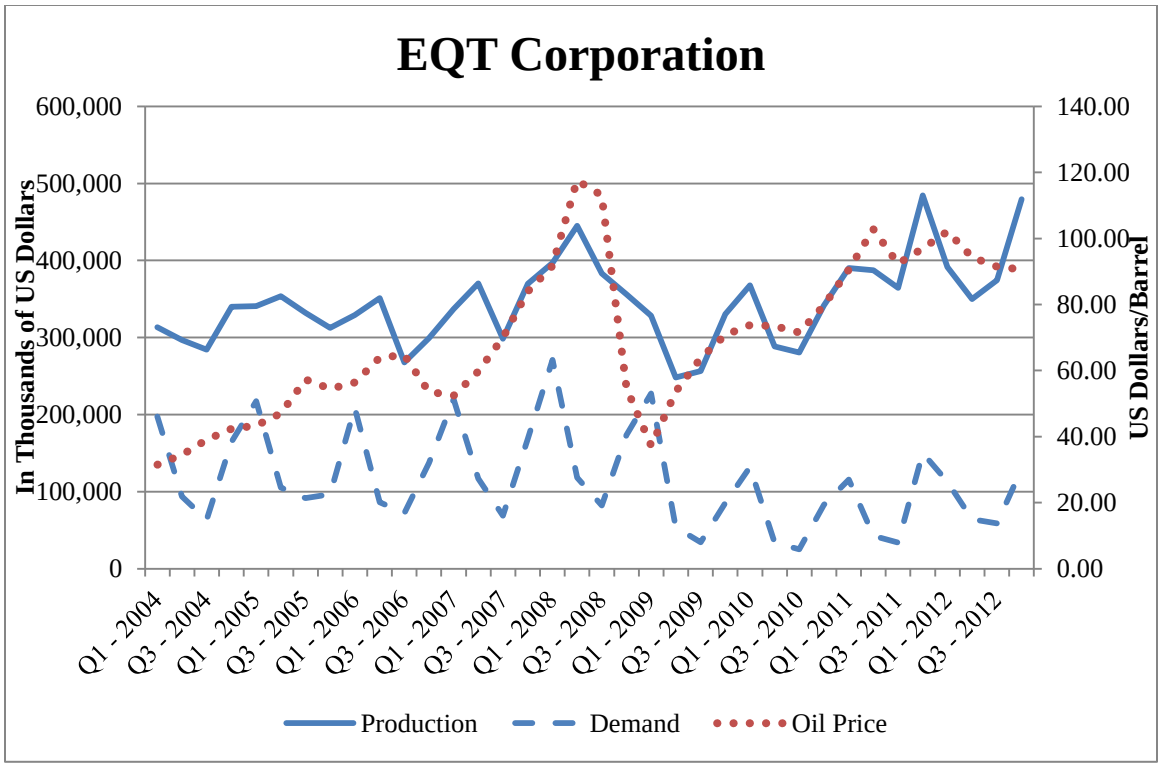

Canadian Natural
In Thousands of US Dollars
US Dollars/Barrel
5,000,000
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

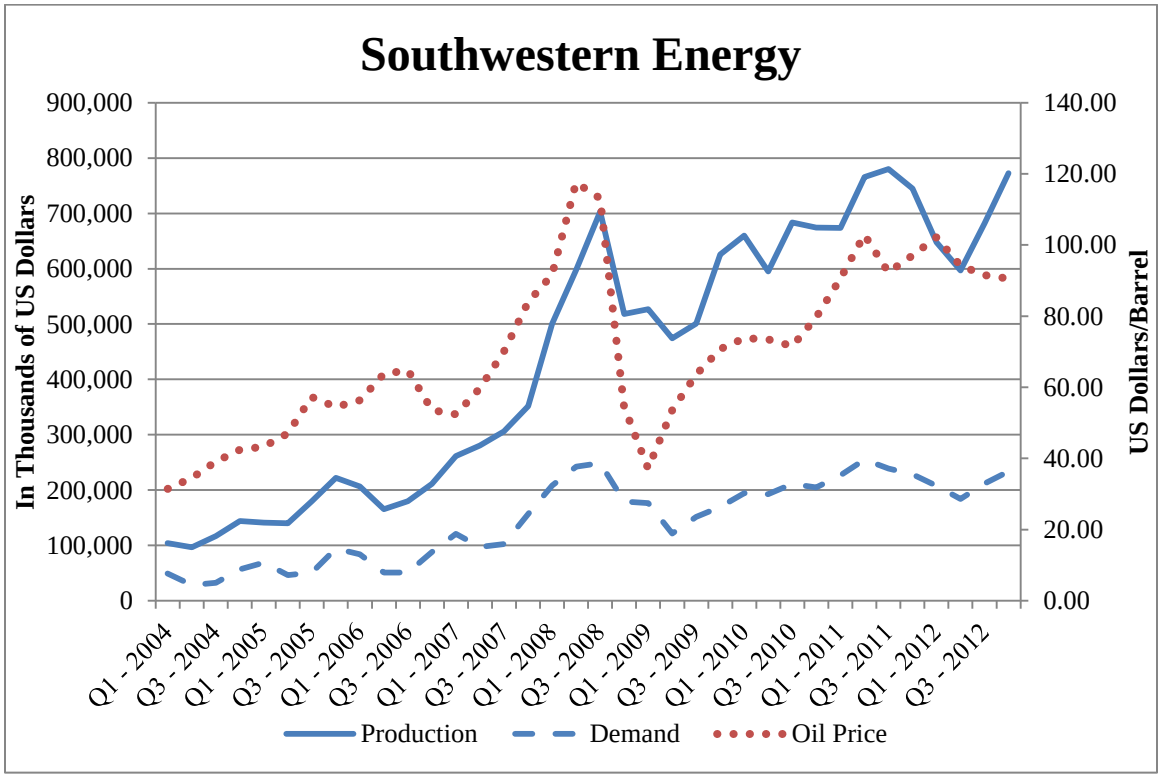

Apache
In Thousands of US Dollars
US Dollars/Barrel
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

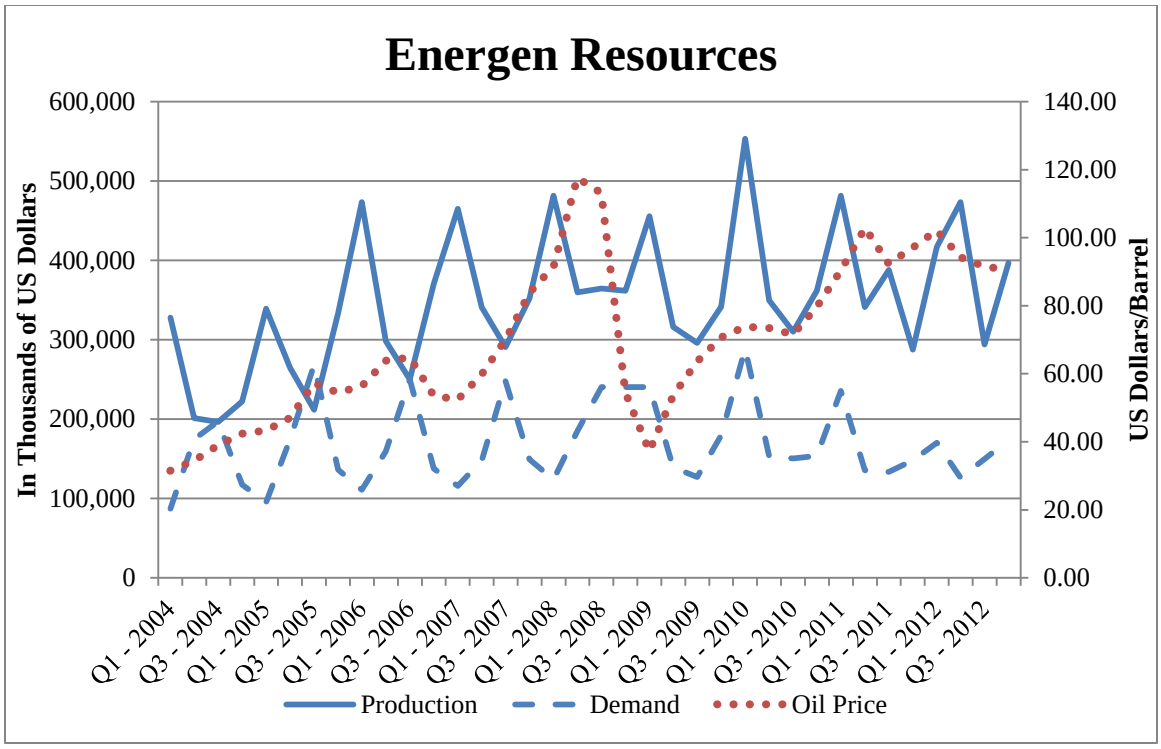

Pioneer Natural Resources
In Thousands of US Dollars
US Dollars/Barrel
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

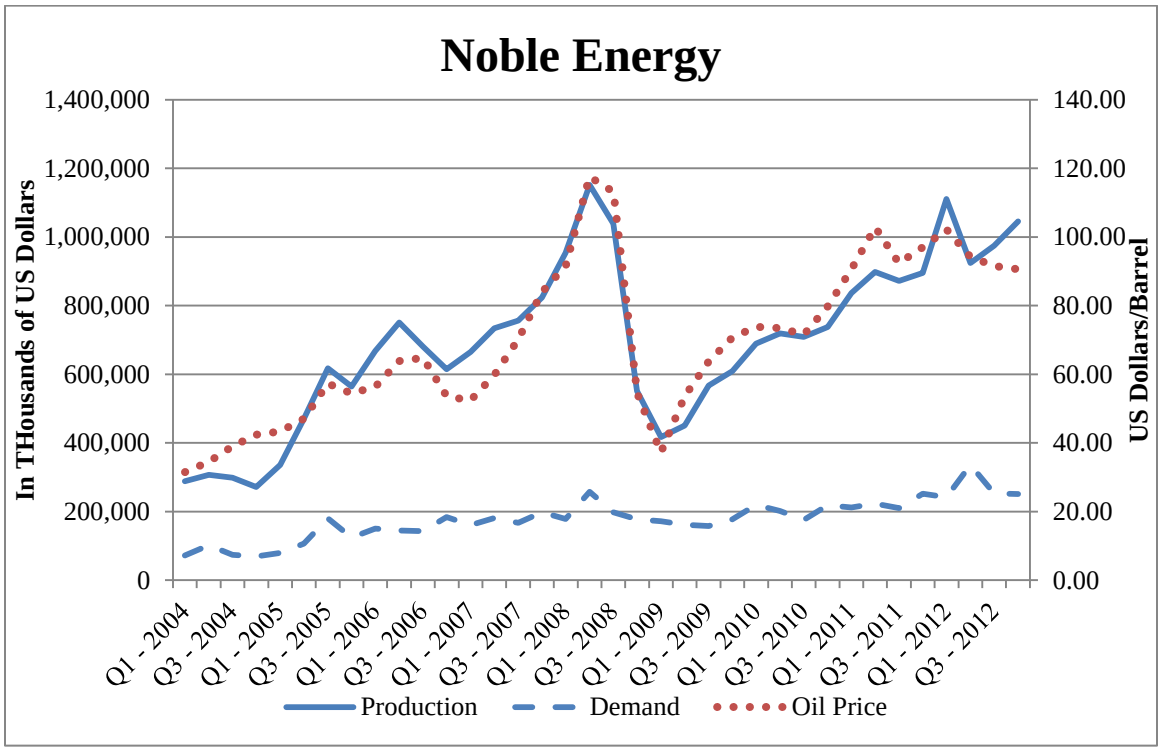

Unit Corp
In Thousands of US Dollars
US Dollars/Barrel
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

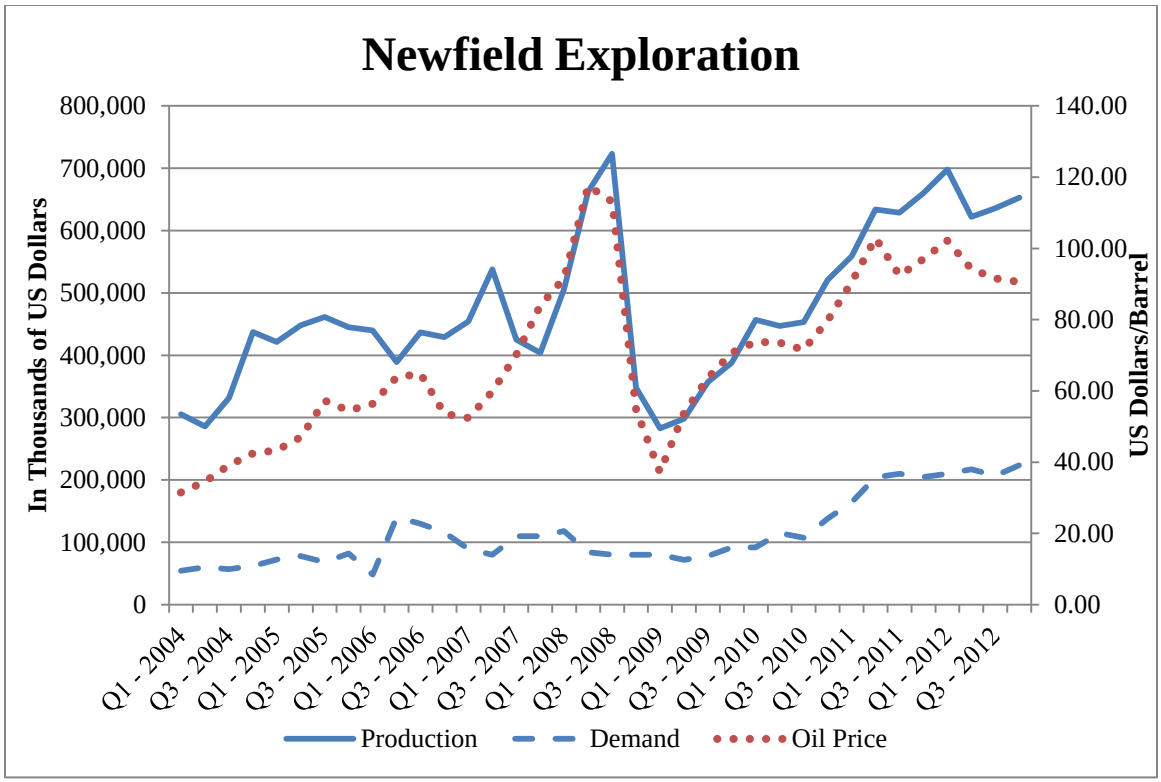

EOG
In Thousands of US Dollars
US Dollars/Barrel
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

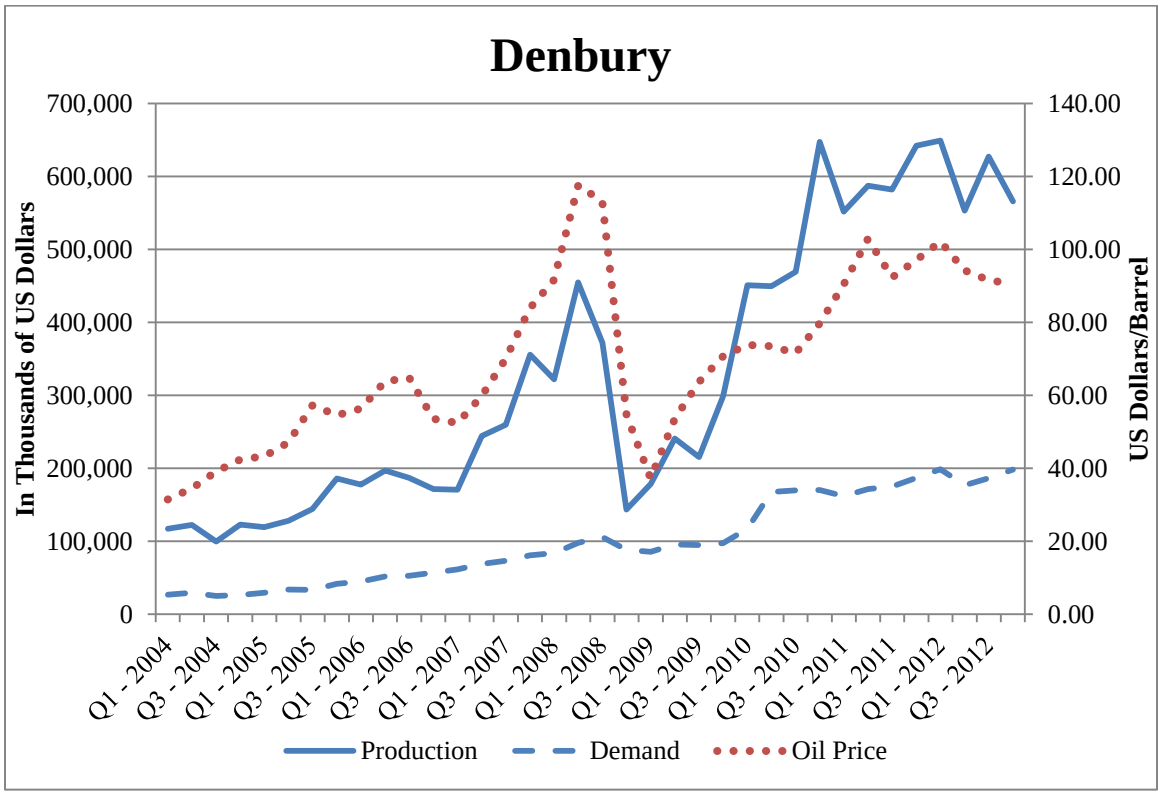

EQT Corporation
In Thousands of US Dollars
US Dollars/Barrel
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

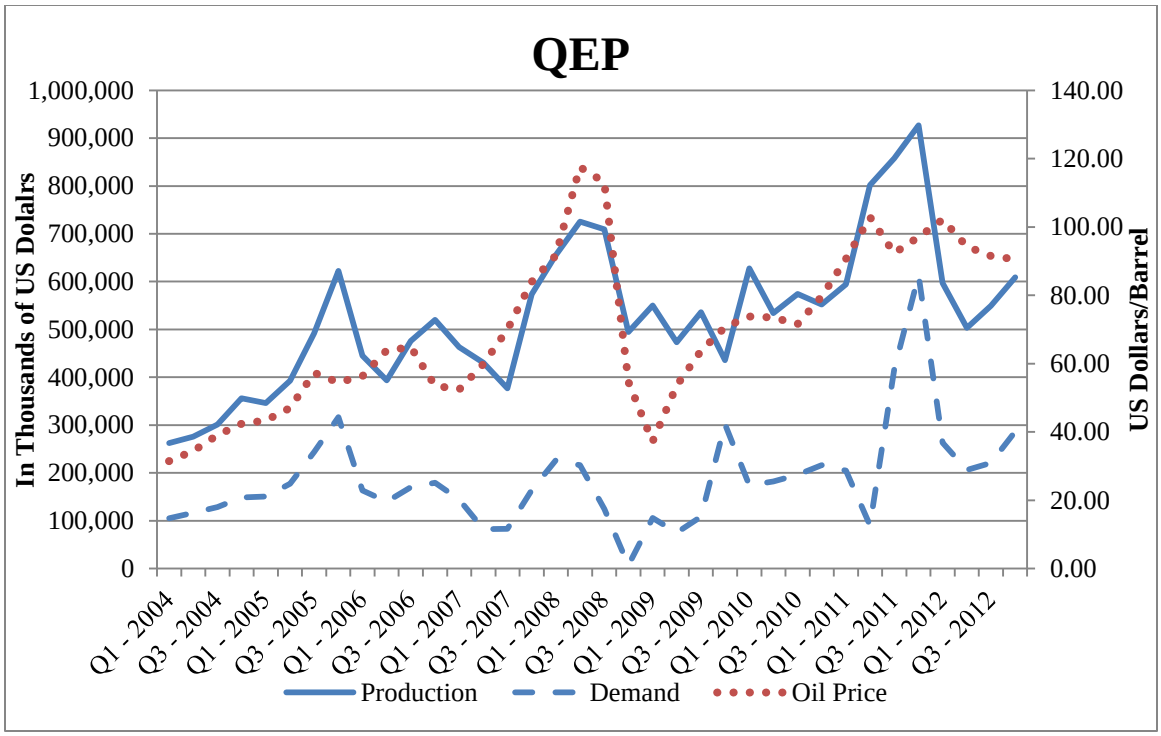

Southwestern Energy
In Thousands of US Dollars
US Dollars/Barrel
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

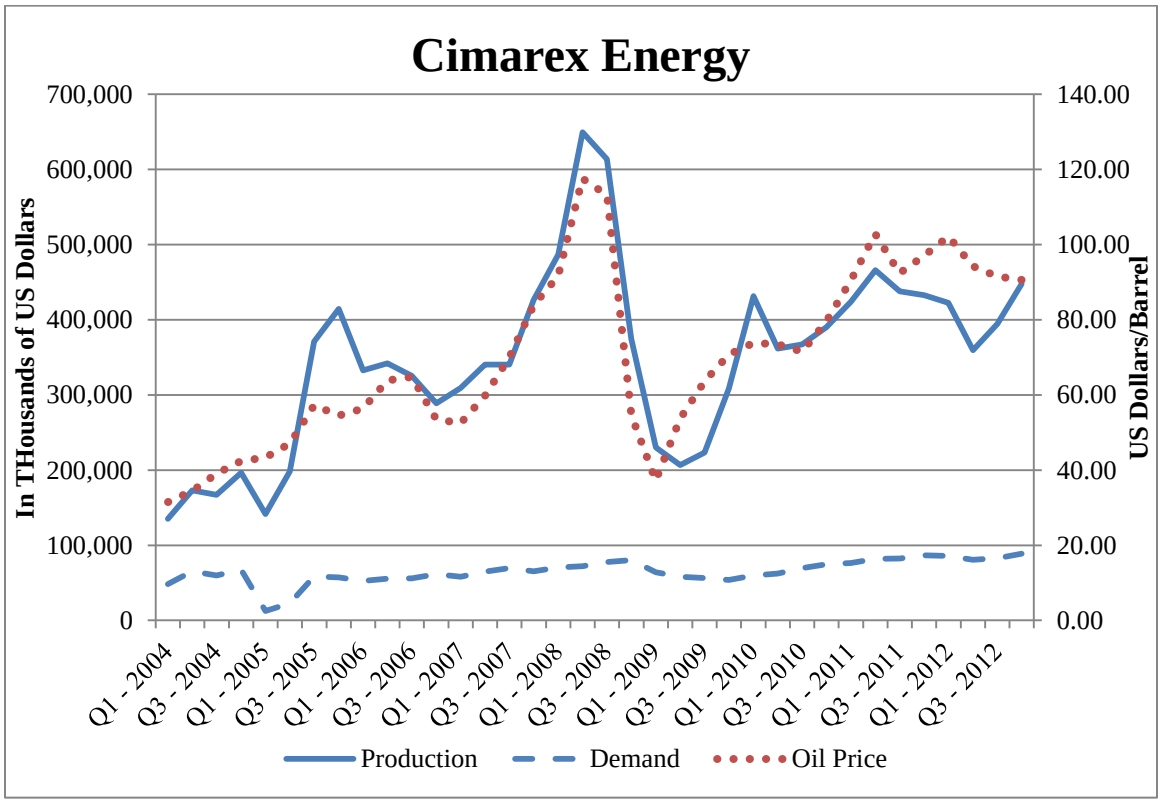

Energen Resources
In Thousands of US Dollars
US Dollars/Barrel
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

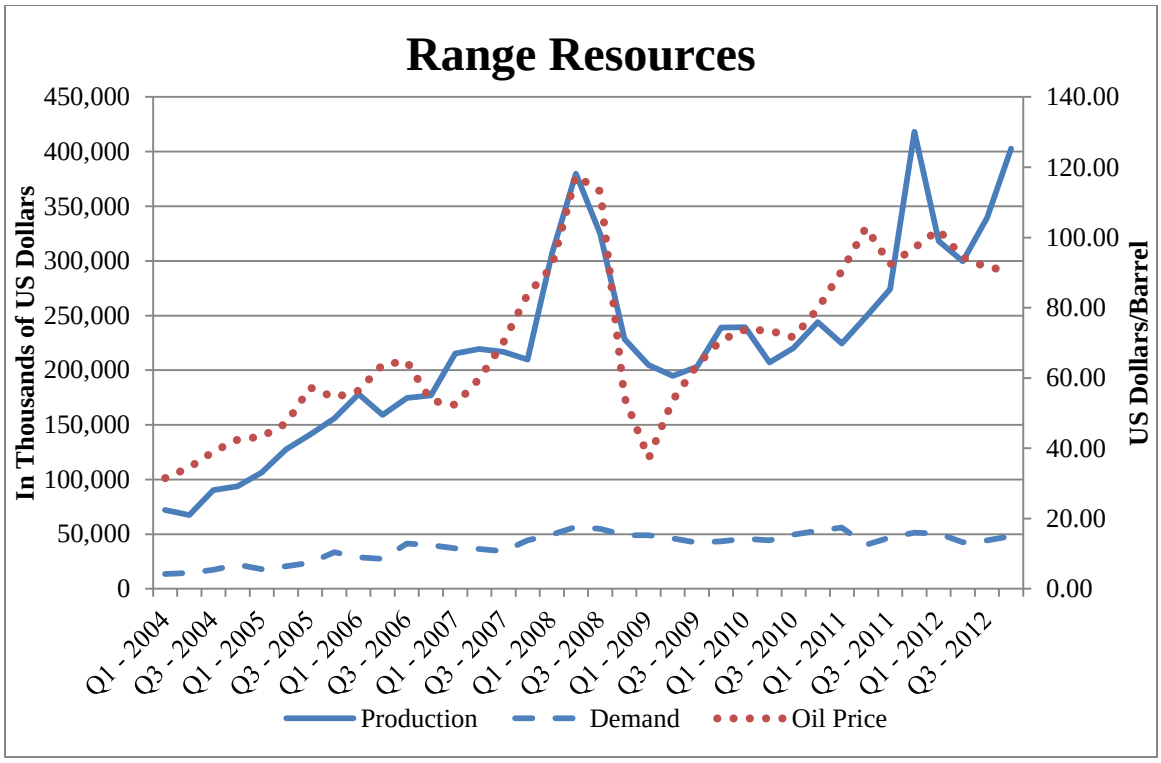

Noble Energy
In THousands of US Dollars
US Dollars/Barrel
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

