A STUDY OF THE RELATIONSHIP BETWEEN THE BASE OIL PRICE AND PROFITABILITY OF REFINERY COMPANIES: THE KOREAN CASE

By

CHOI, You Mi

THESIS

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

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Table of contents

ABSTRACT

A study of the relationship between the base oil price and profitability of refinery companies: the Korean case

By

You Mi Choi

This paper analyzes the relationship between the base oil price, announced by international pricing organizations, and the profitability of refinery companies. Specifically, this study examines the relationship between the Group II 150N and 500N base oil price and the profitability of major Korean companies in the 150N and 500N market. The study finds that the operating profit ratios of the Korean companies are closely related to changes in the 150N/500N base oil price.

Part 1. Introduction

Base oil is a raw material of lubricating oil that minimizes the frictional heat that occurs between machines. According to the American Petroleum Institute (API), base oil is classified into five groups: I, II, III, IV, and V. The current trend of supply and demand for base oil is very strongly related to the market demand for automobile and industrial lubricants. To meet this market demand and supply, two pricing firms, ICIS and Argus, publish tradable price for the market and help set a reasonable price for the industry. These international firms efficiently apply oil prices to the current market situation, and such prices then appear in firms' financial statements. For example, several researchers have studied how crude oil prices affect firms' financial statements, and there is no doubt that such prices affect petroleum companies' sales and net income, as well as those of companies in industries affected by oil price changes. In addition, this raises concerns about how base oil prices affect oil and gas entities, particularly through their financial statements. Therefore, this research aims to find meaningful results regarding the relationship between the base oil price and oil and gas entities' financial situation.