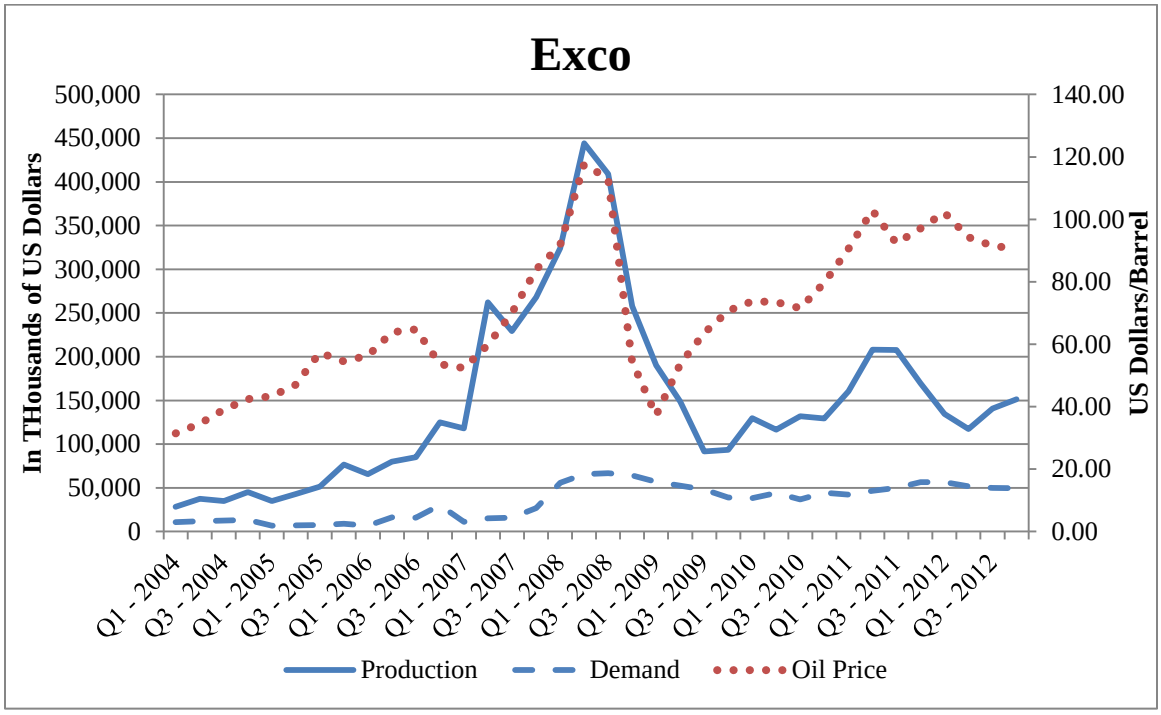

Newfield Exploration
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
In Thousands of US Dollars
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
US Dollars/Barrel
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

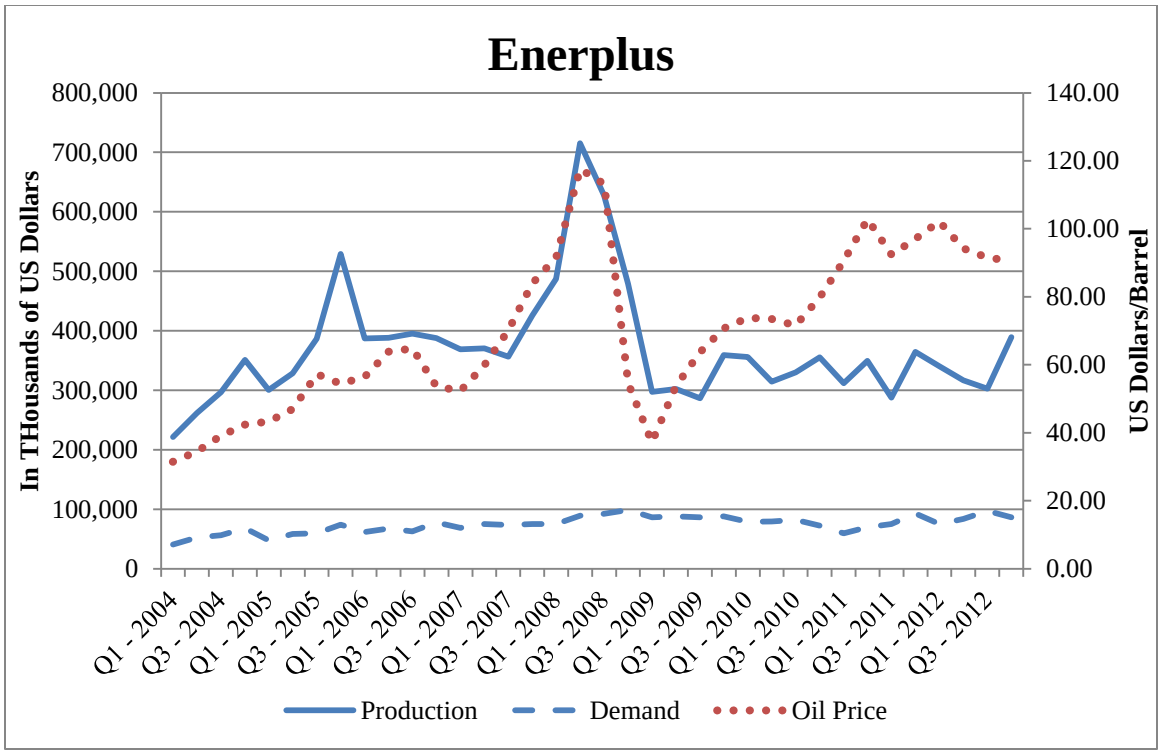

Denbury
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
In Thousands of US Dollars
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
US Dollars/Barrel
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

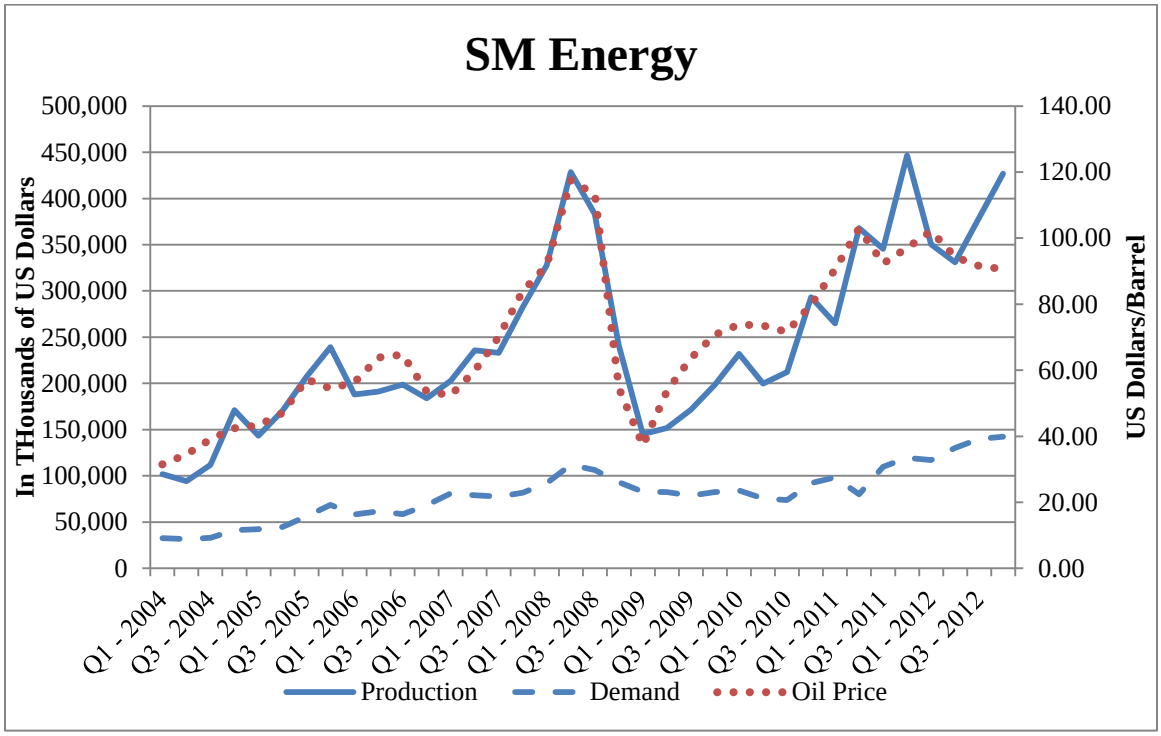

QEP
In Thousands of US Dolalrs
US Dollars/Barrel
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

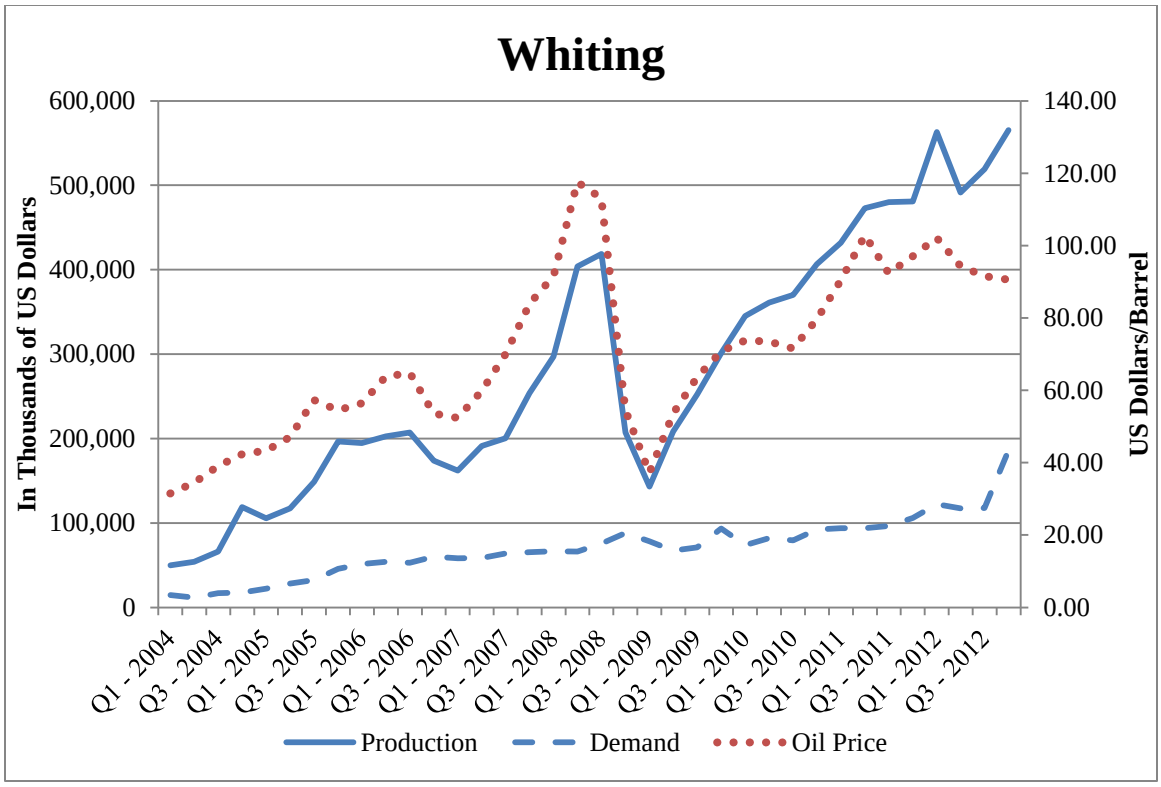

Cimarex Energy
In THousands of US Dollars
US Dollars/Barrel
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

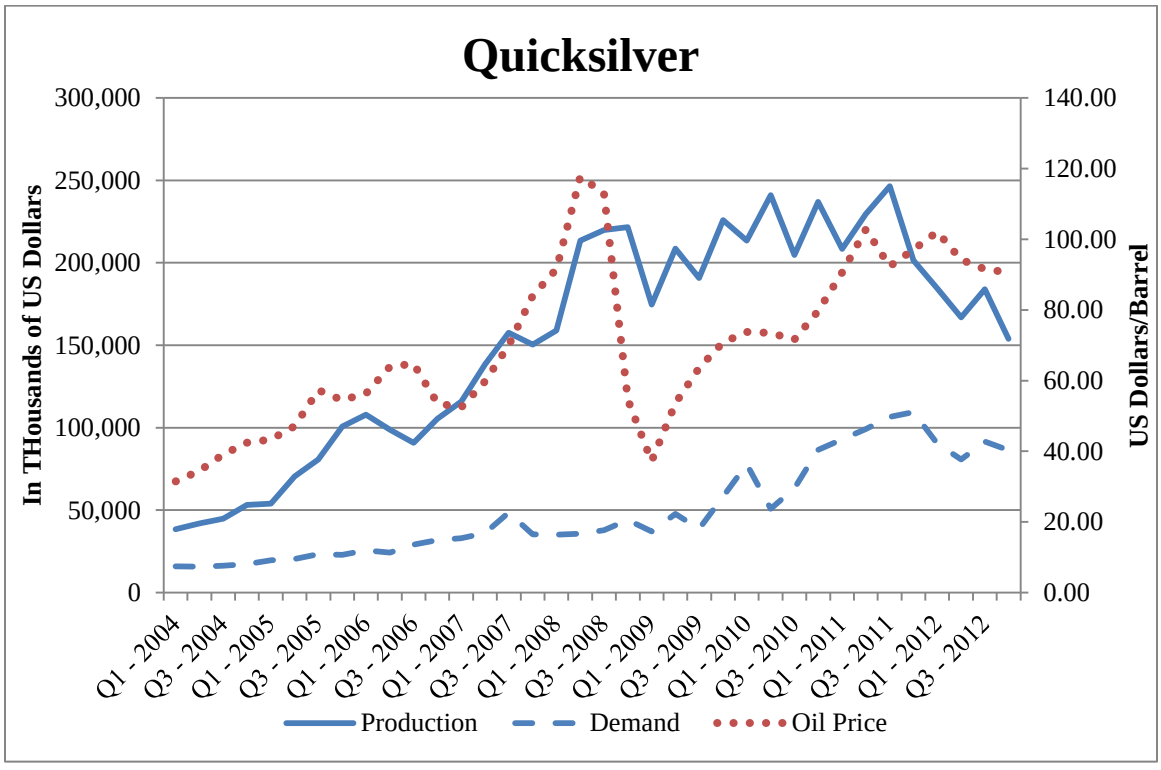

Range Resources
In Thousands of US Dollars
US Dollars/Barrel
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

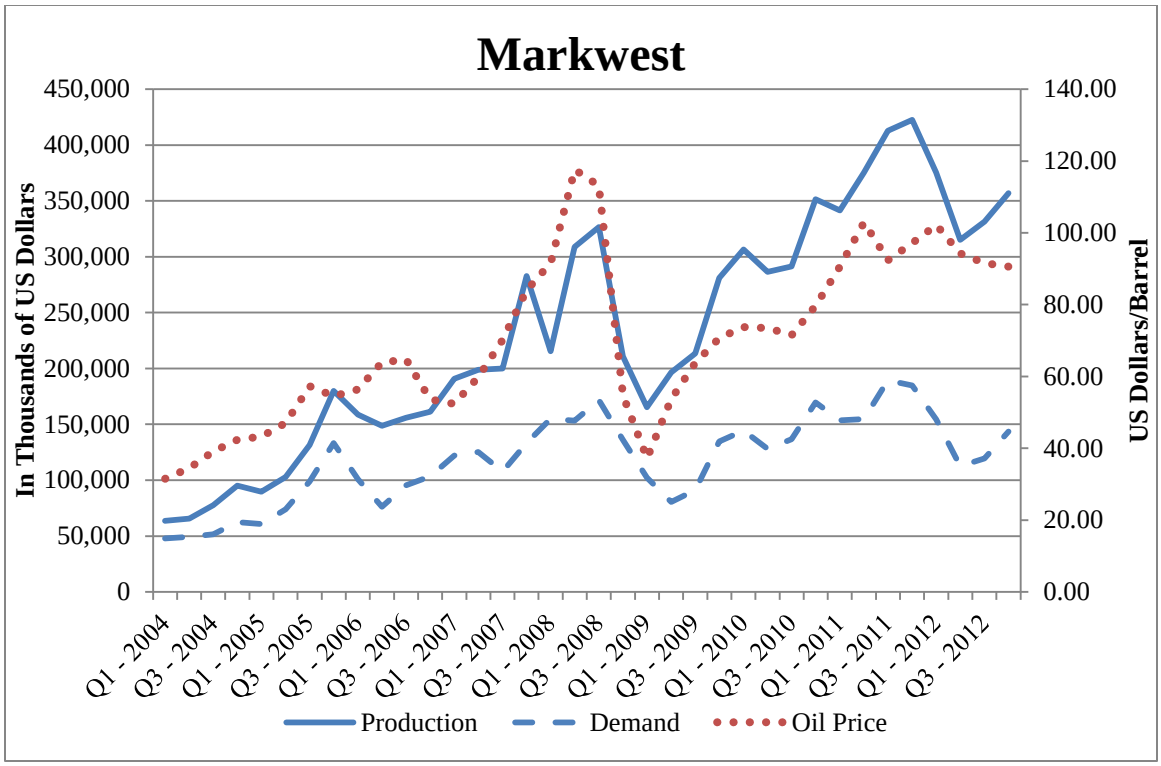

Exco
In THousands of US Dollars
US Dollars/Barrel
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

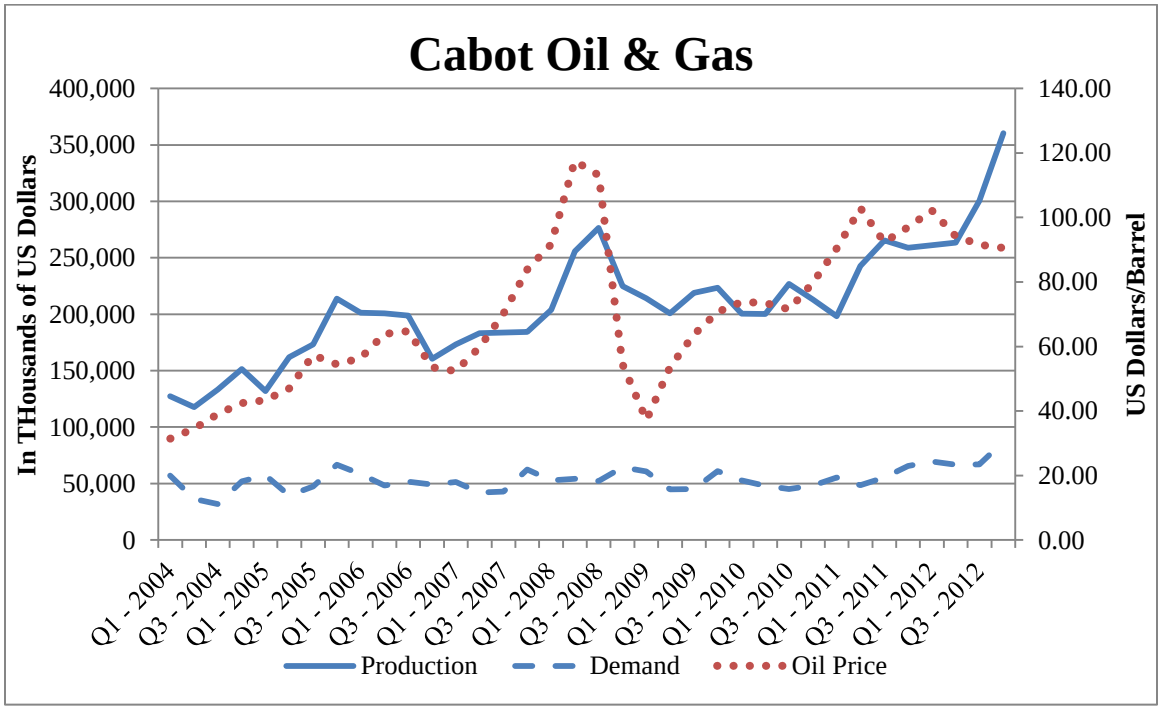

Enerplus
In THousands of US Dollars
US Dollars/Barrel
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

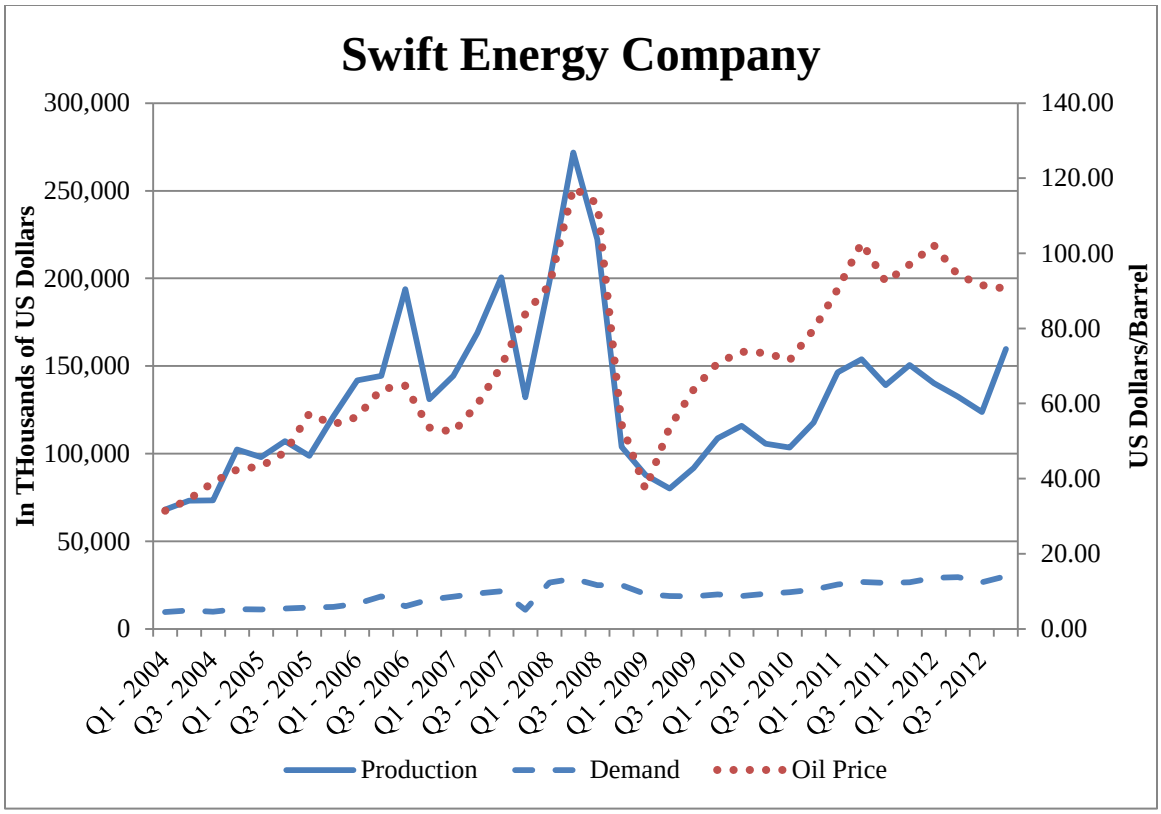

SM Energy
In THousands of US Dollars
US Dollars/Barrel
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

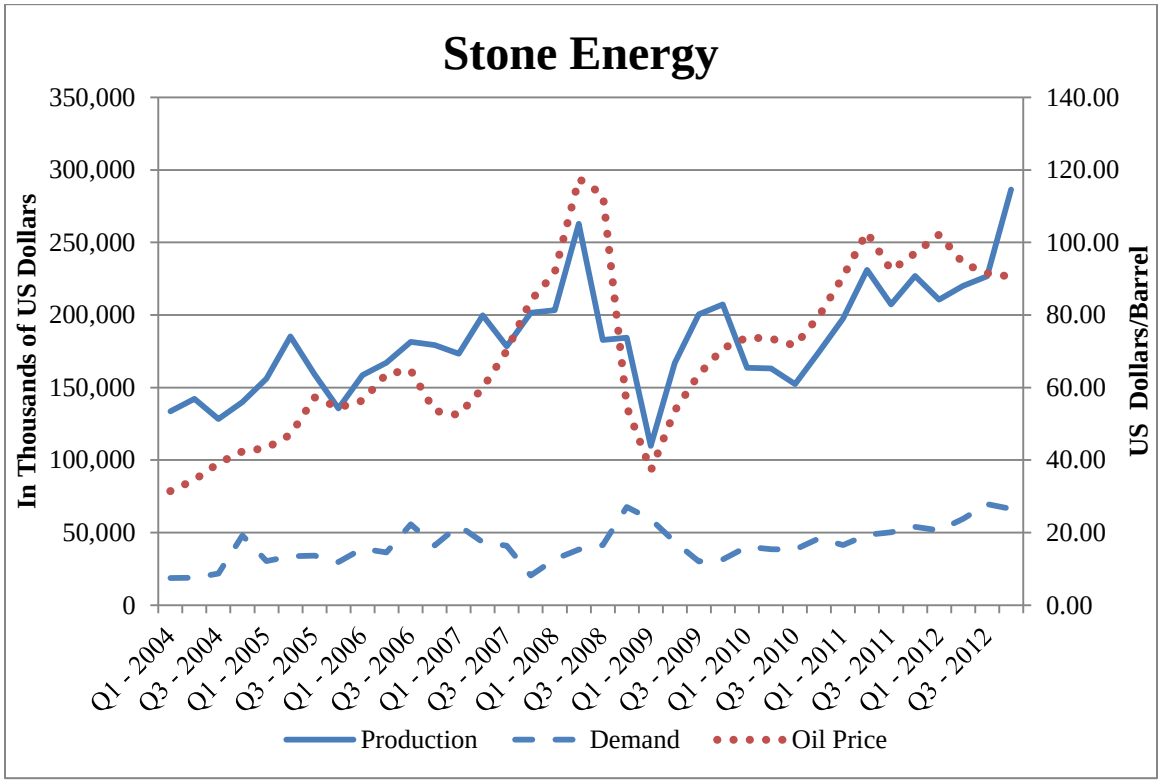

Whiting
In Thousands of US Dollars
US Dollars/Barrel
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

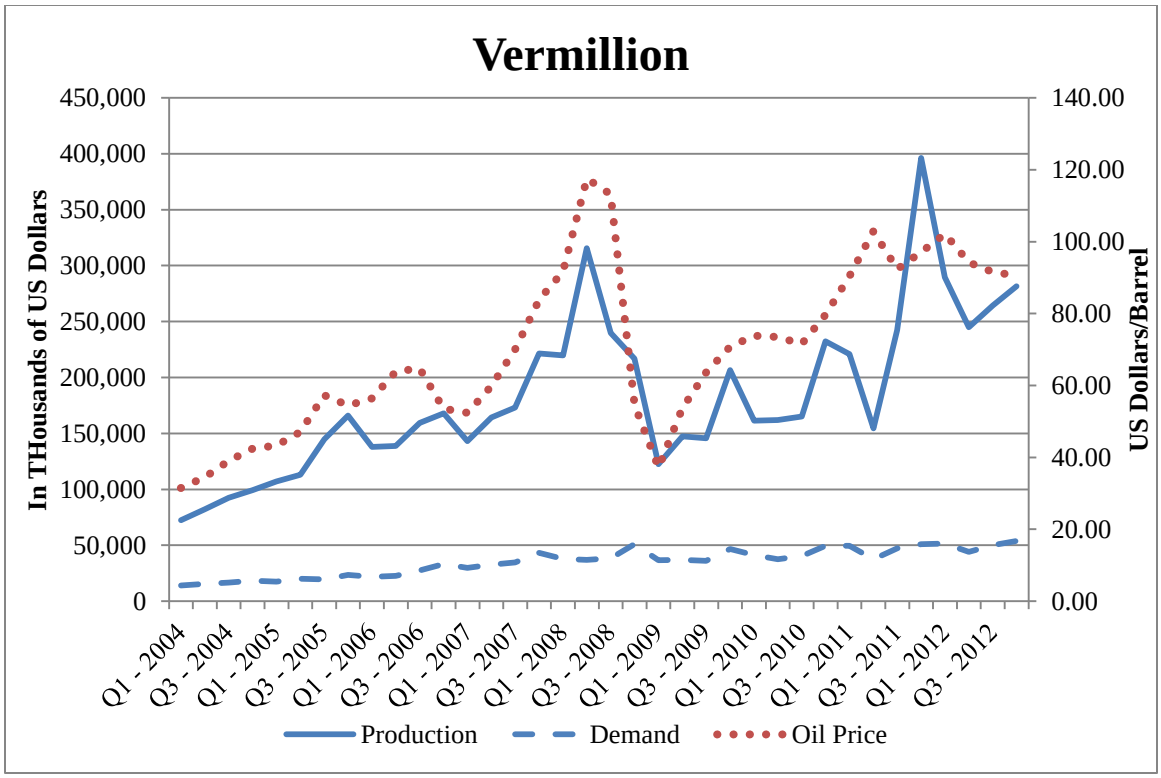

Quicksilver
In THousands of US Dollars
US Dollars/Barrel
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

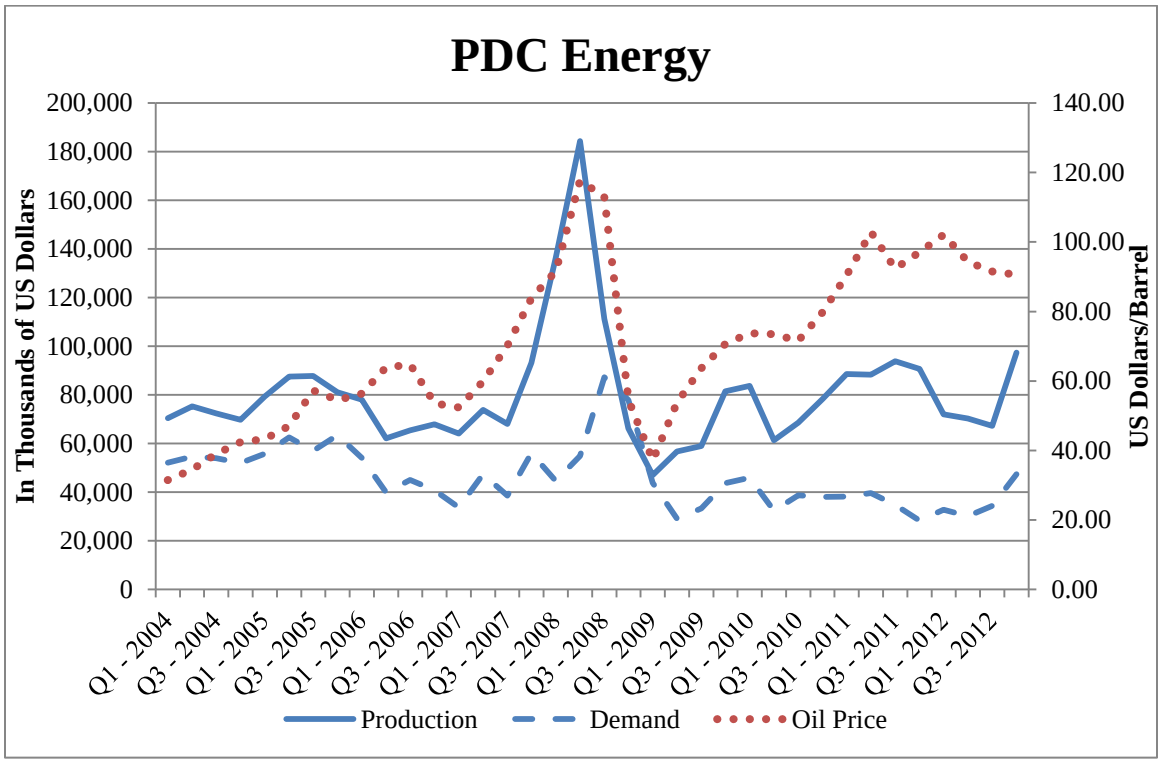

Markwest
In Thousands of US Dollars
US Dollars/Barrel
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

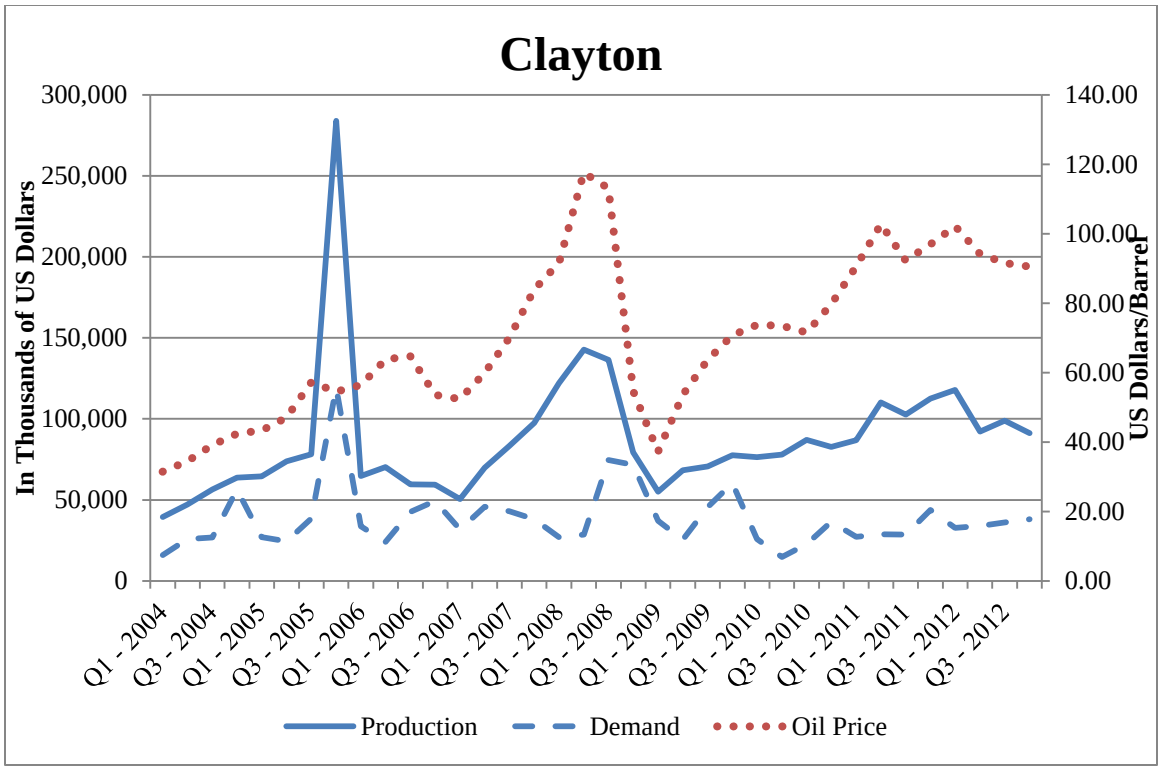

Cabot Oil & Gas
In THousands of US Dollars
US Dollars/Barrel
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

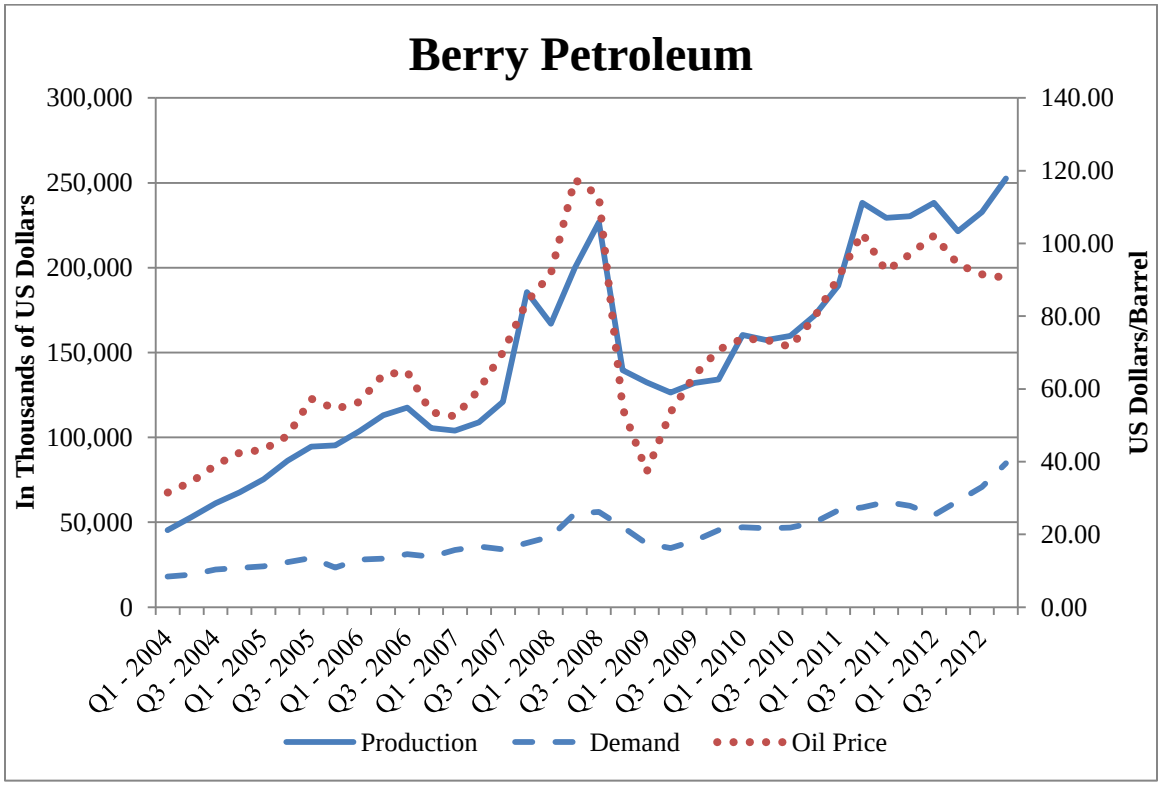

Swift Energy Company
In THousands of US Dollars
US Dollars/Barrel
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

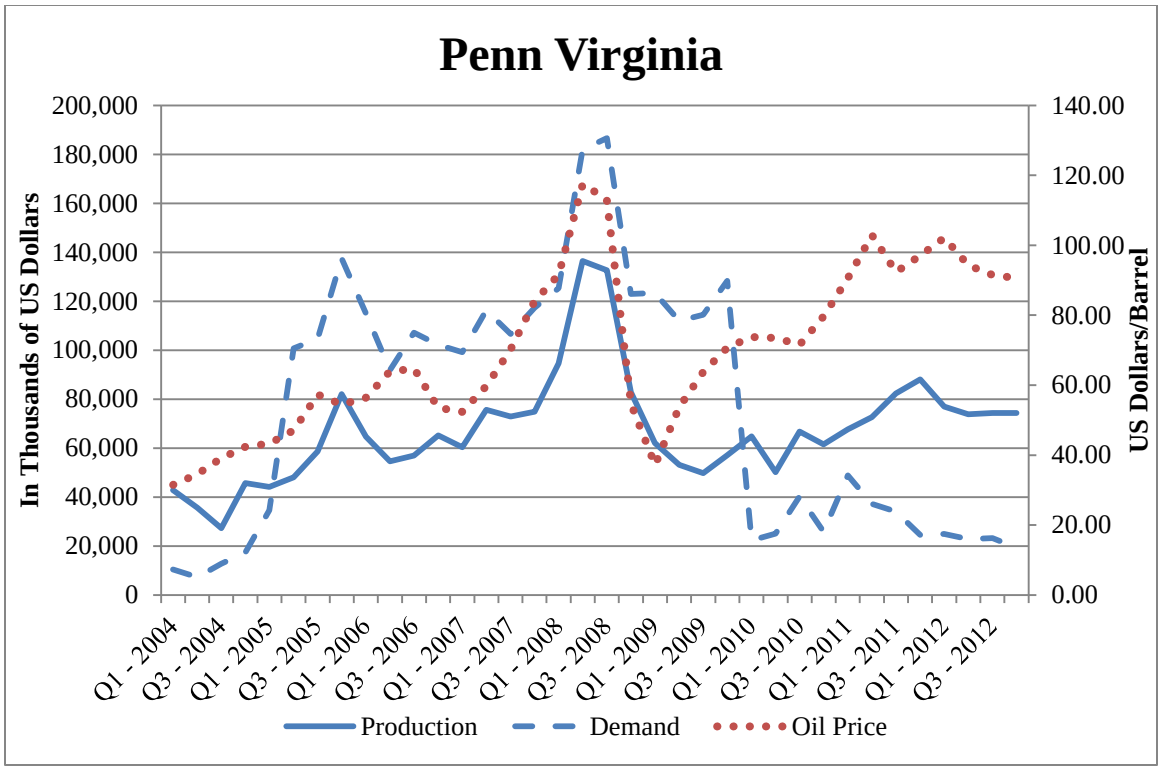

Stone Energy
In Thousands of US Dollars
US Dollars/Barrel
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

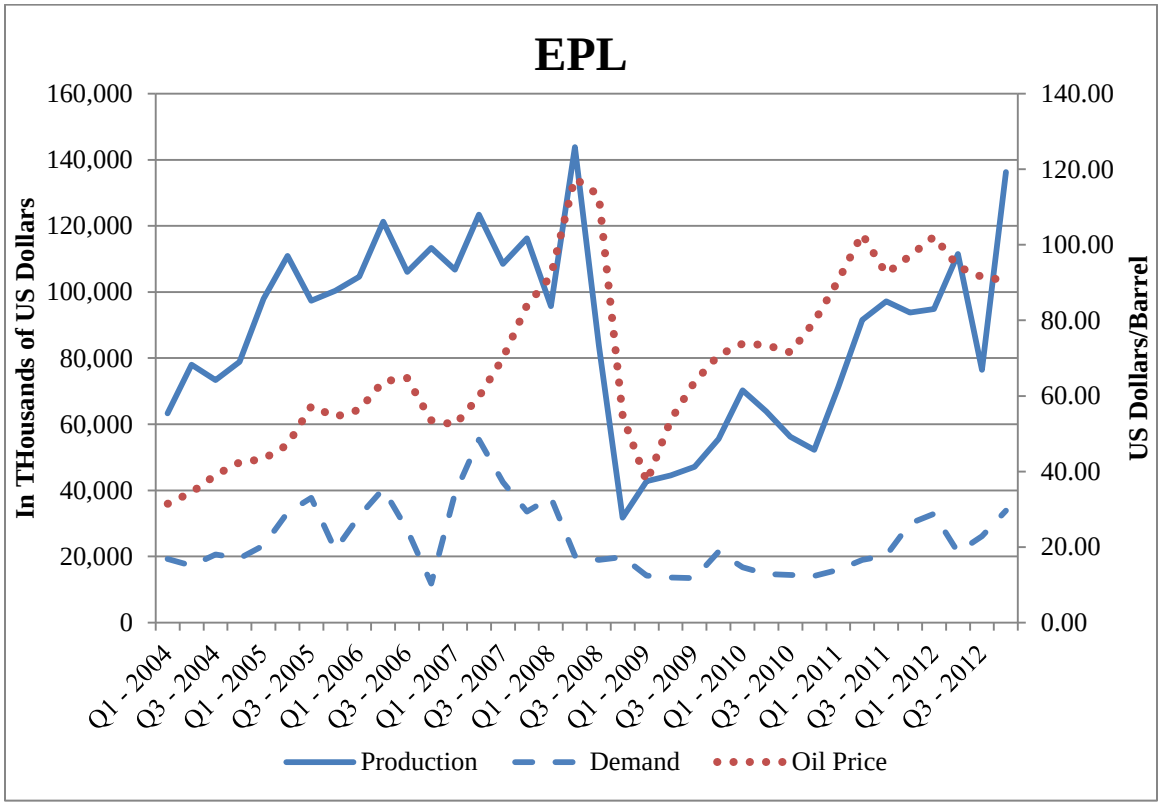

Vermillion
In THousands of US Dollars
US Dollars/Barrel
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

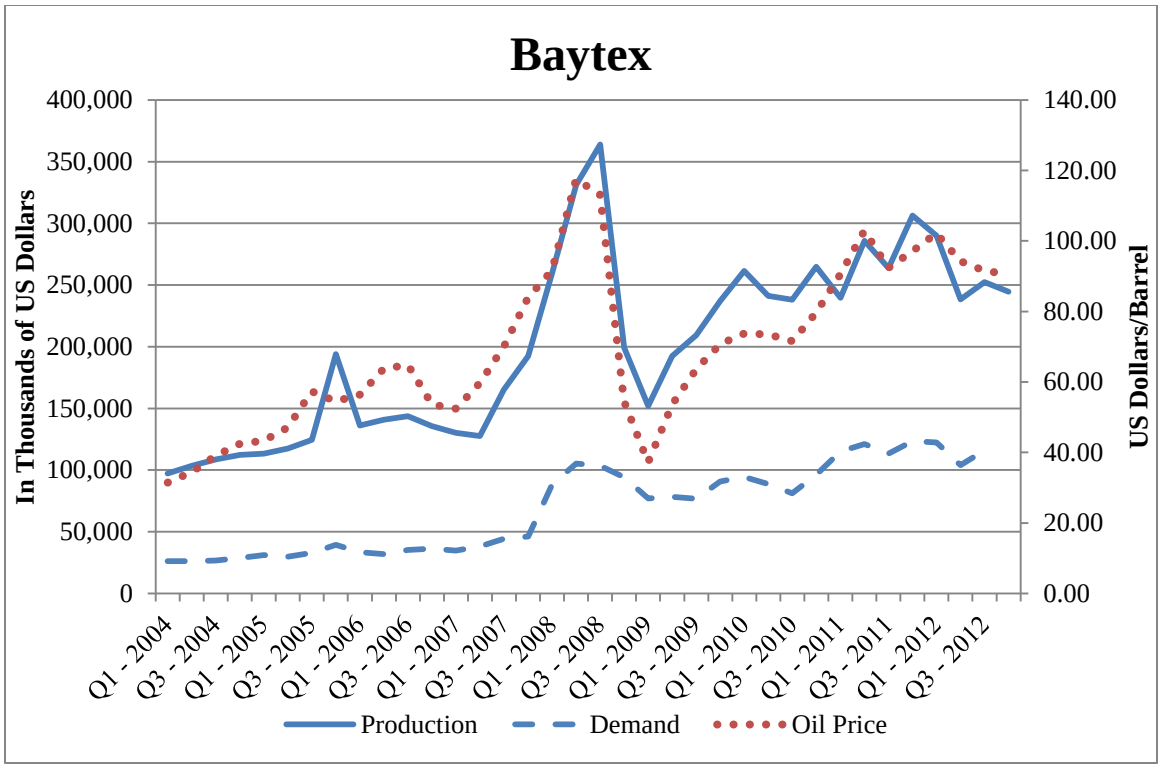

PDC Energy
In Thousands of US Dollars
US Dollars/Barrel
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

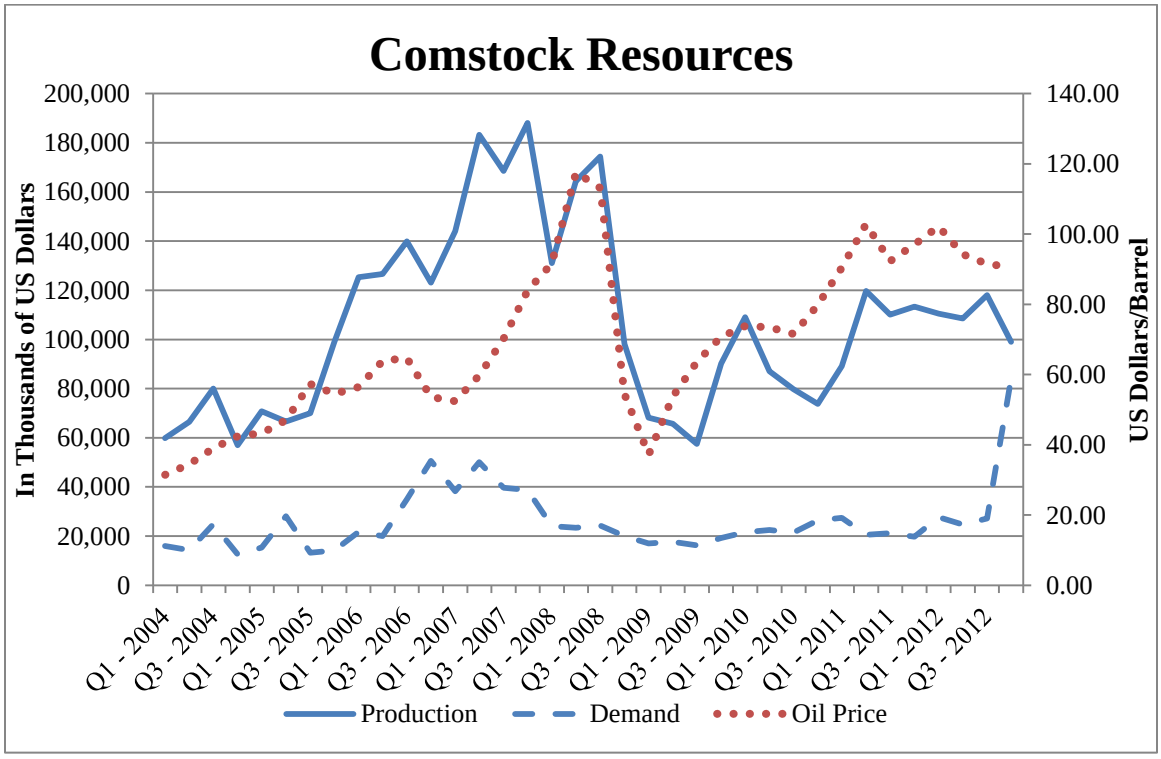

Clayton
In Thousands of US Dollars
US Dollars/Barrel
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

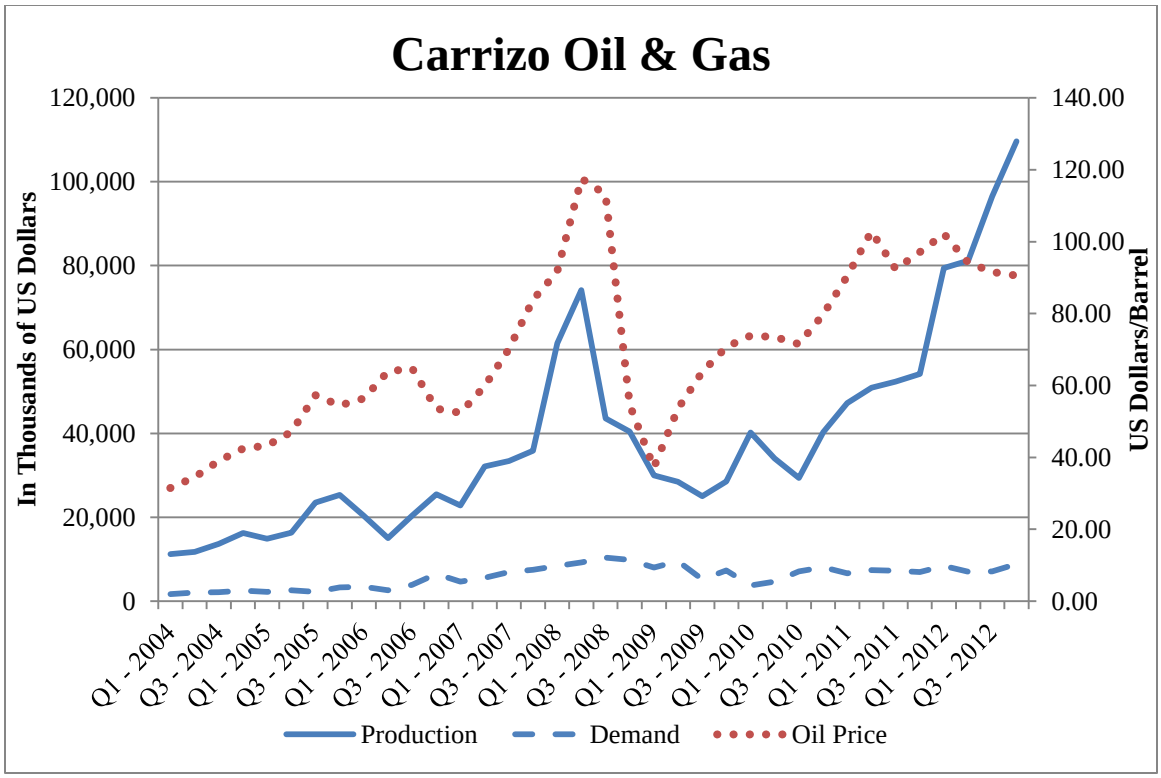

Berry Petroleum
In Thousands of US Dollars
US Dollars/Barrel
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

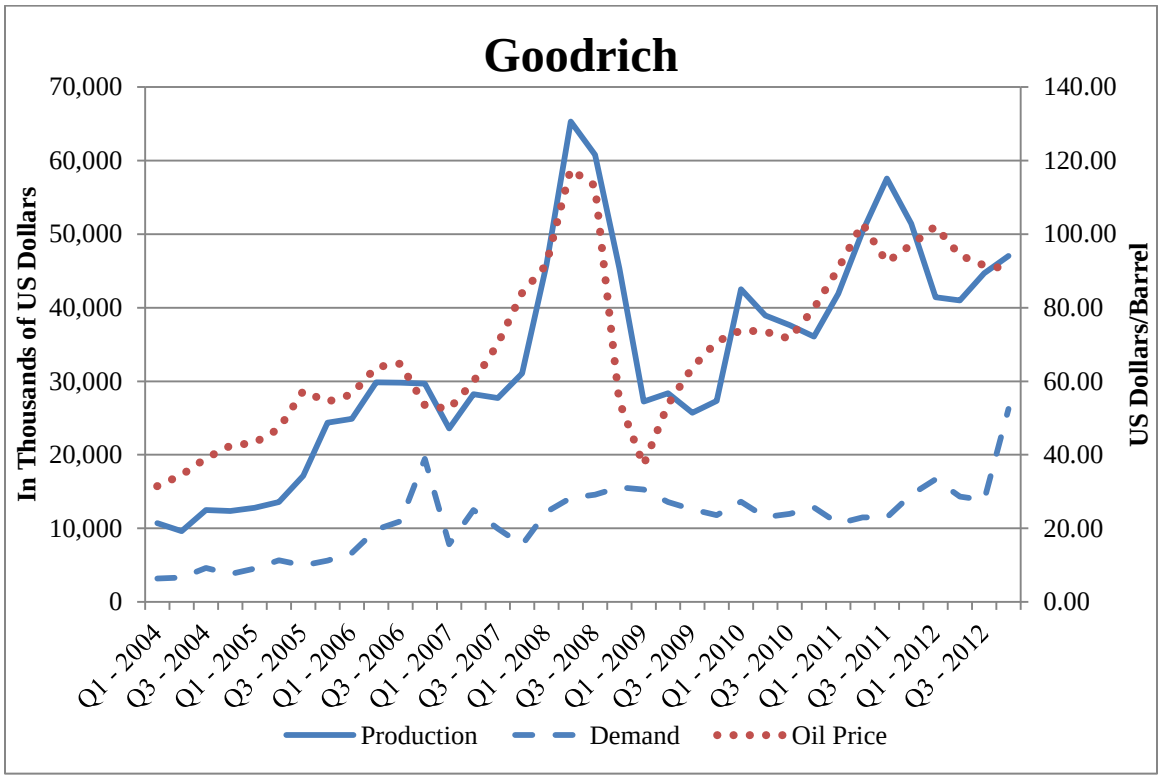

Penn Virginia
In Thousands of US Dollars
US Dollars/Barrel
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

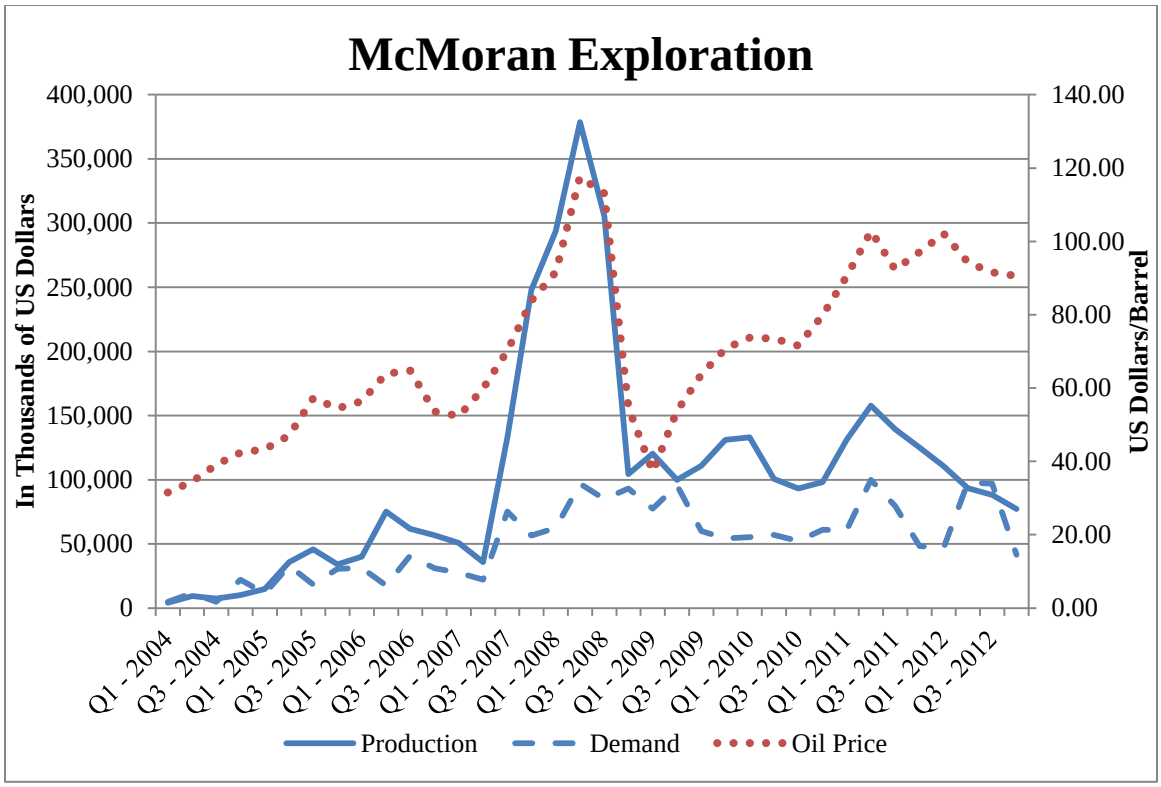

EPL
In THousands of US Dollars
US Dollars/Barrel
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

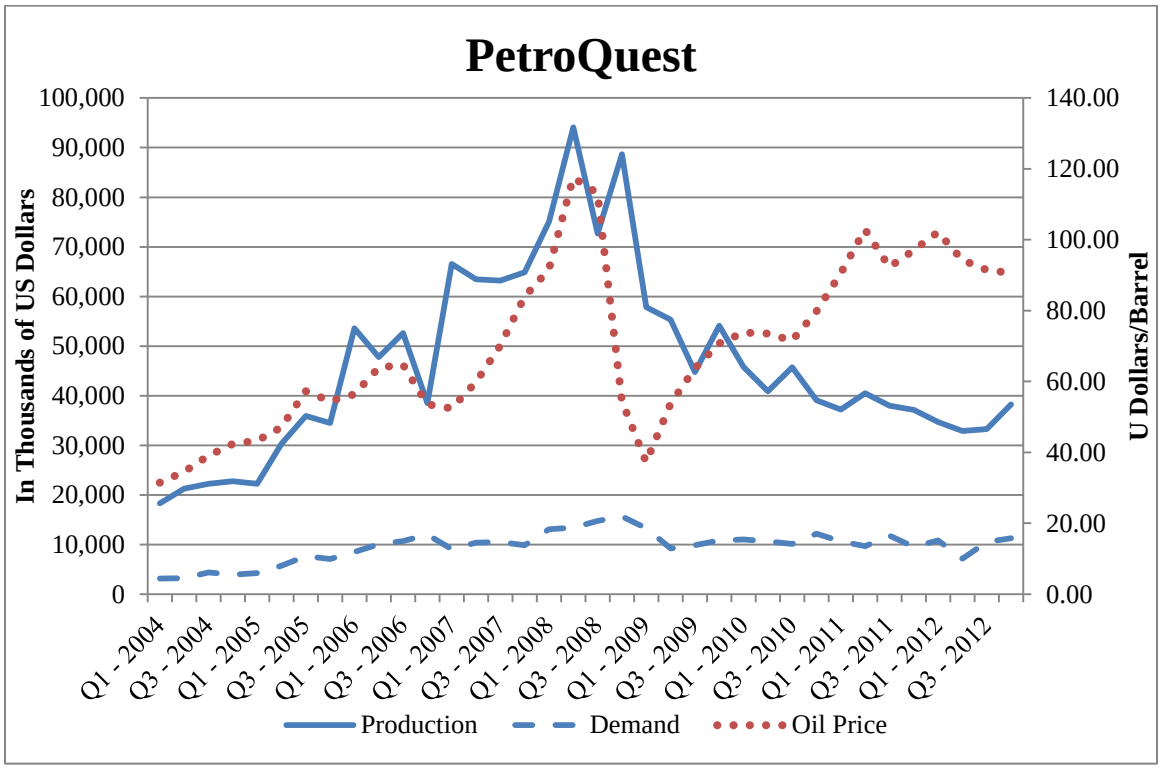

Baytex
In Thousands of US Dollars
US Dollars/Barrel
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

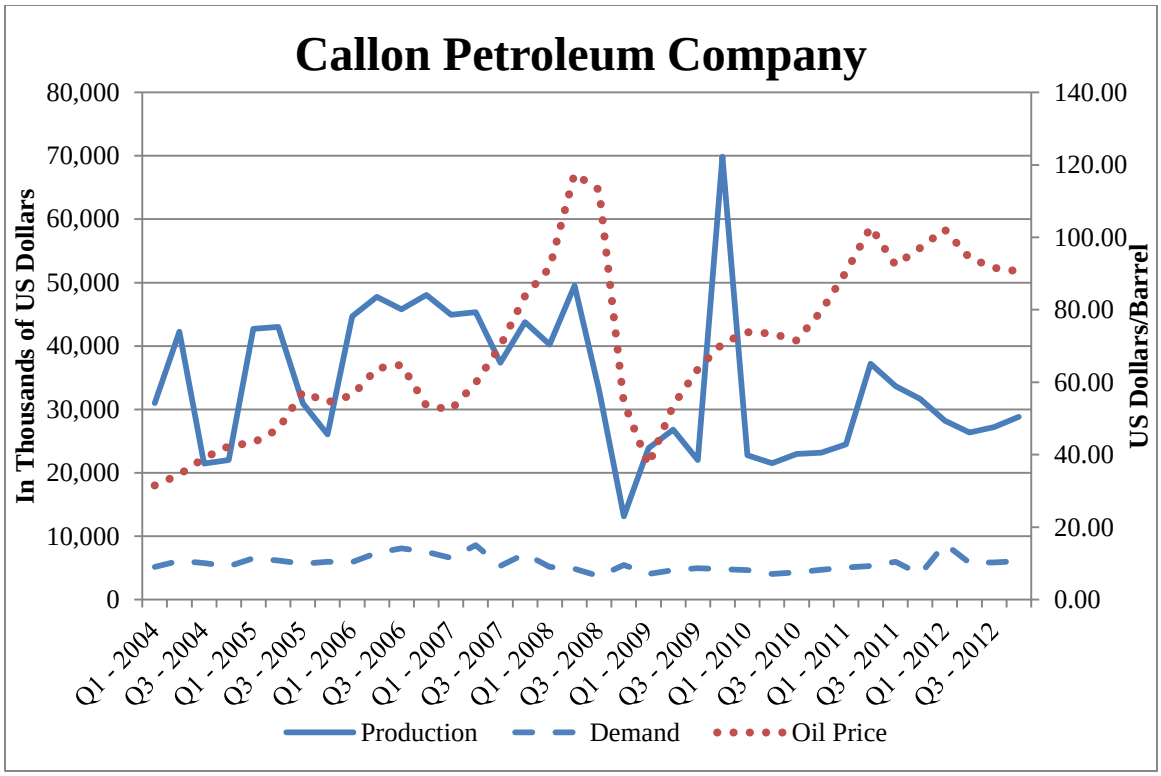

Comstock Resources
In Thousands of US Dollars
US Dollars/Barrel
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

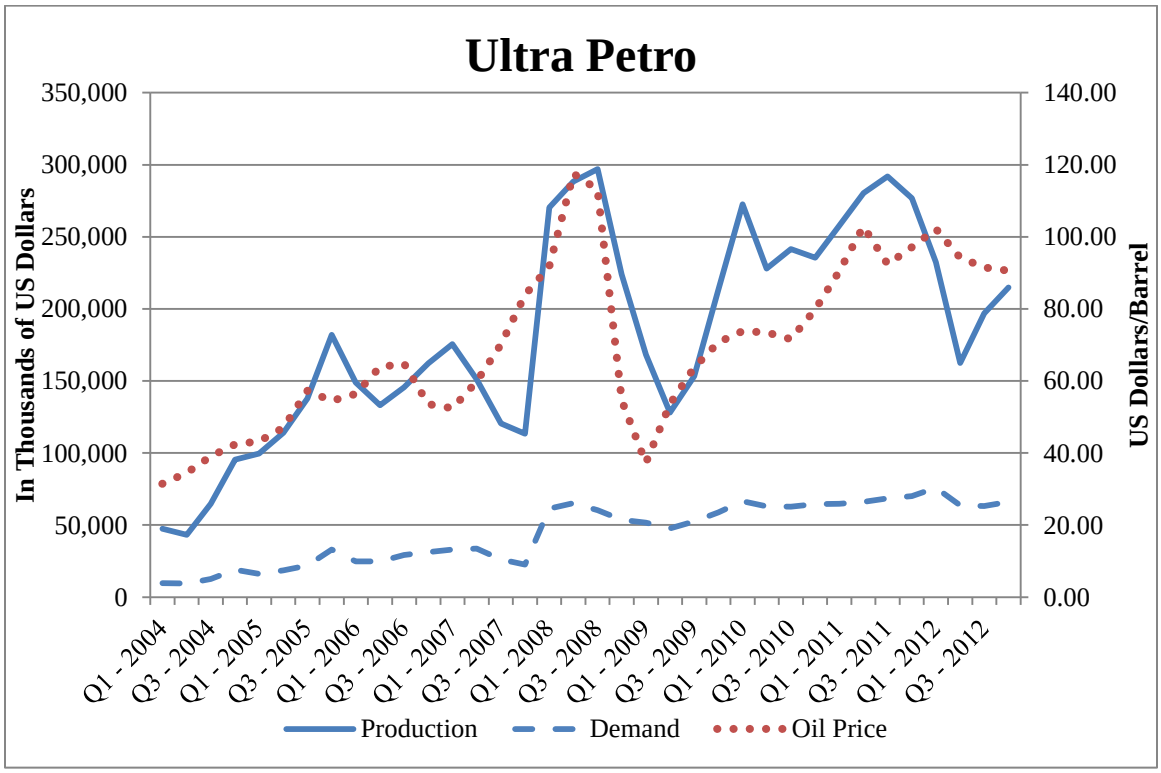

Carrizo Oil & Gas
In Thousands of US Dollars
US Dollars/Barrel
120,000
100,000
80,000
60,000
40,000
20,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

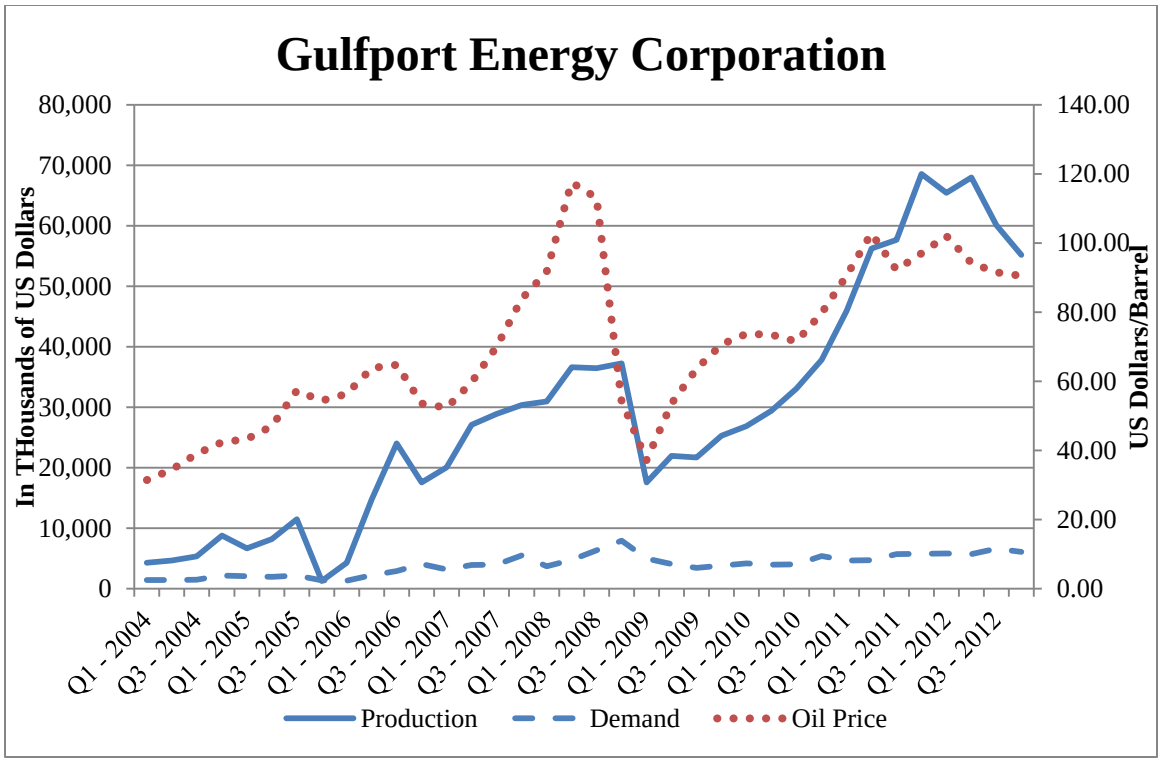

Goodrich
In Thousands of US Dollars
US Dollars/Barrel
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

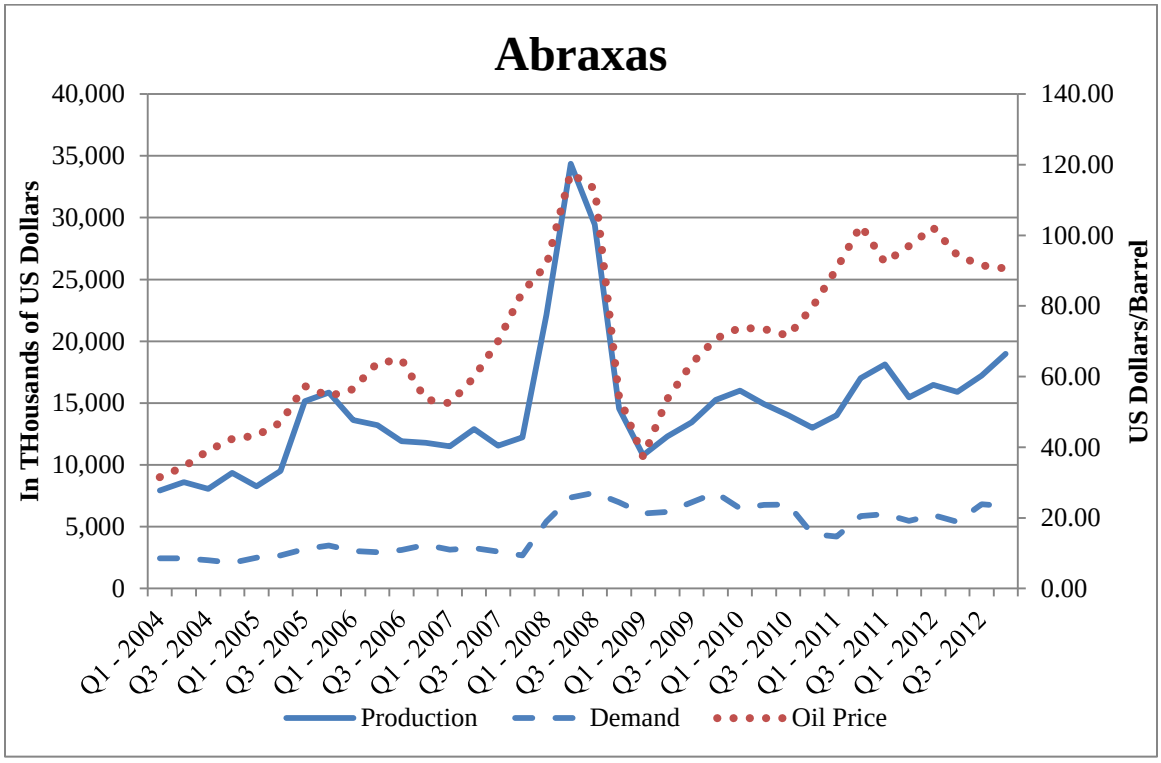

McMoran Exploration
In Thousands of US Dollars
US Dollars/Barrel
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

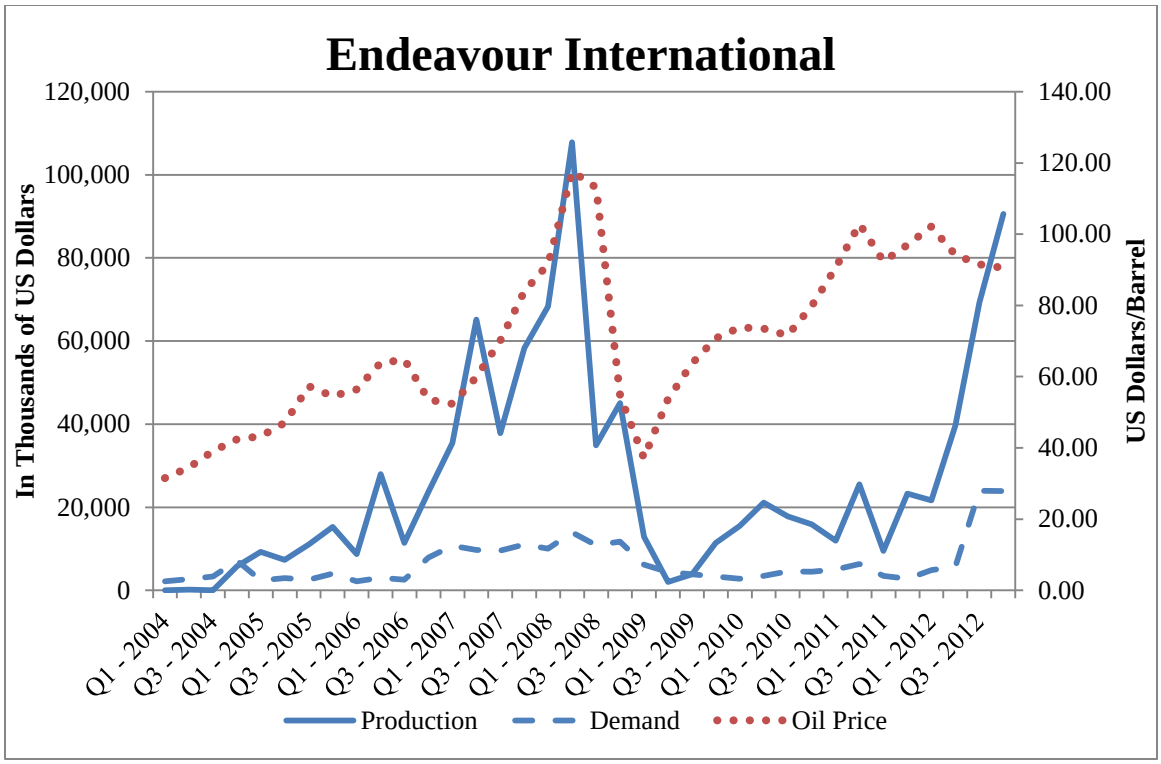

PetroQuest
In Thousands of US Dollars
U Dollars/Barrel
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

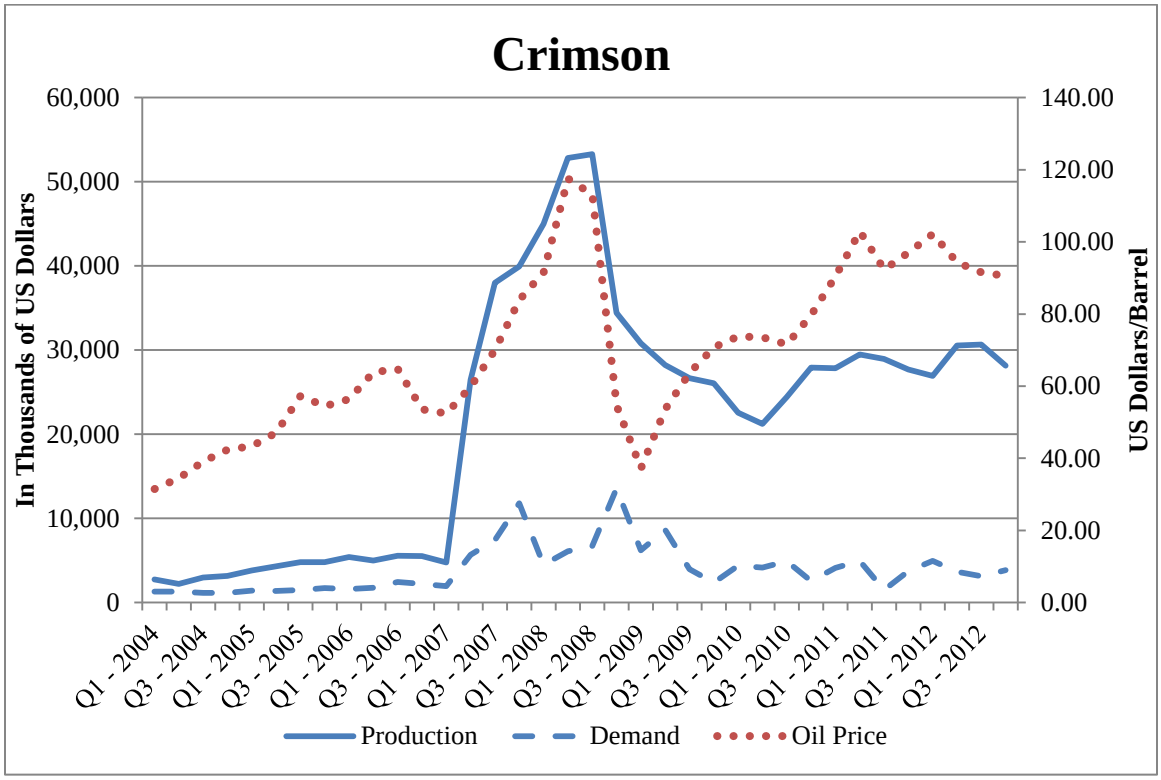

Callon Petroleum Company
In Thousands of US Dollars
US Dollars/Barrel
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

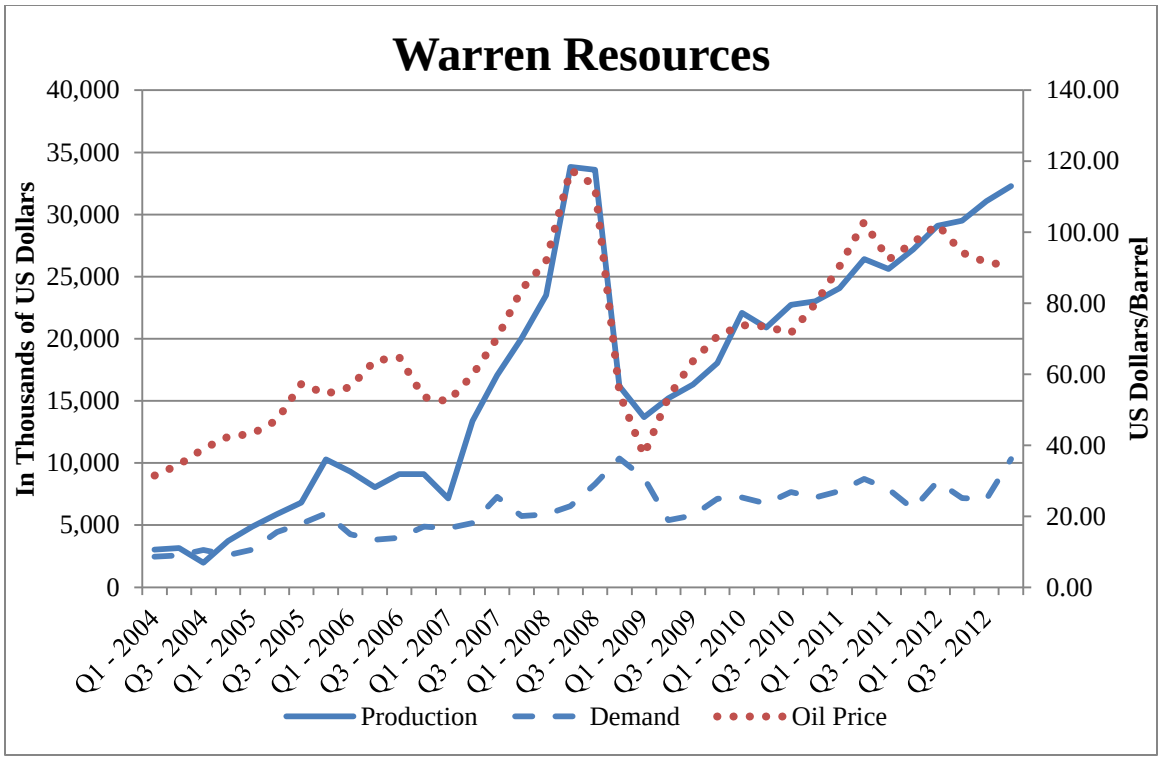

Ultra Petro
In Thousands of US Dollars
US Dollars/Barrel
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

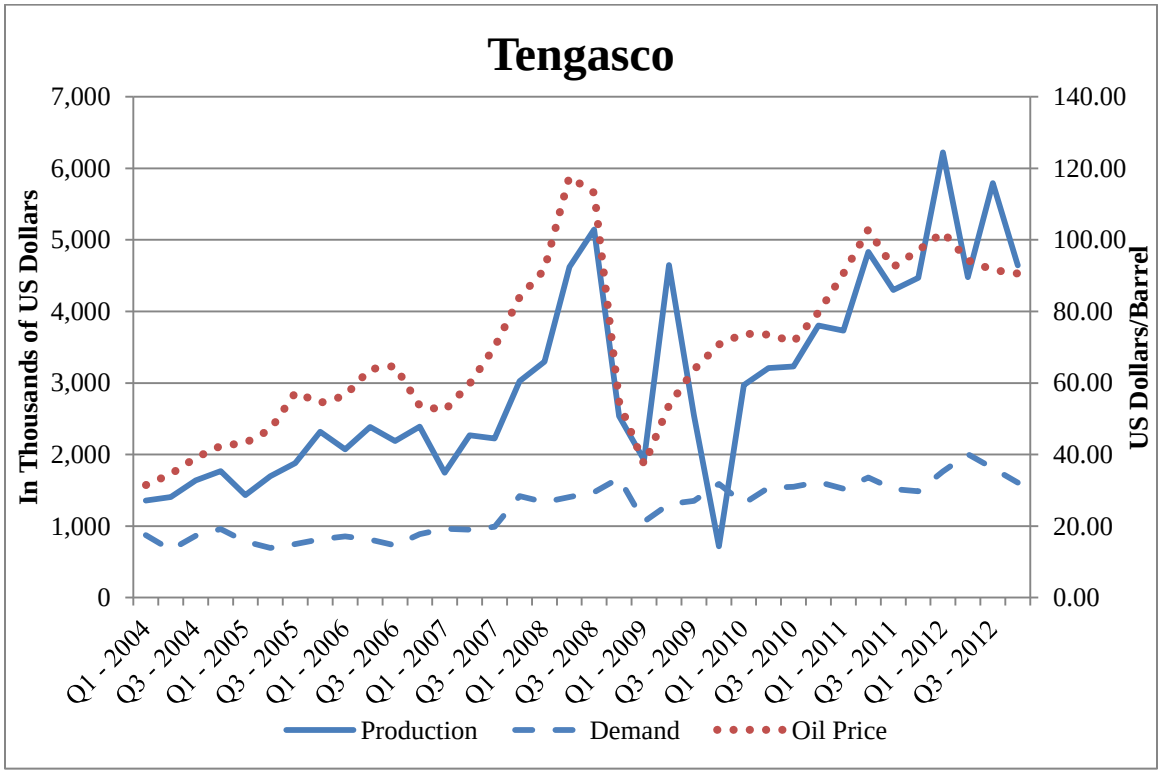

Gulfport Energy Corporation
In THousands of US Dollars
US Dollars/Barrel
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

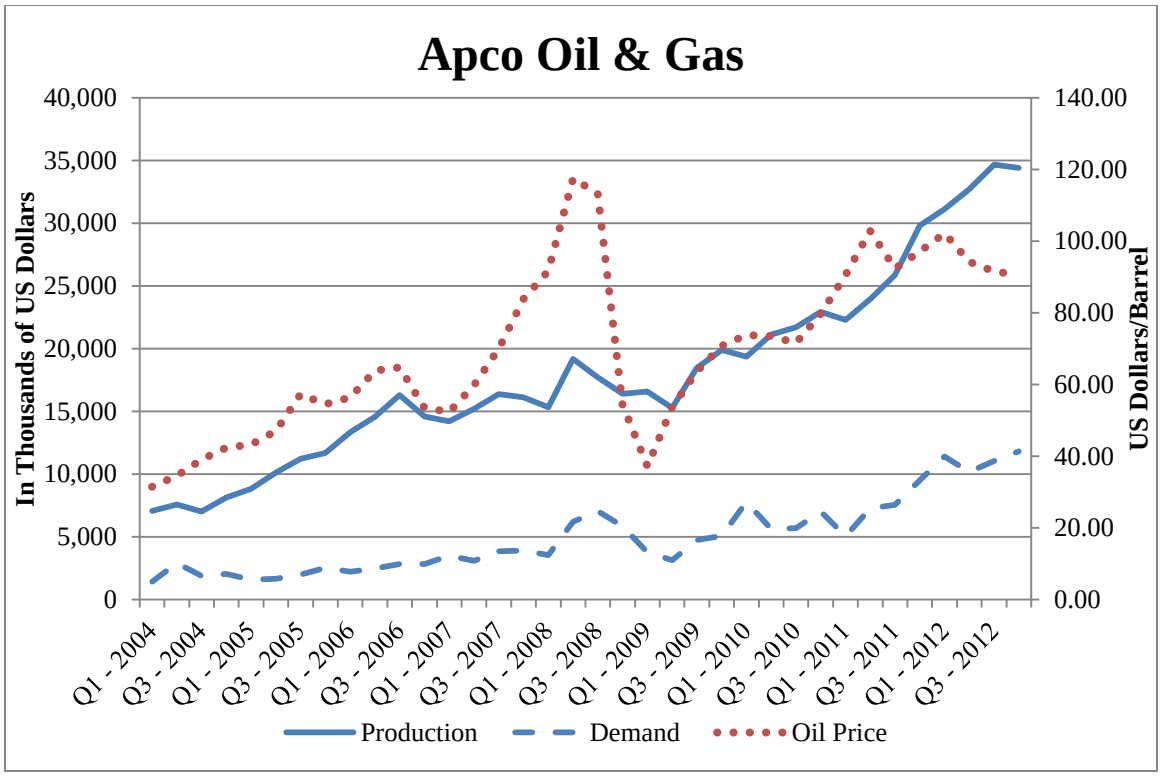

Abraxas
In THousands of US Dollars
US Dollars/Barrel
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

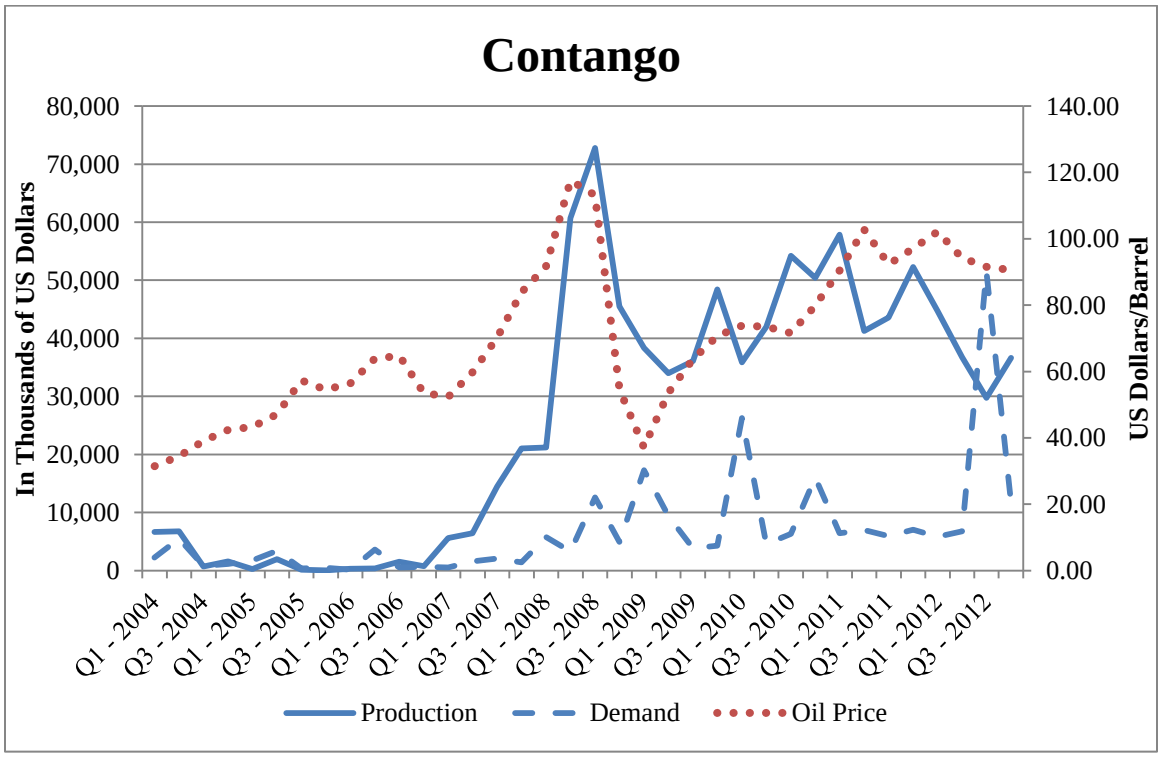

Endeavour International
In Thousands of US Dollars
US Dollars/Barrel
120,000
100,000
80,000
60,000
40,000
20,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price


Crimson
In Thousands of US Dollars
US Dollars/Barrel
60,000
50,000
40,000
30,000
20,000
10,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

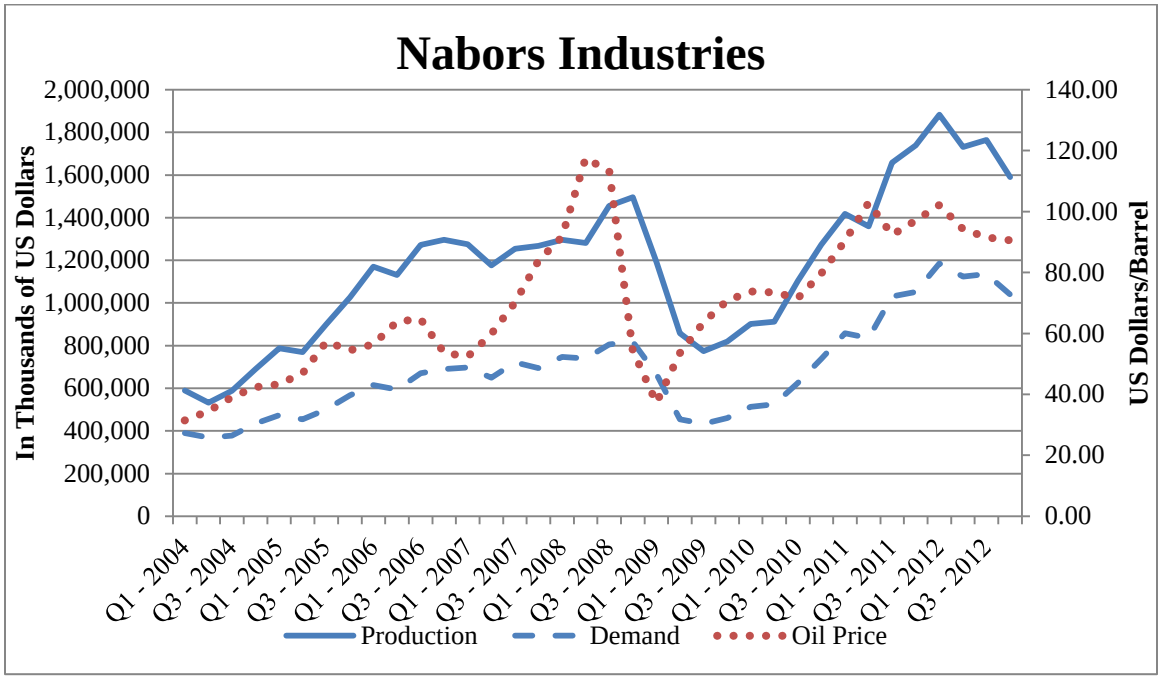

Warren Resources
In Thousands of US Dollars
US Dollars/Barrel
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

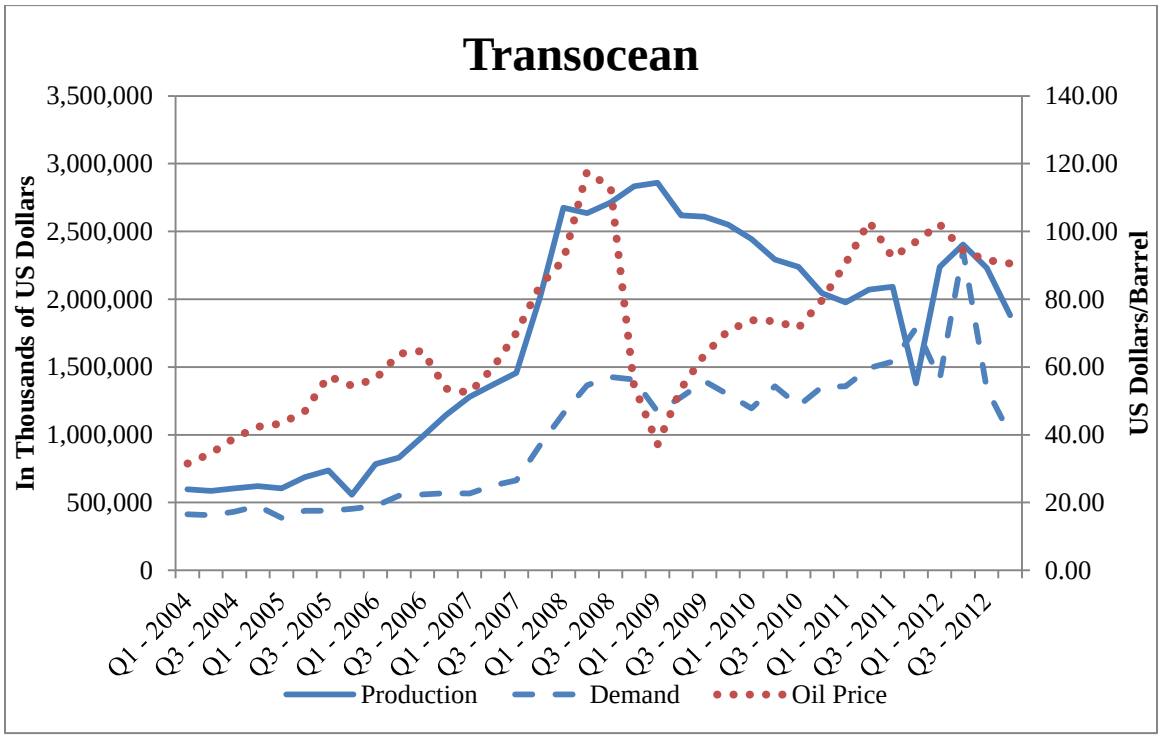

Tengasco
In Thousands of US Dollars
US Dollars/Barrel
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

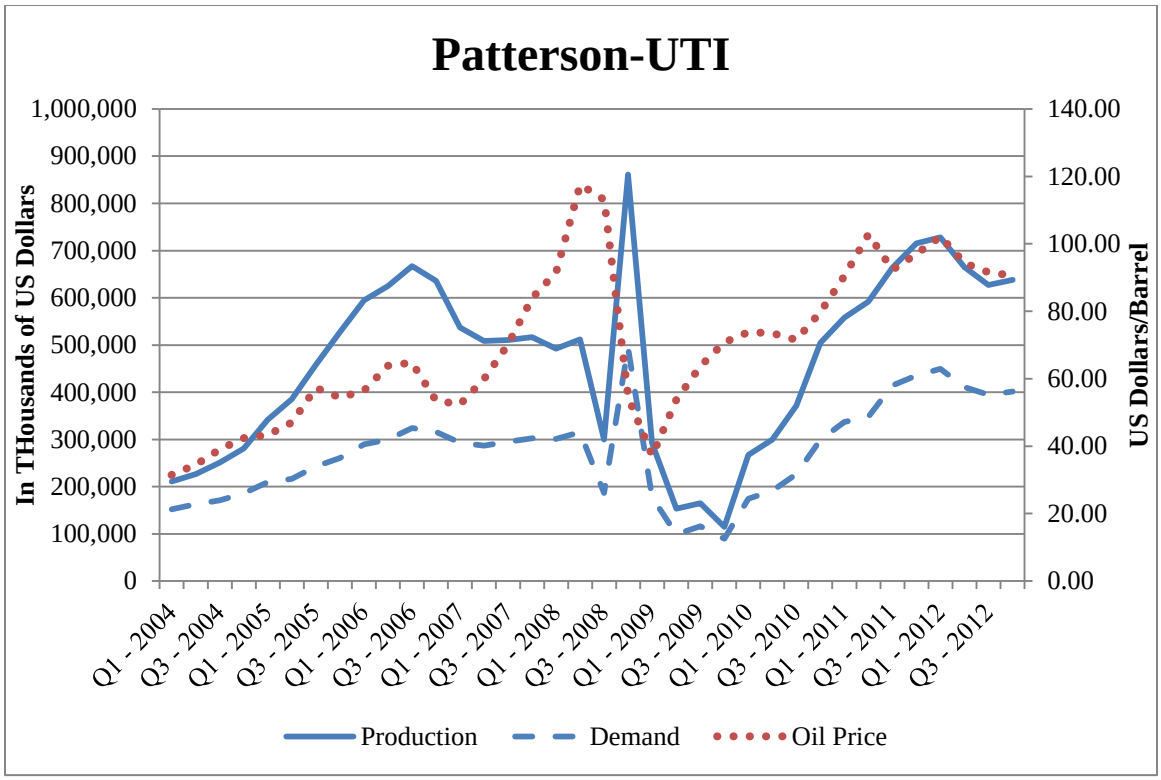

Apco Oil & Gas
In Thousands of US Dollars
US Dollars/Barrel
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

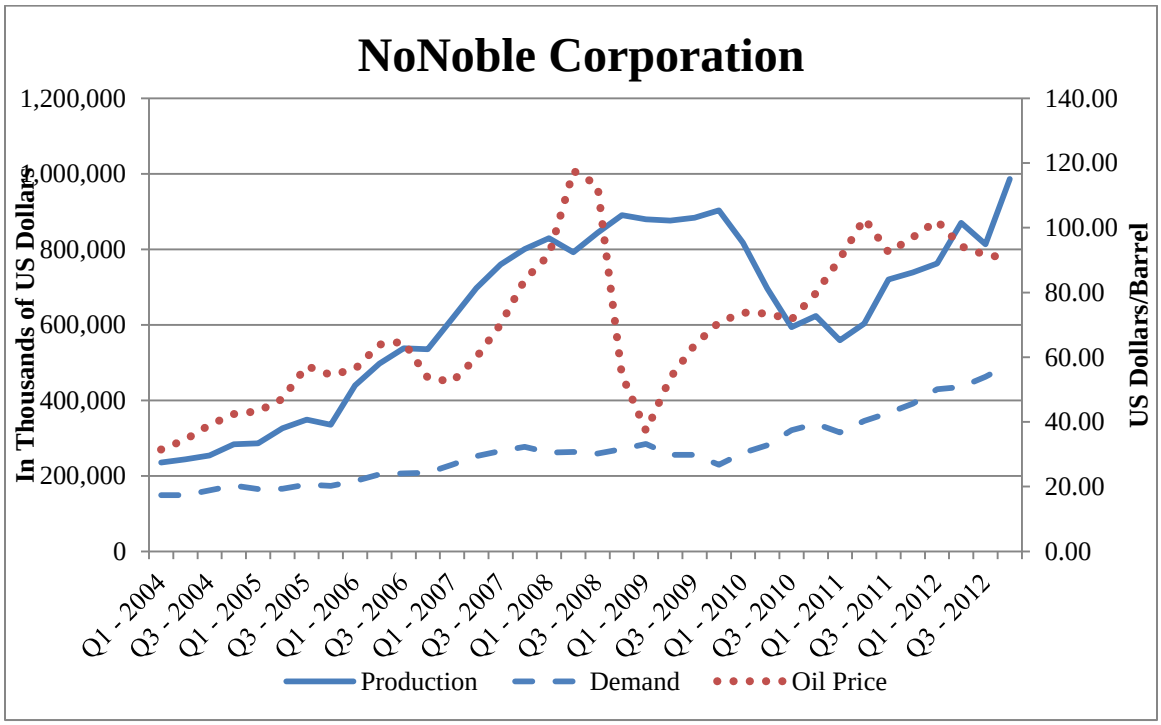

Contango
In Thousands of US Dollars
US Dollars/Barrel
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

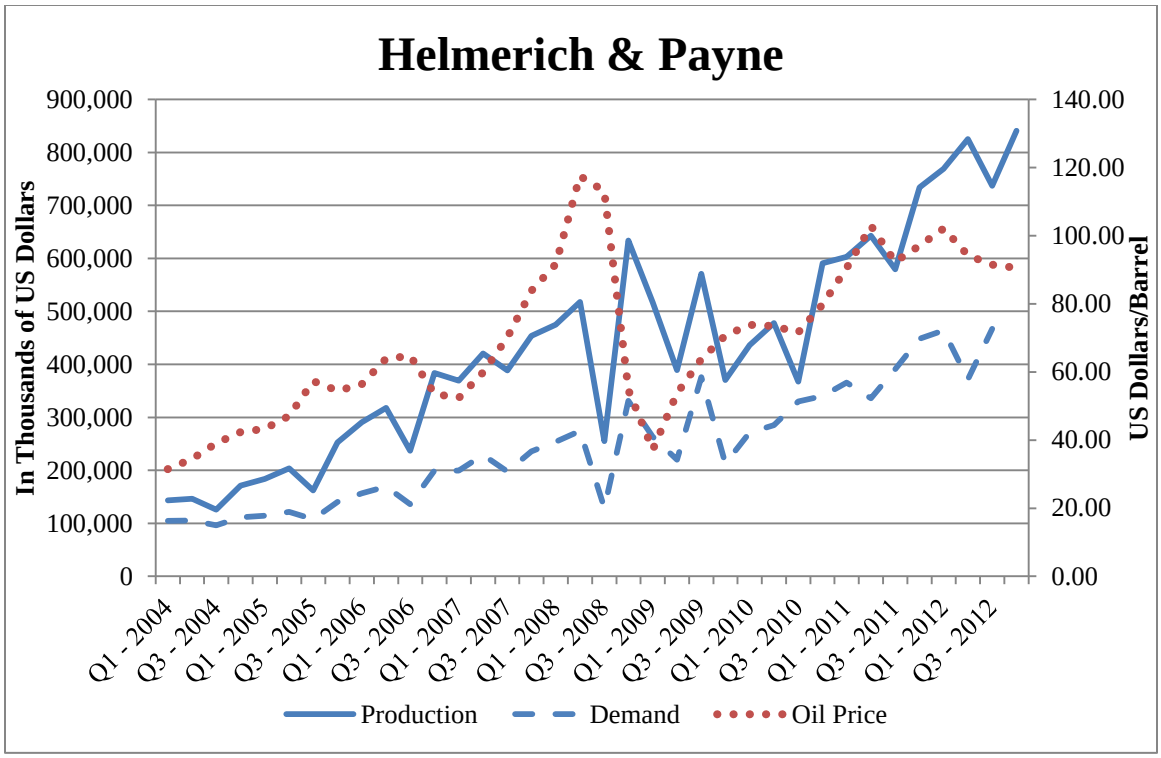
Appendix 4. Plotted Production and Demand Graphs of Each Company in the Drilling Level

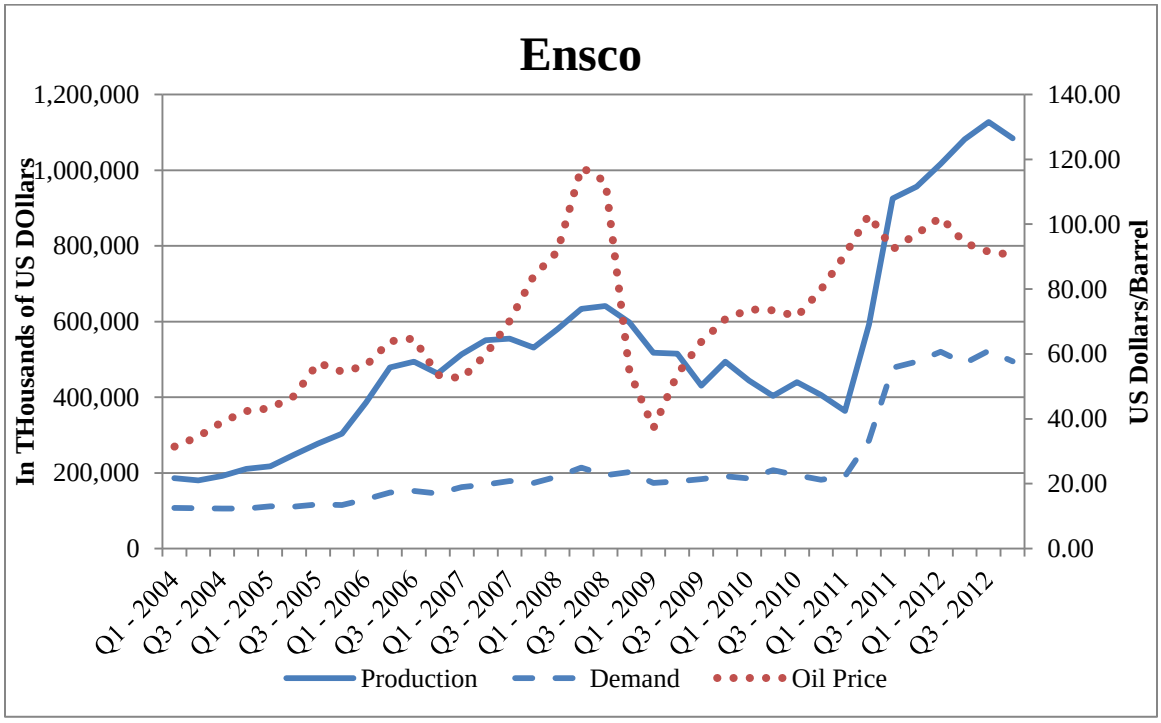


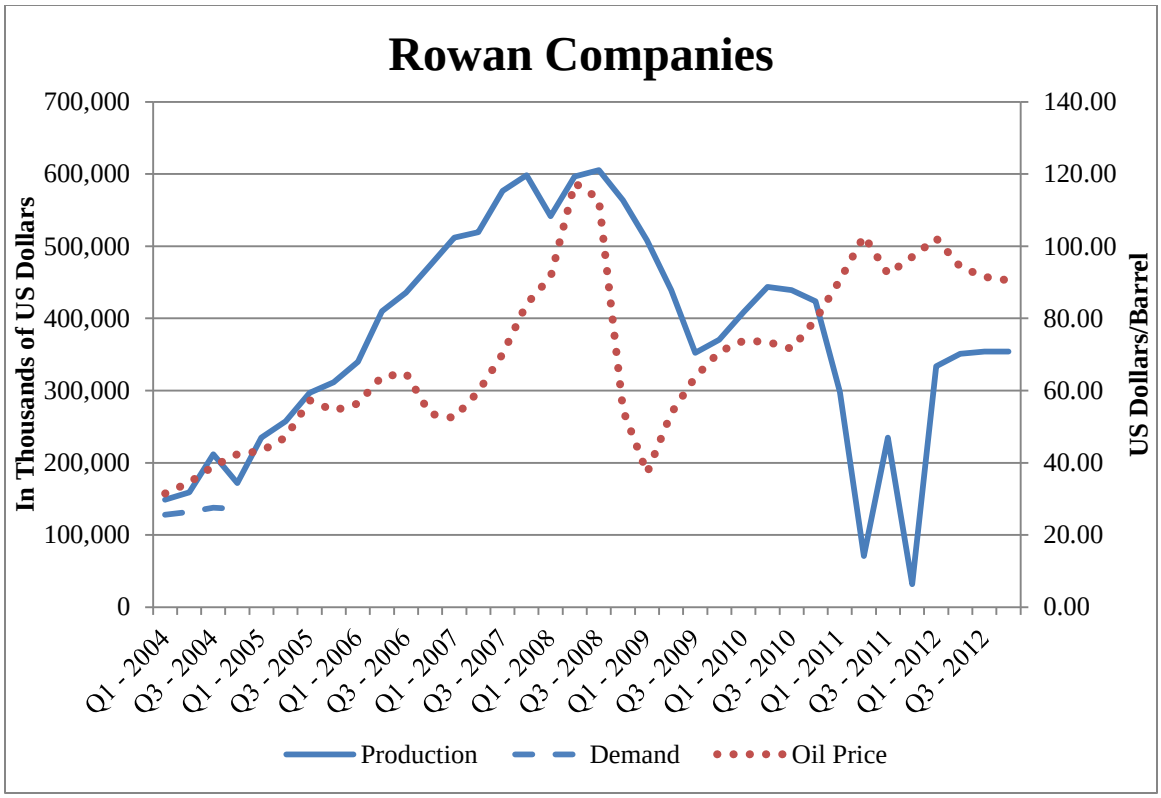



Patterson-UTI
In THousands of US Dollars
US Dollars/Barrel
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

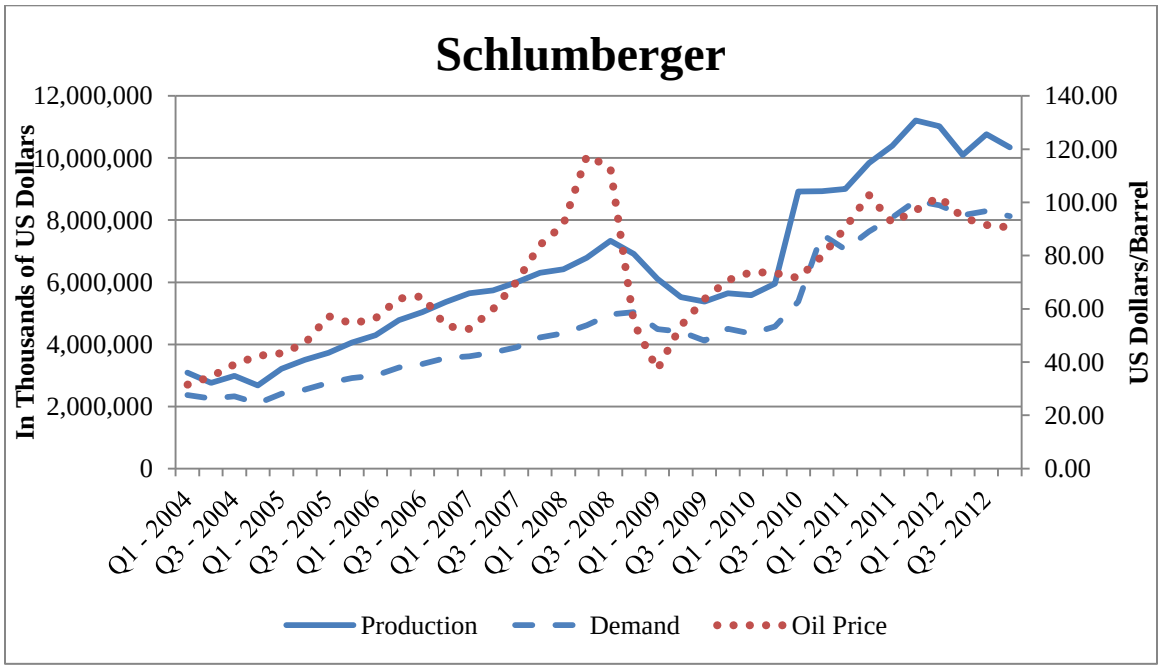

NoNoble Corporation
In Thousands of US Dollars
US Dollars/Barrel
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

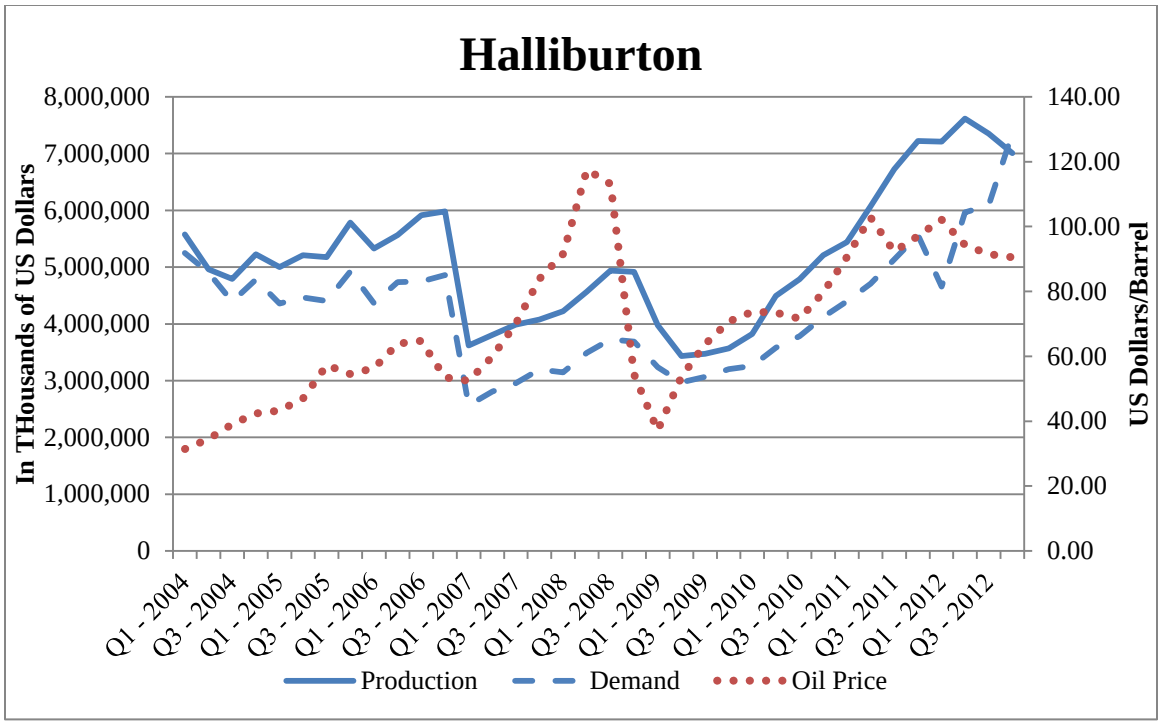

Helmerich & Payne
In Thousands of US Dollars
US Dollars/Barrel
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

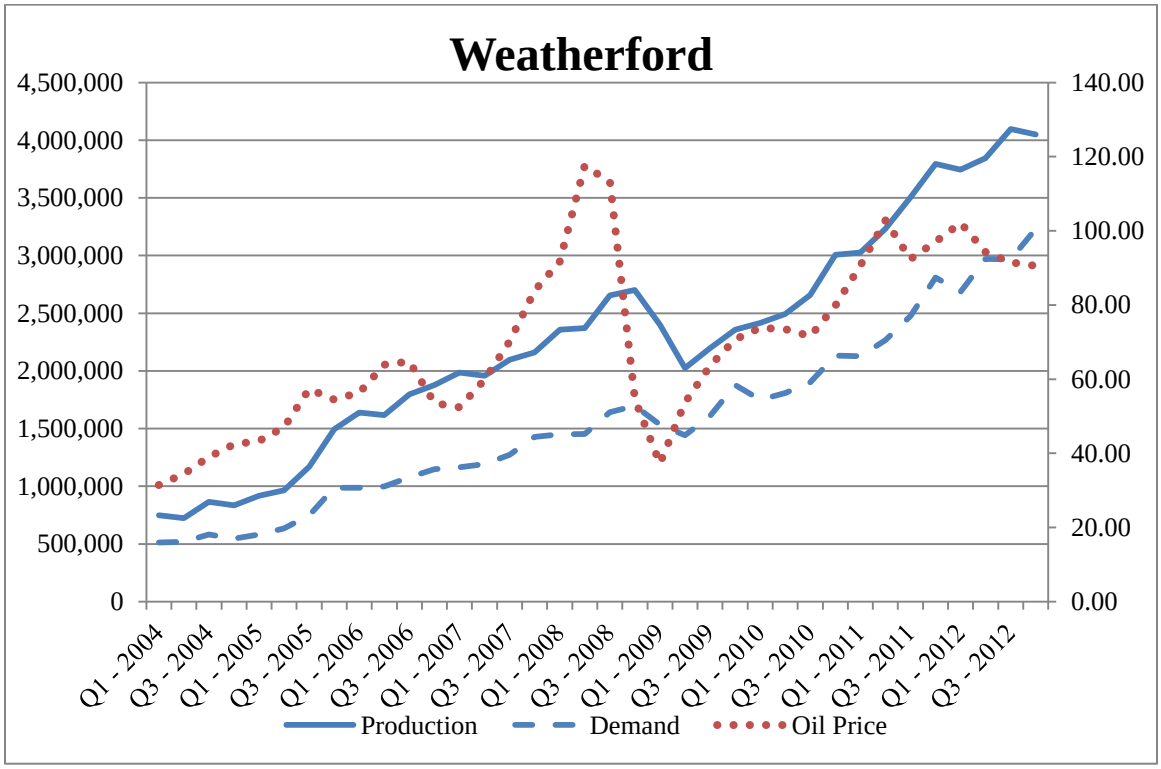

Ensco
In THousands of US DOllars
US Dollars/Barrel
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

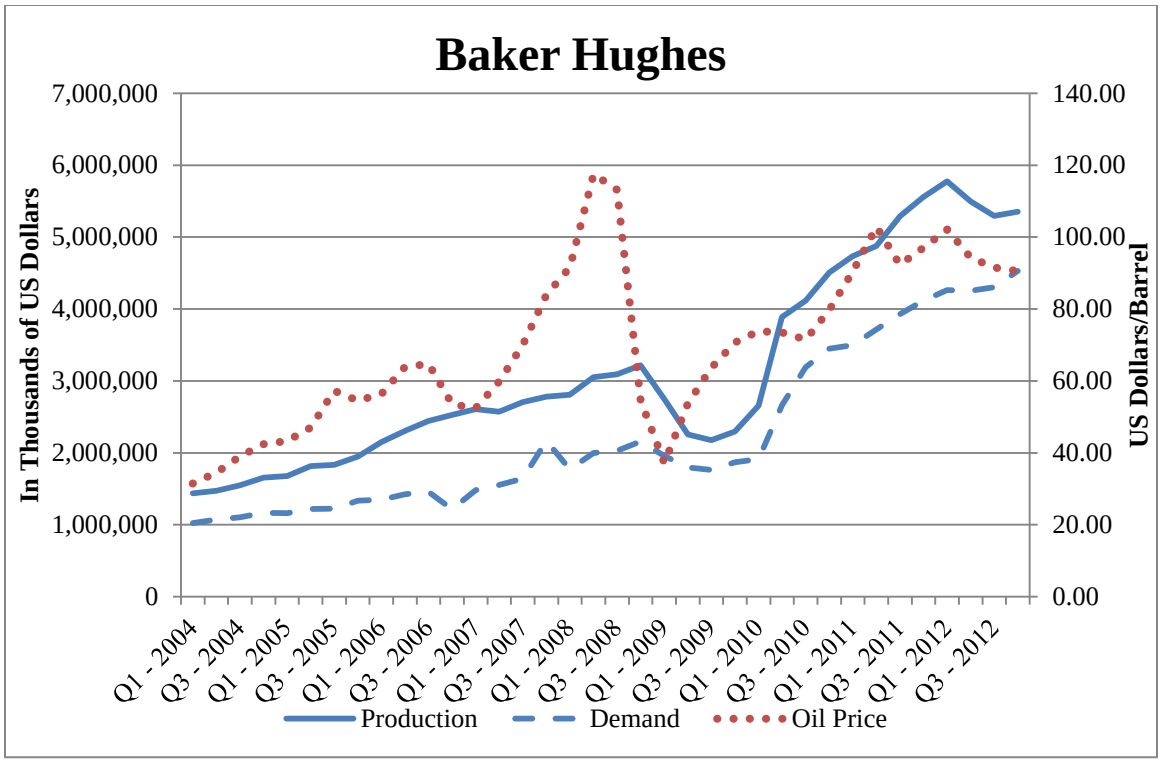


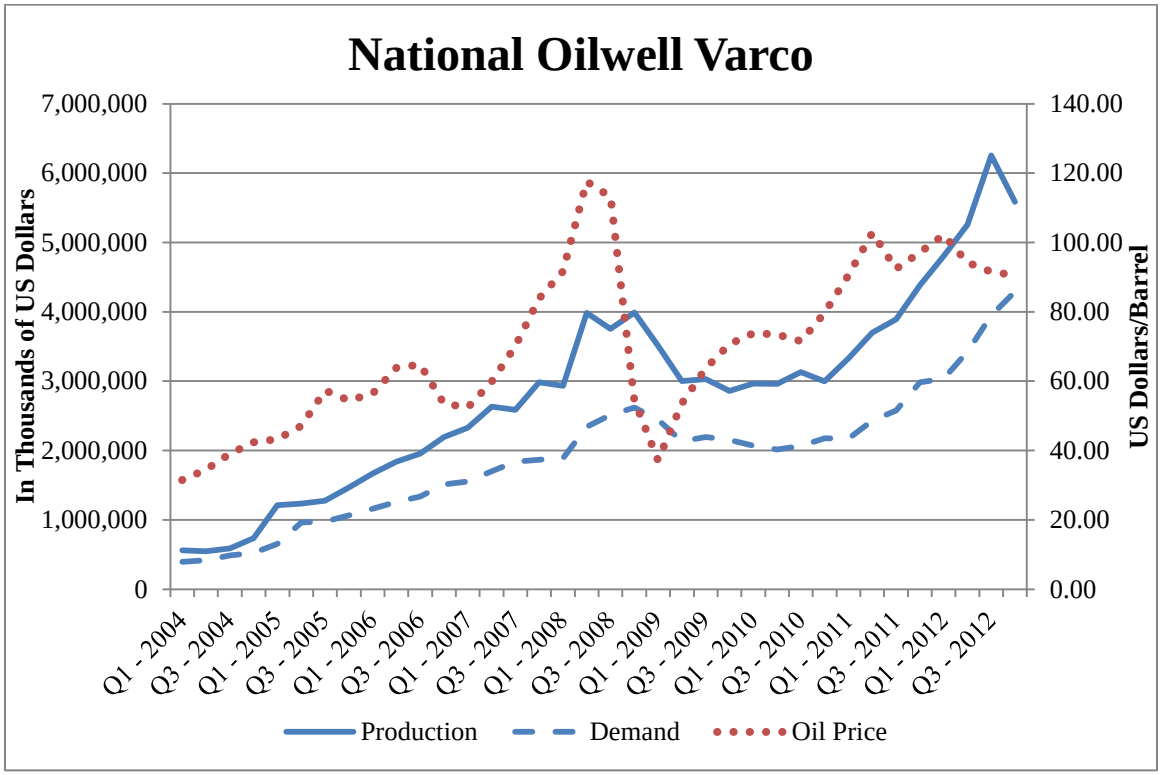
Appendix 5. Plotted Production and Demand Graphs of Each Company in the Service and Equipment Level

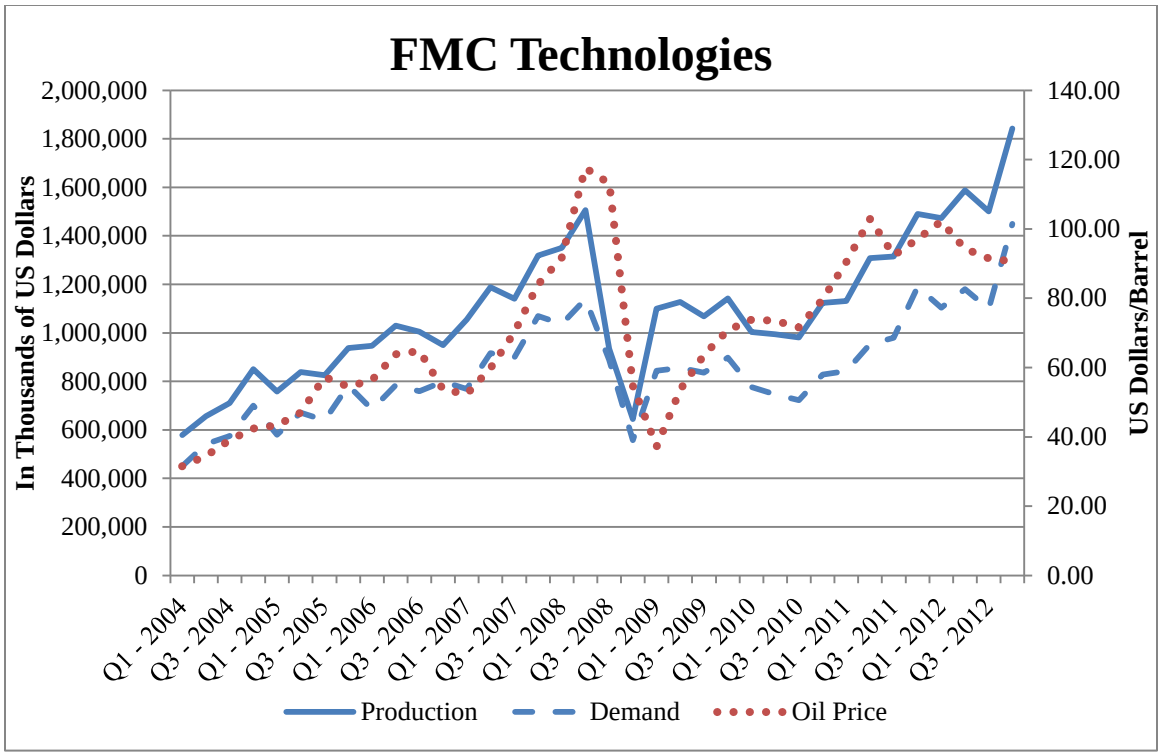


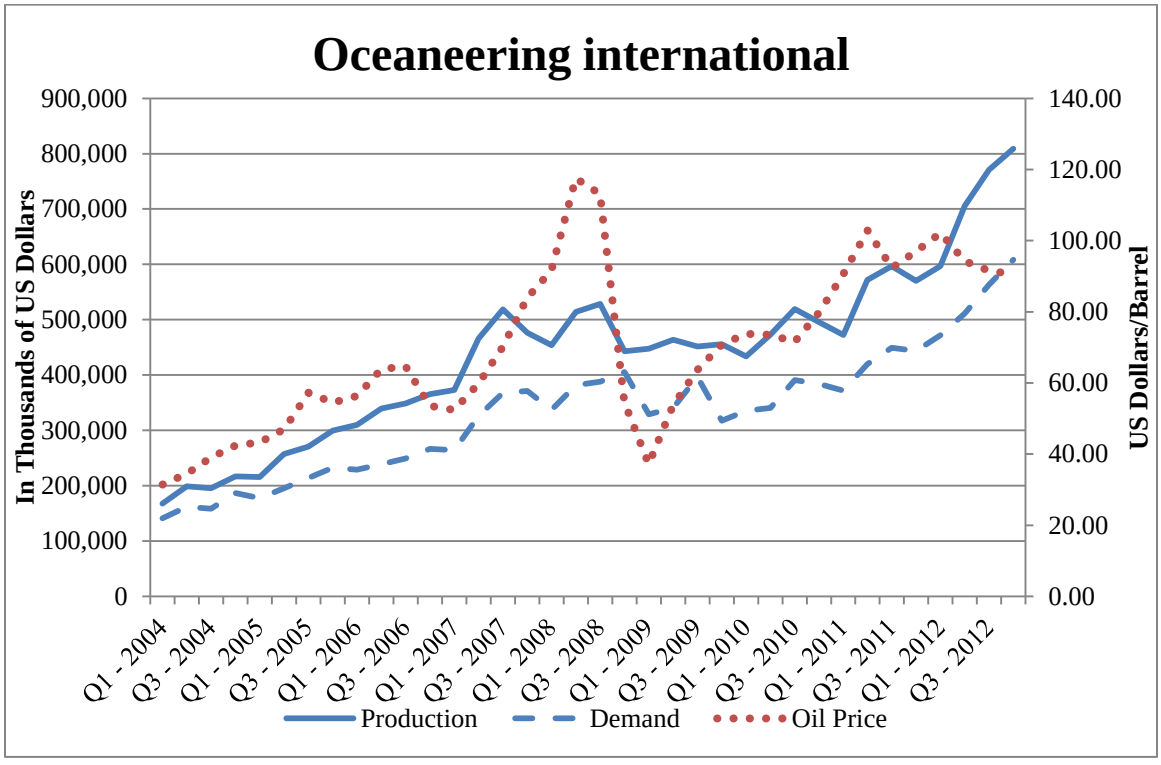

Halliburton
In THousands of US Dollars
US Dollars/Barrel
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

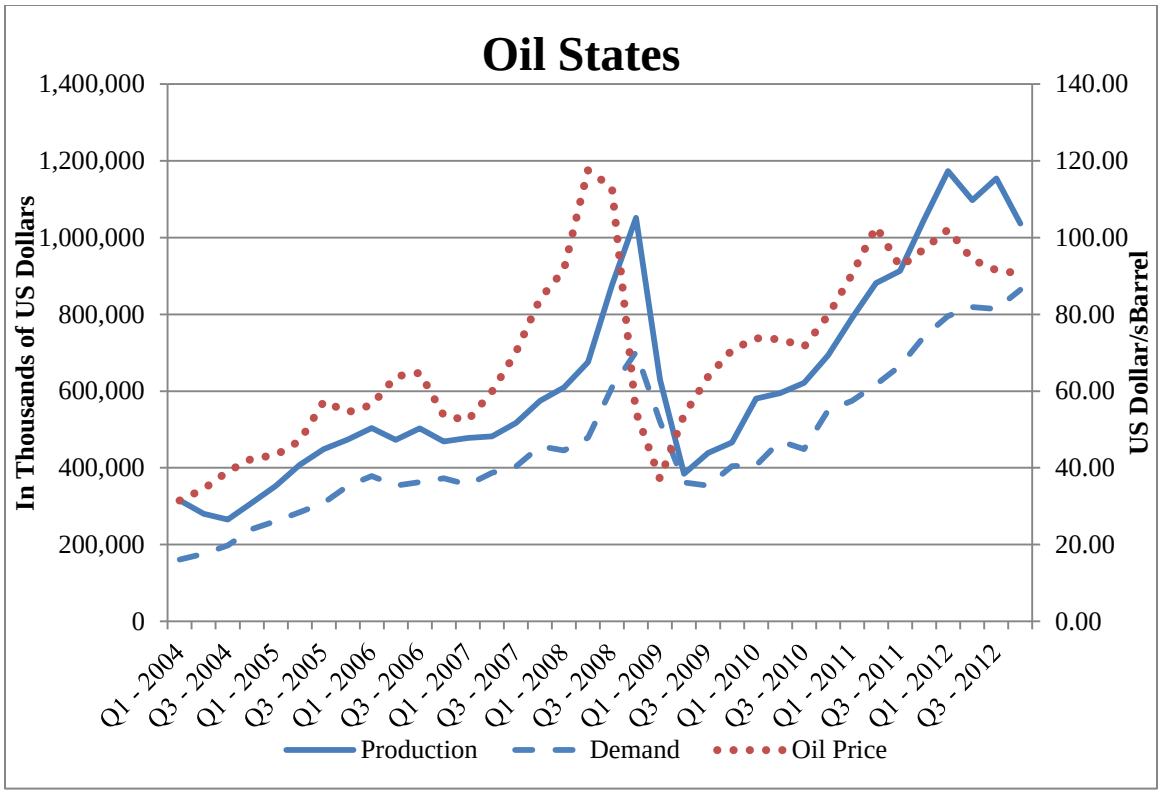

Weatherford
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

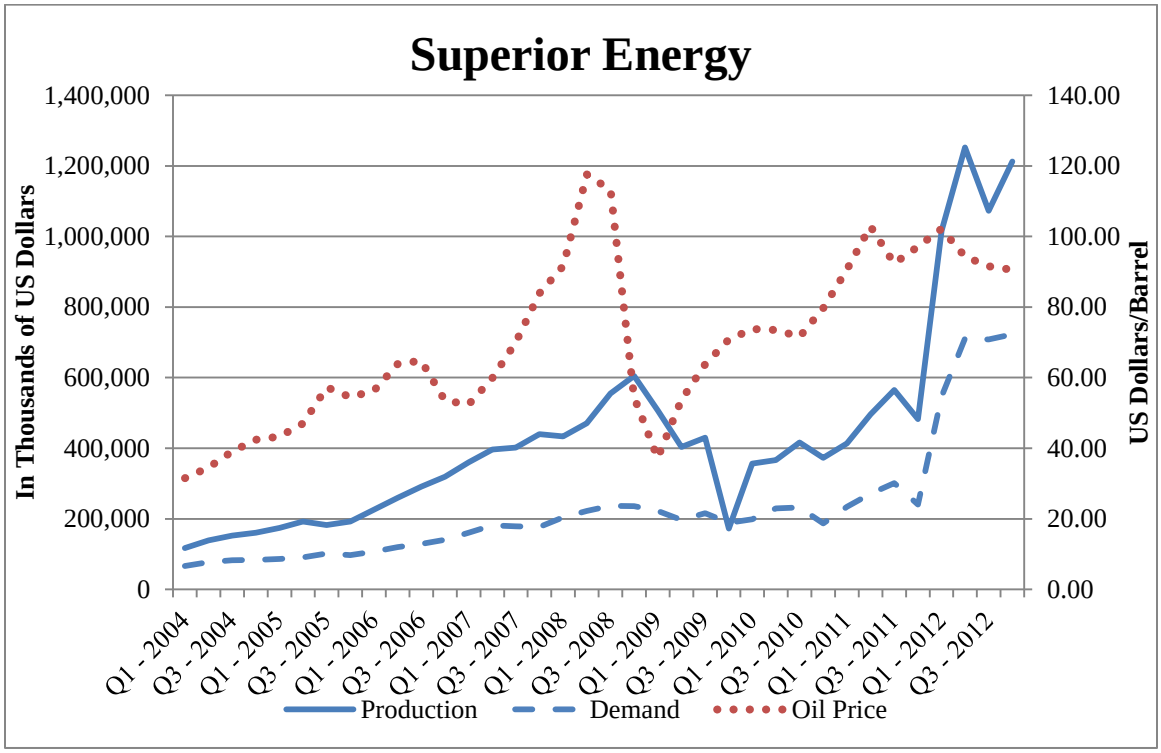

Baker Hughes
In Thousands of US Dollars
US Dollars/Barrel
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

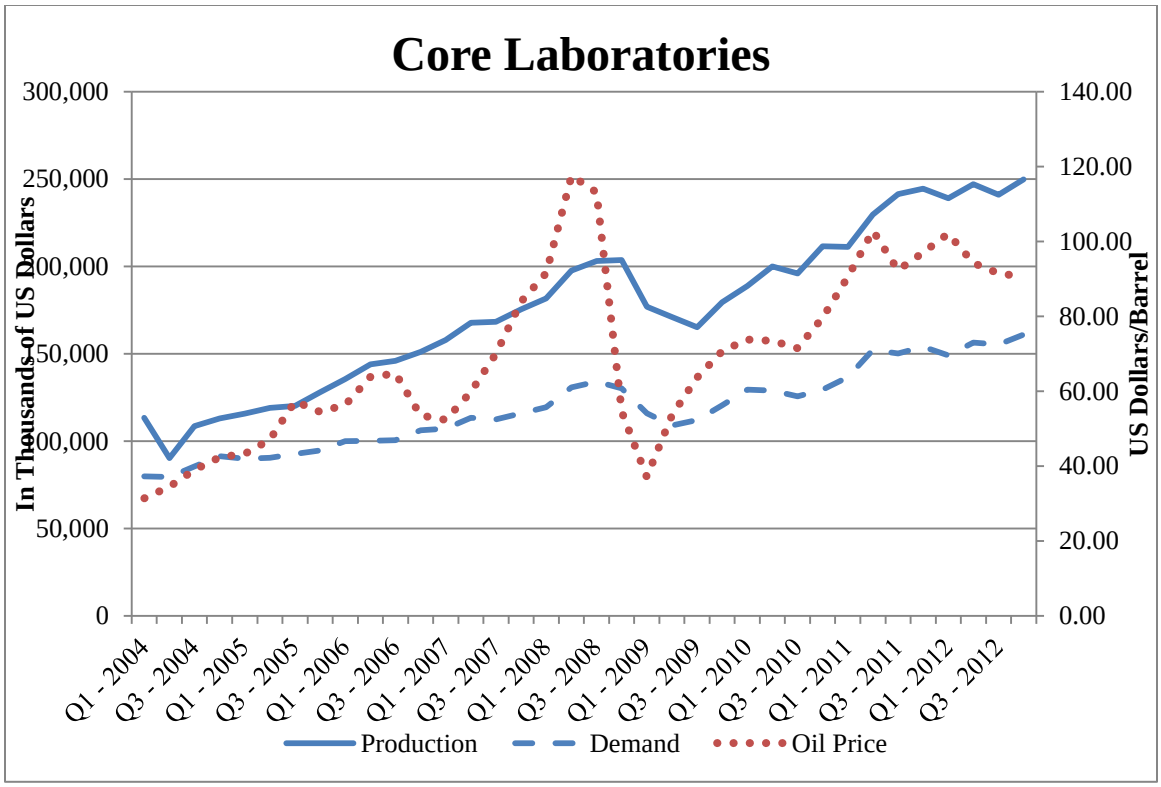

National Oilwell Varco
In Thousands of US Dollars
US Dollars/Barrel
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

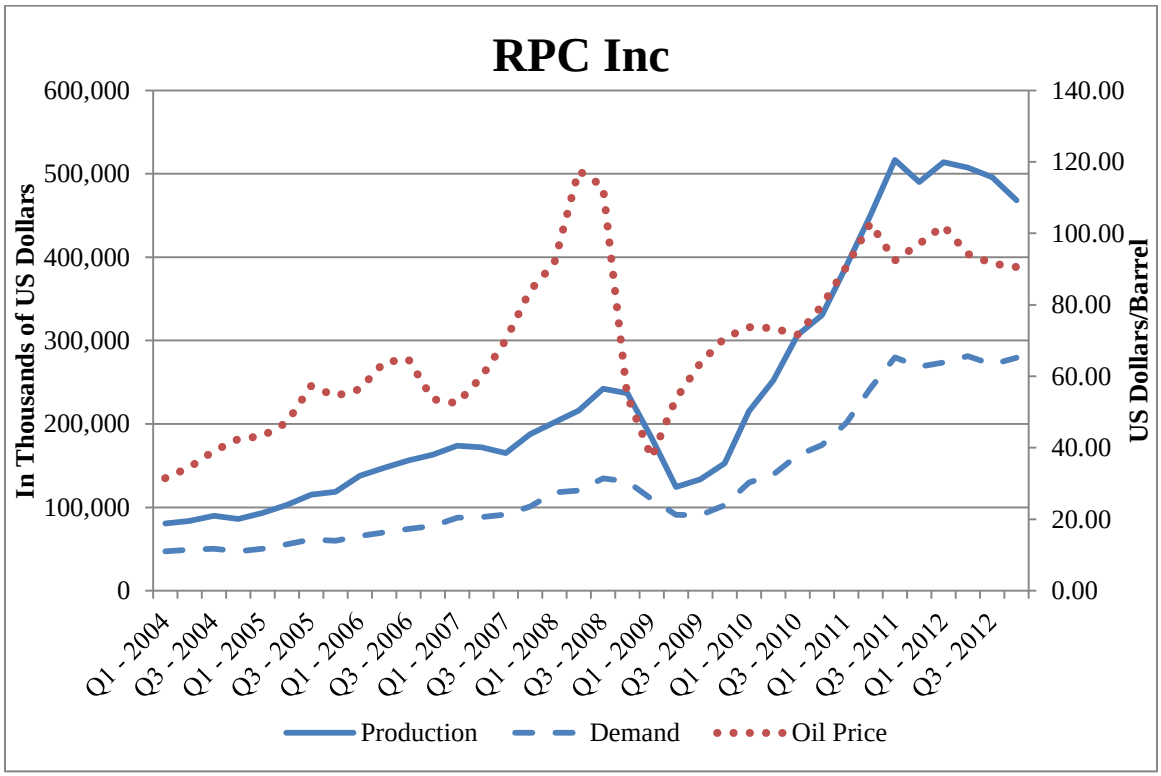

FMC Technologies
In Thousands of US Dollars
US Dollars/Barrel
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

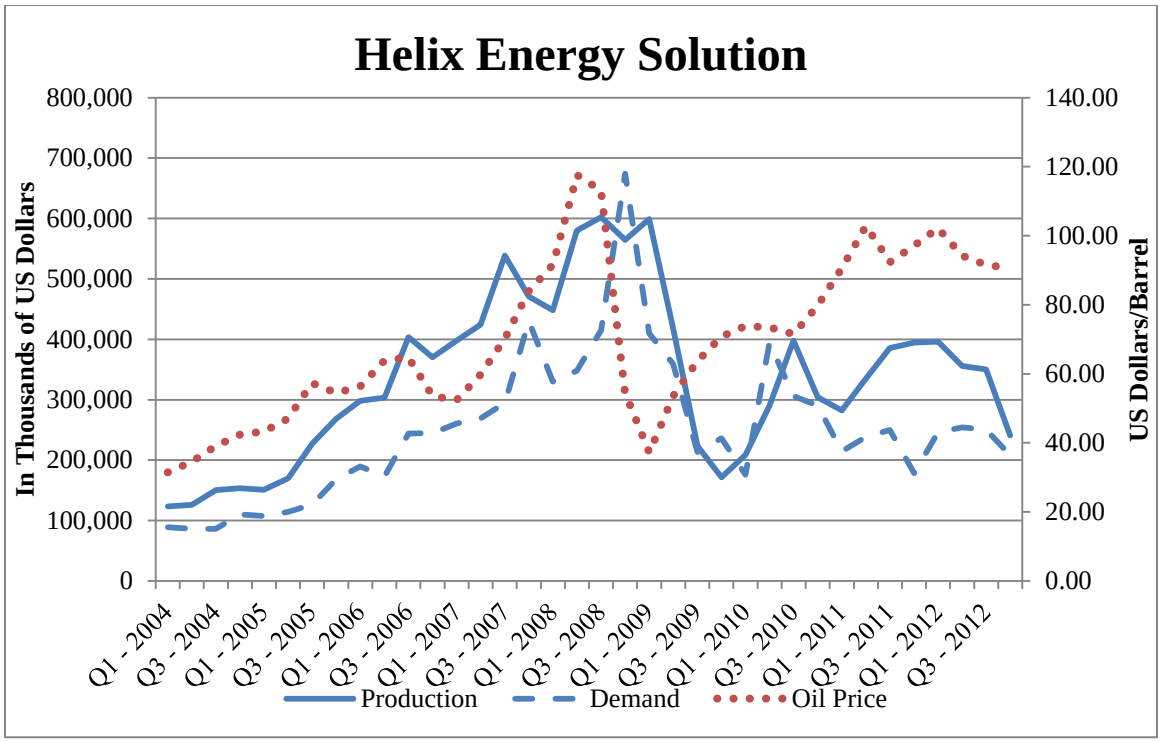

Oceaneering international
In Thousands of US Dollars
US Dollars/Barrel
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

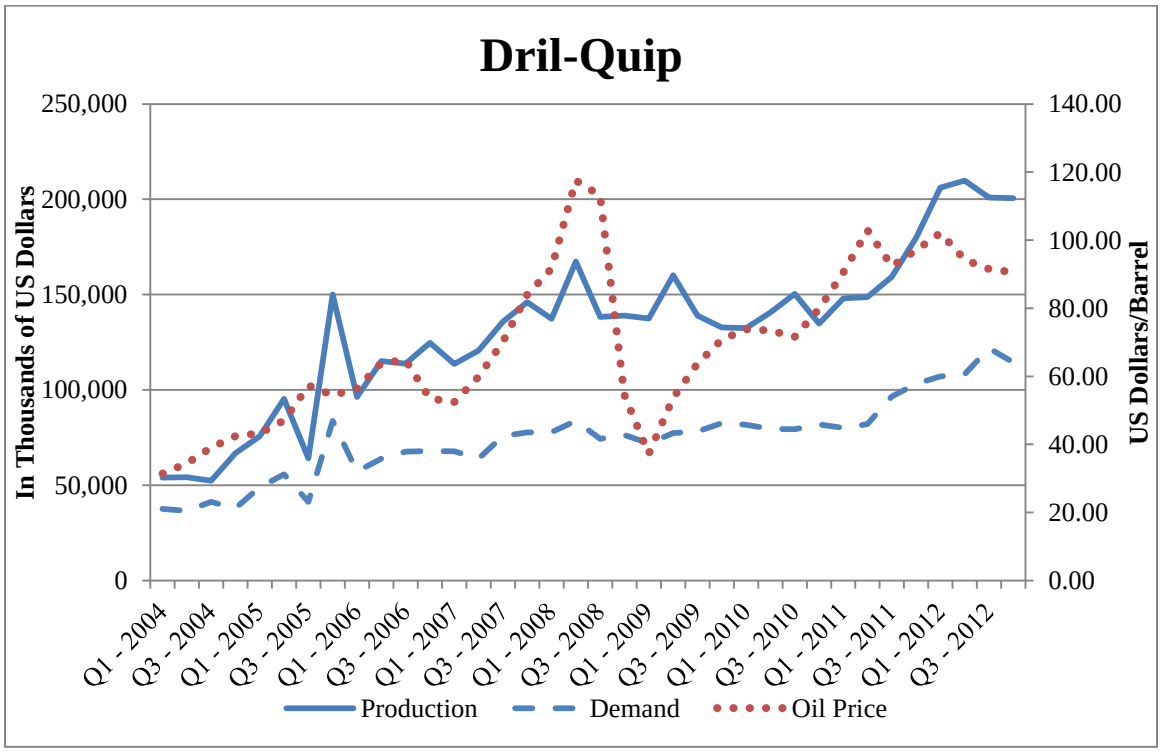

Oil States
In Thousands of US Dollars
US Dollar/sBarrel
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

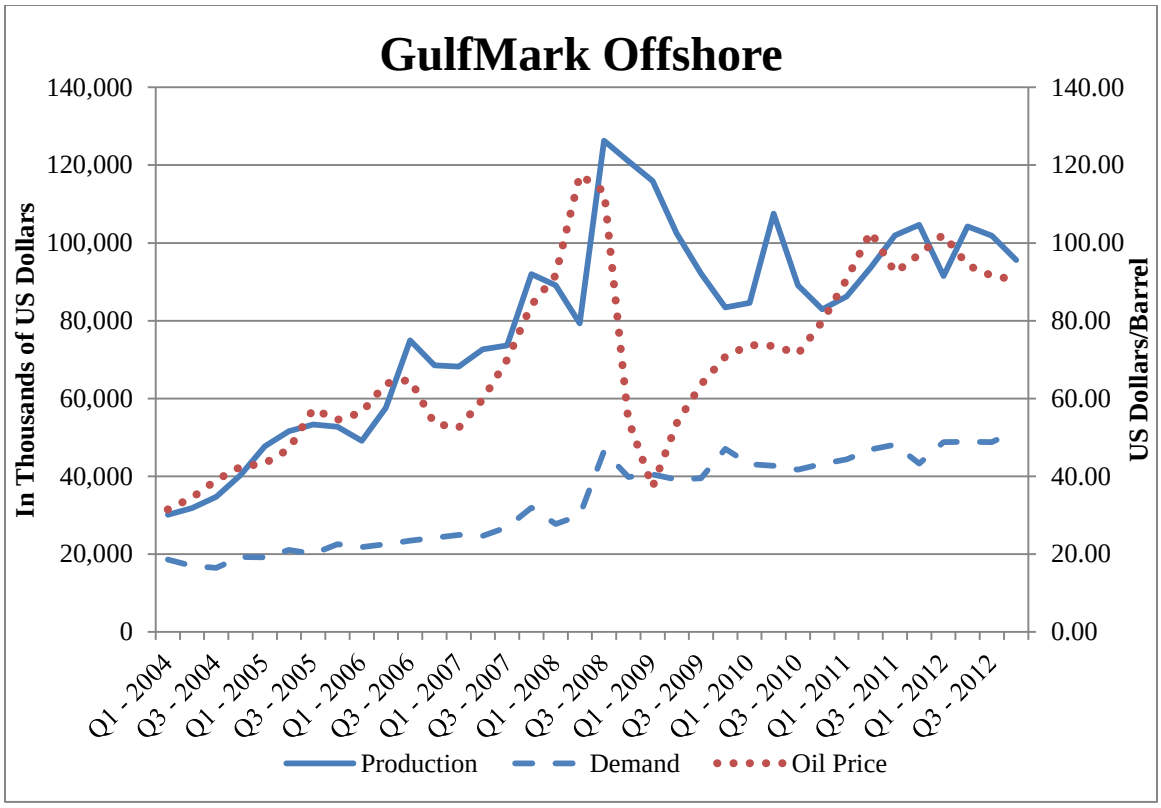

Superior Energy
In Thousands of US Dollars
US Dollars/Barrel
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

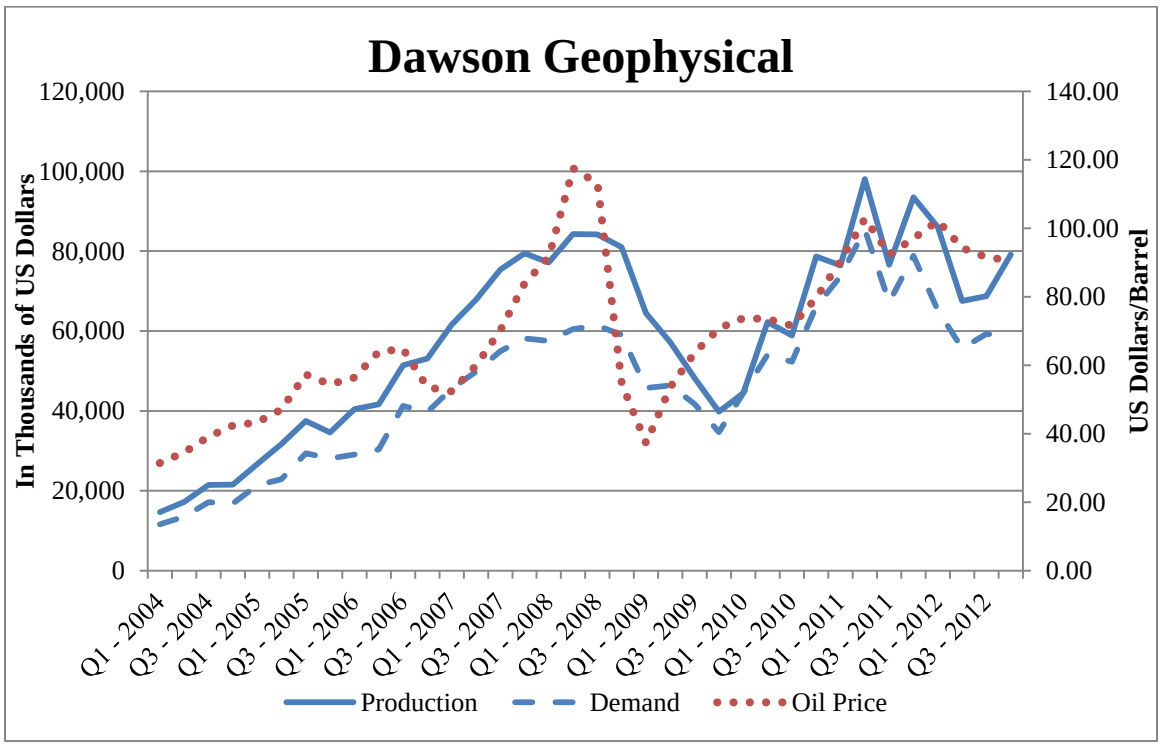

Core Laboratories
In Thousands of US Dollars
US Dollars/Barrel
300,000
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

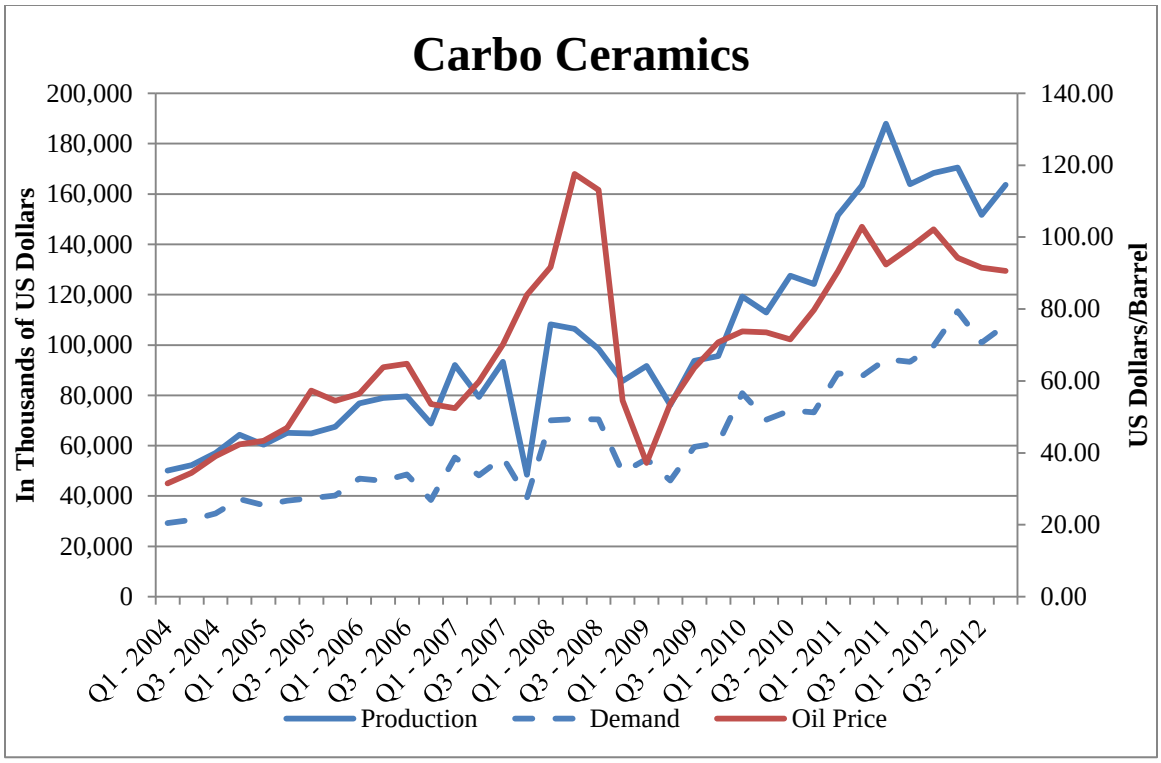

RPC Inc
In Thousands of US Dollars
US Dollars/Barrel
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

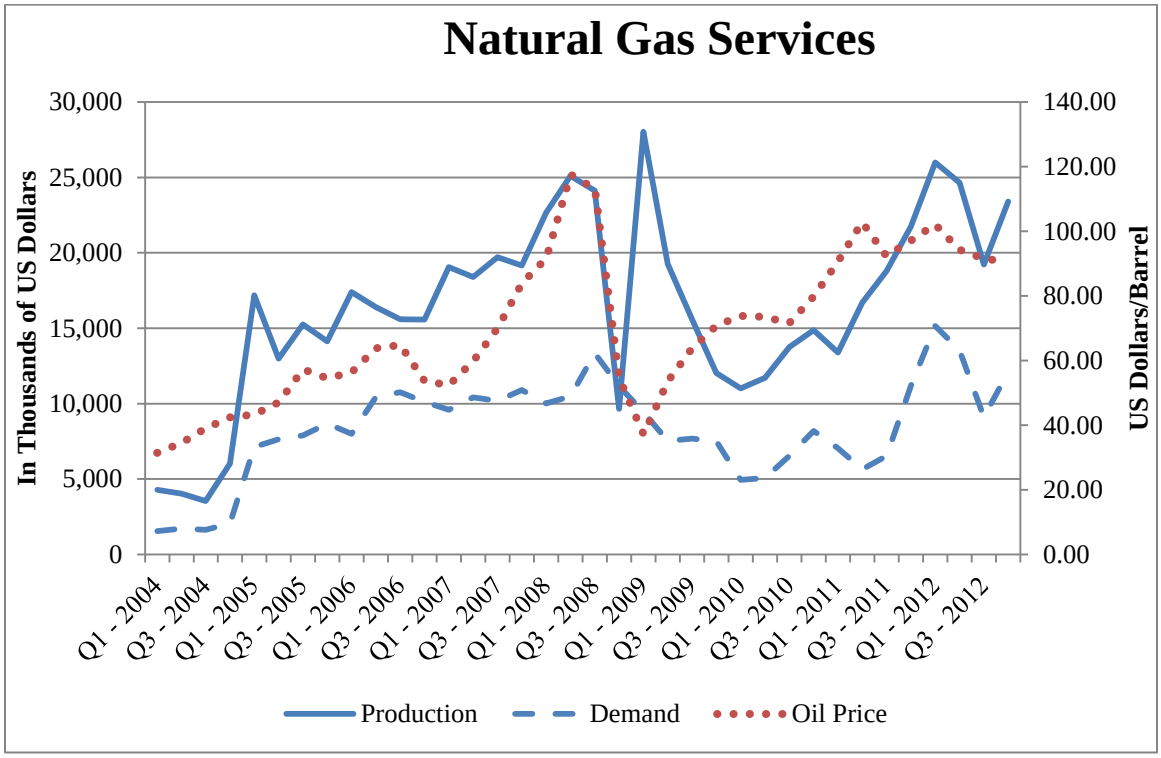

Helix Energy Solution
In Thousands of US Dollars
US Dollars/Barrel
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

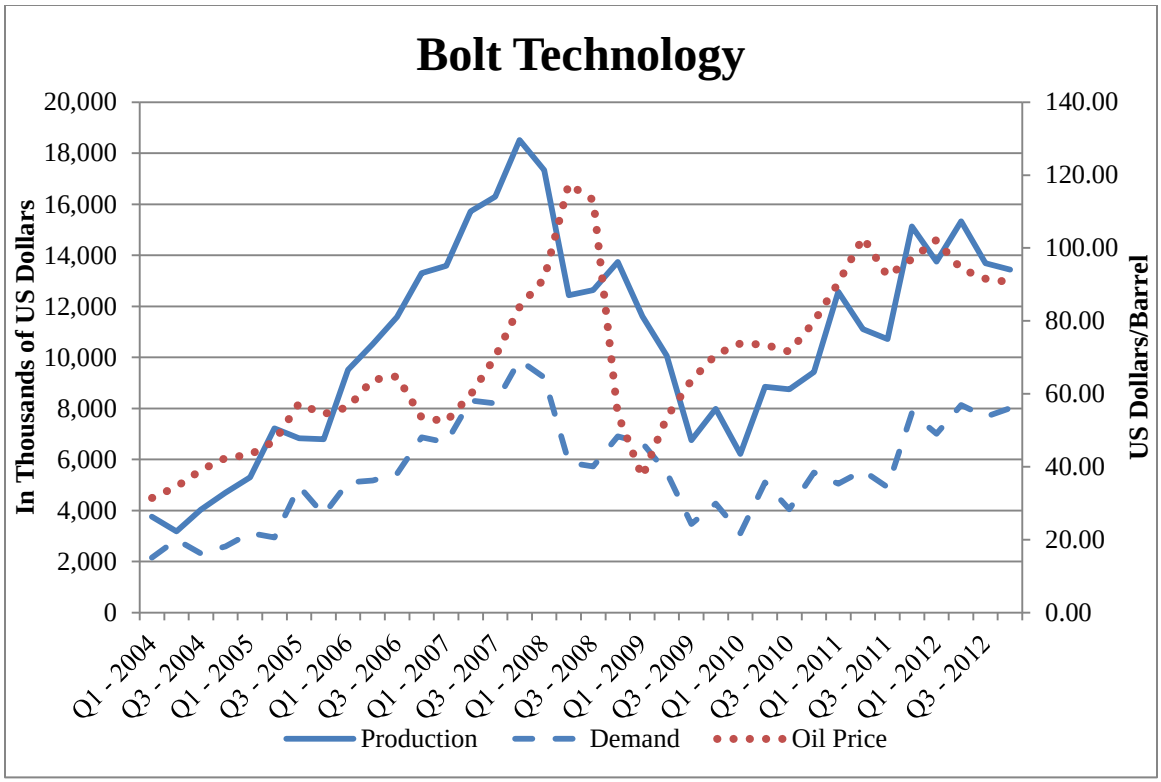

Dril-Quip
In Thousands of US Dollars
US Dollars/Barrel
250,000
200,000
150,000
100,000
50,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price


GulfMark Offshore
In Thousands of US Dollars
US Dollars/Barrel
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price


Dawson Geophysical
In Thousands of US Dollars
US Dollars/Barrel
120,000
100,000
80,000
60,000
40,000
20,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price


Carbo Ceramics
In Thousands of US Dollars
US Dollars/Barrel
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price


Natural Gas Services
In Thousands of US Dollars
US Dollars/Barrel
30,000
25,000
20,000
15,000
10,000
5,000
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Q1 - 2004
Q3 - 2004
Q1 - 2005
Q3 - 2005
Q1 - 2006
Q3 - 2006
Q1 - 2007
Q3 - 2007
Q1 - 2008
Q3 - 2008
Q1 - 2009
Q3 - 2009
Q1 - 2010
Q3 - 2010
Q1 - 2011
Q3 - 2011
Q1 - 2012
Q3 - 2012
Production
Demand
Oil Price

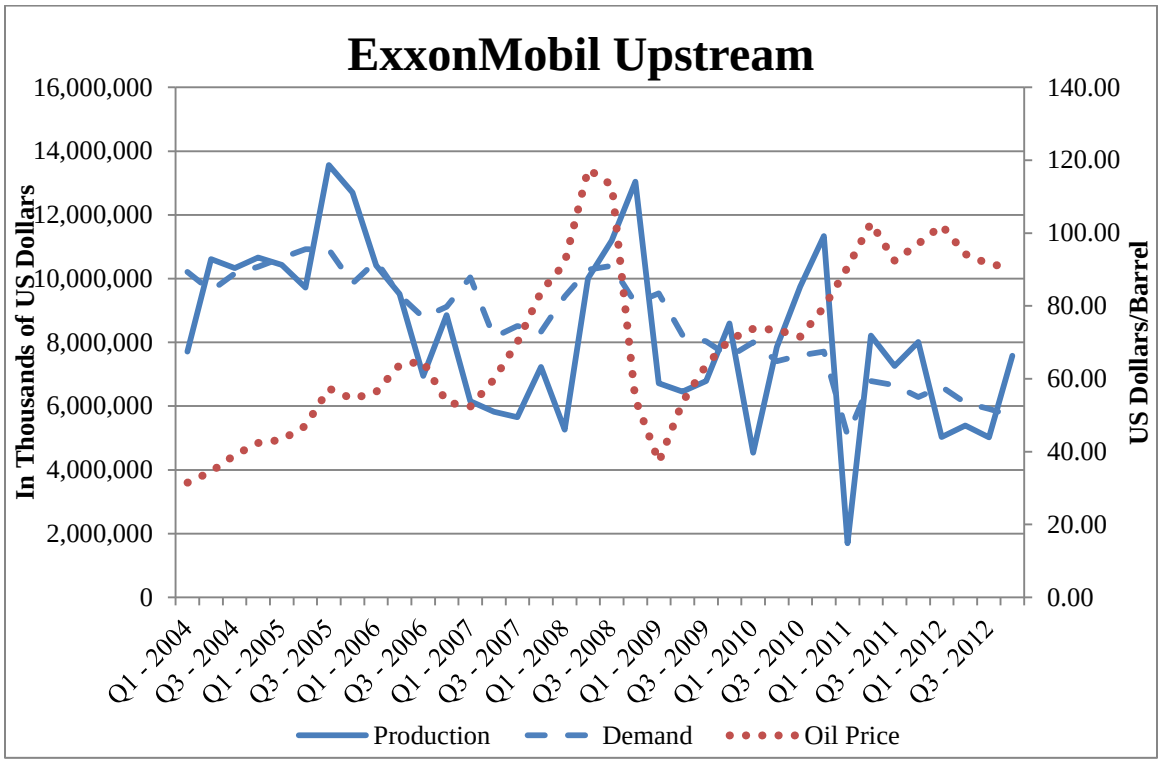


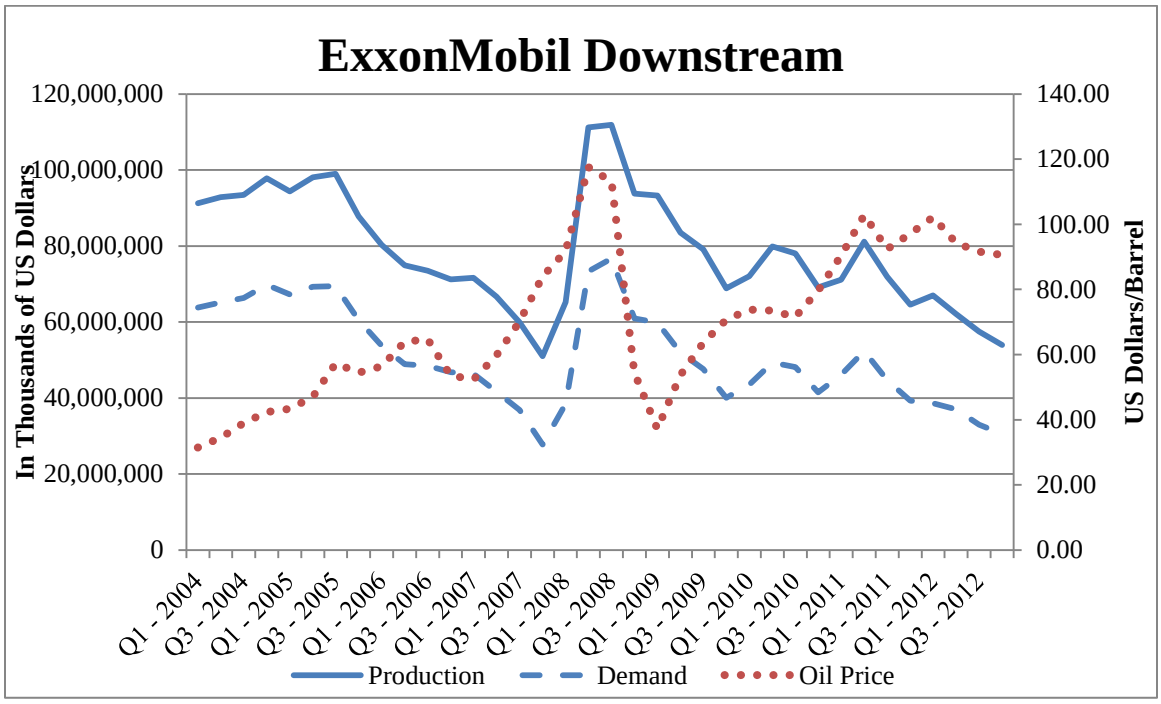
Appendix 6. Each Level's Demand Values According to Each Quarter (in thousands of US Dollars)

Quarter	Service and Equipment	Drilling	Upstream	Midstream	Downstream
1	15,946,799	2,740,361	12,721,810	23,606,035	30,756,070
2	16,855,431	2,932,954	15,351,792	22,943,046	33,147,327
3	17,540,837	2,905,349	18,122,334	23,920,412	34,862,211
4	18,965,476	3,085,856	21,811,403	25,355,248	33,469,843

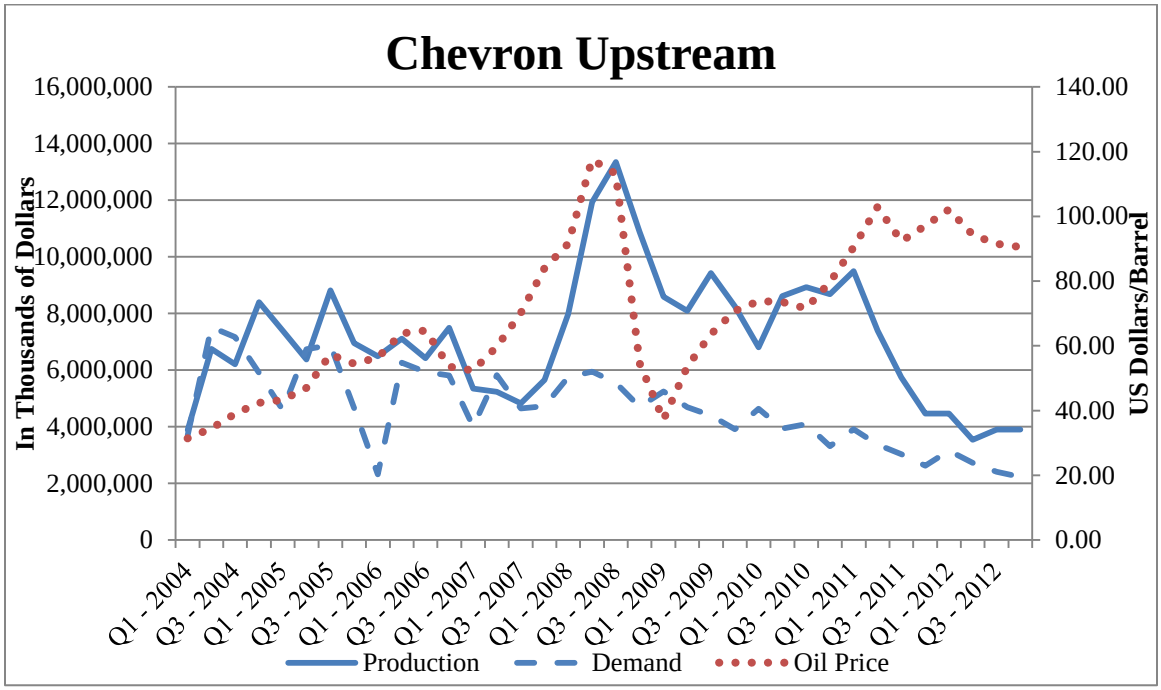
Appendix 7. Plotted Production and Demand Graphs of Integrated Companies

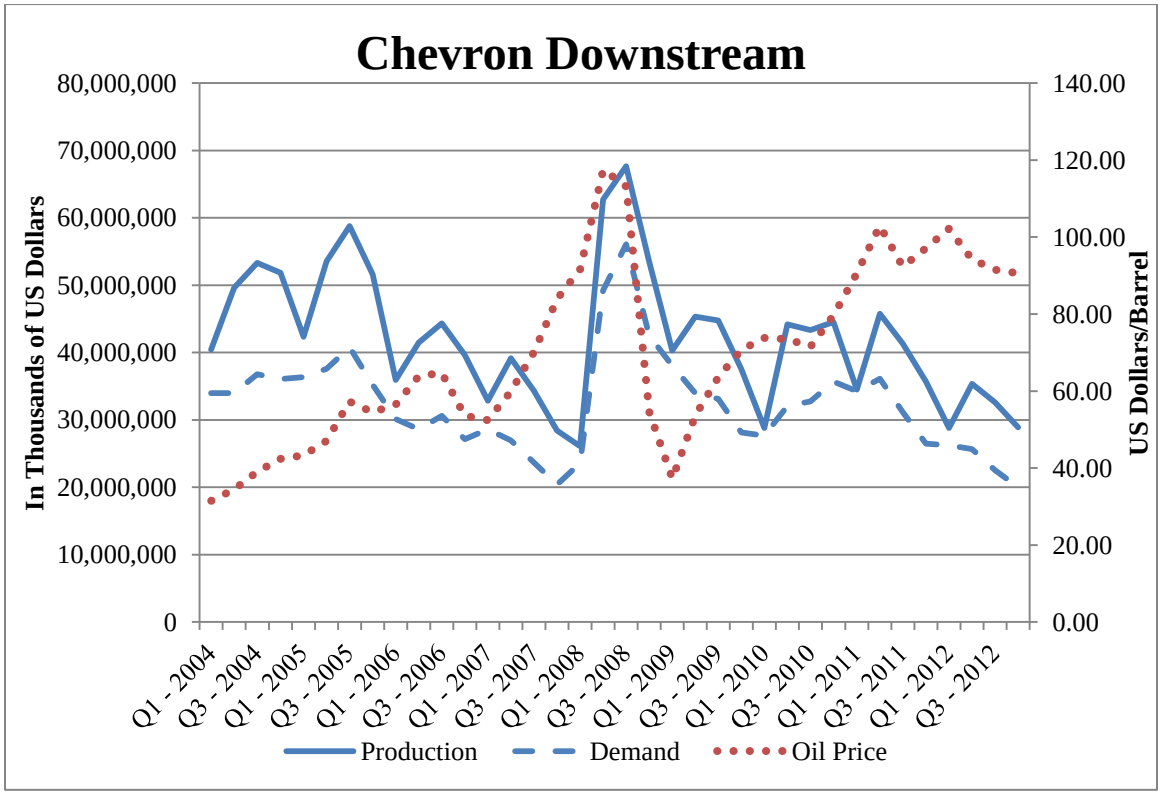
Appendix 7.1. ExxonMobil Plotted Production and Demand



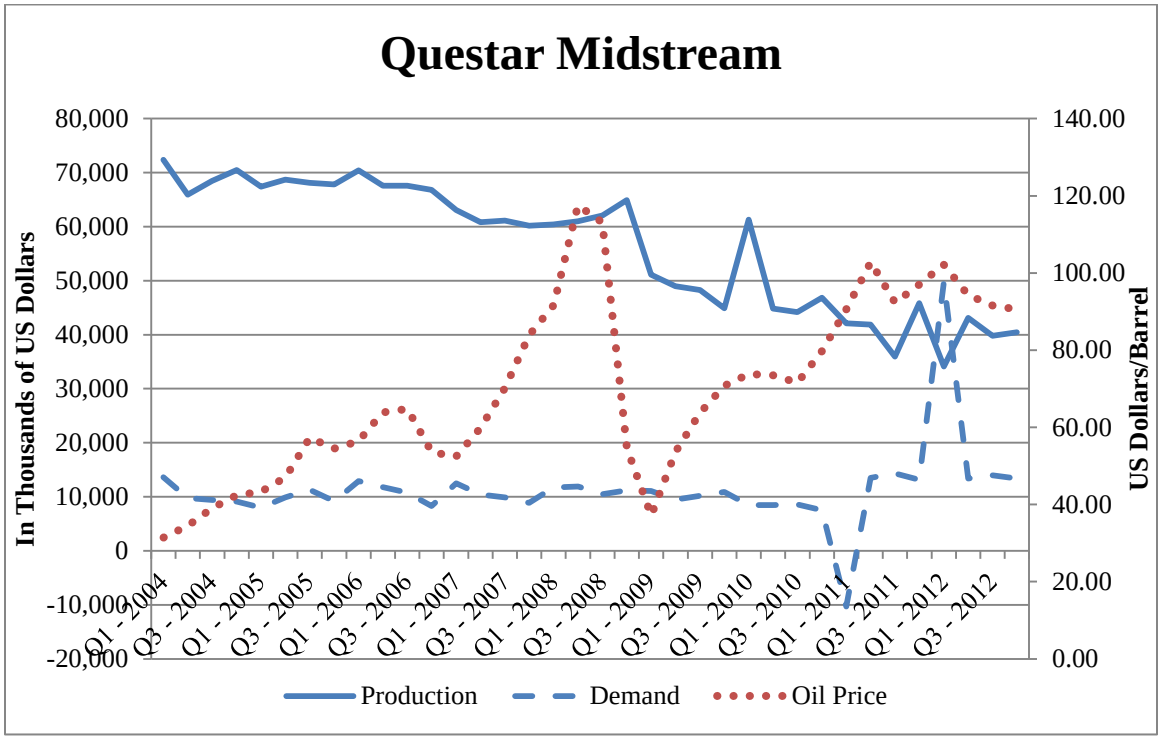


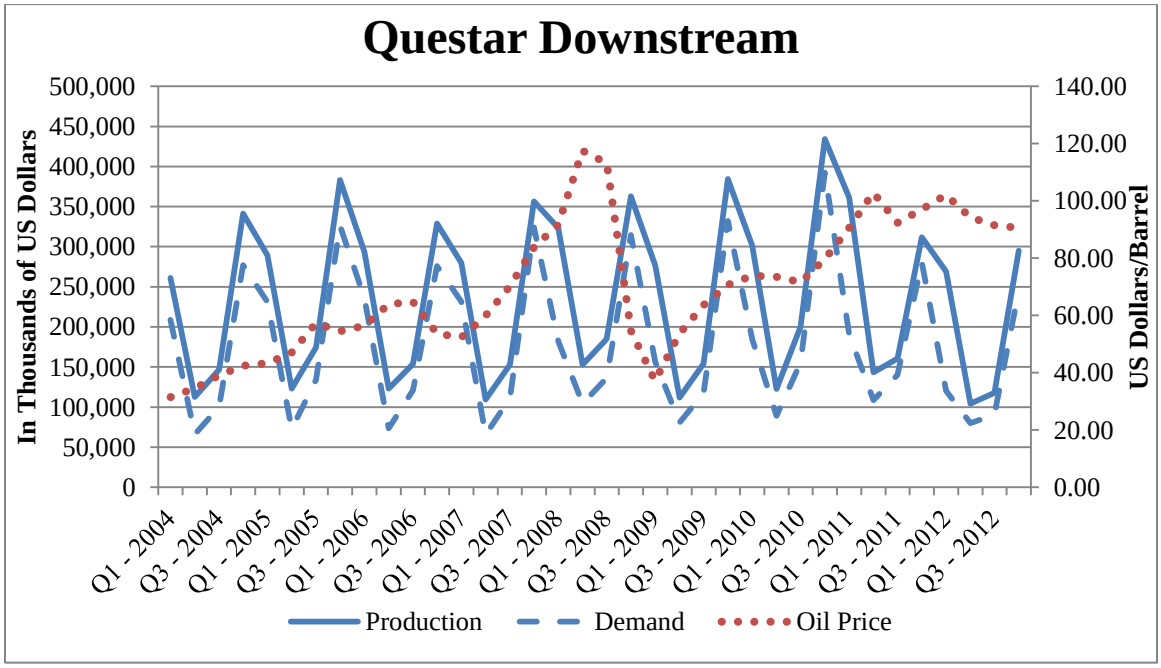
Appendix 7.2. Chevron Plotted Production and Demand





Appendix 7.3. Questar Corporation Plotted Production and Demand





VITA

Mina Azhar

Candidate for the Degree of

Master of Science

Thesis: THE STUDY OF THE BULLWHIP EFFECT IN THE OIL AND GAS INDUSTRY

Major Field: Industrial Engineering and Management

Biographical:

Education:
Completed the requirements for the Master of Science in Industrial Engineering and Management at Oklahoma State University, Stillwater, Oklahoma in December, 2013.

Completed the requirements for the Bachelor of Science in Industrial and Systems Engineering at Korean Advanced Institute of Science and Technology, Daejeon, South Korea in 2011.

Experience:
Research Assistant (Aug. 2012 - Dec 2013) *New Product Development Center, Oklahoma State University*, Stillwater, Oklahoma, USA.
Intern (Sep. 2011 – Dec. 2011) *Kaizen Section, Vehicle Logistics Division, Toyota Astra Motor*, Jakarta, Indonesia.
Intern (Jan. 2011 - May 2011) *Smart Transportation Lab, Korean Advanced Institute of Science and Technology*, Daejeon, South Korea
Intern (June 2010 – Dec. 2011) *Complex Stochastic & Service System Design Lab,Korean Advanced Institute of Science and Technology*, Daejeon, South Korea.
Intern (Dec. 2010 – Jan. 2011) *Financial System Stability Bureau, Central Bank of Indonesia*, Jakarta, Indonesia.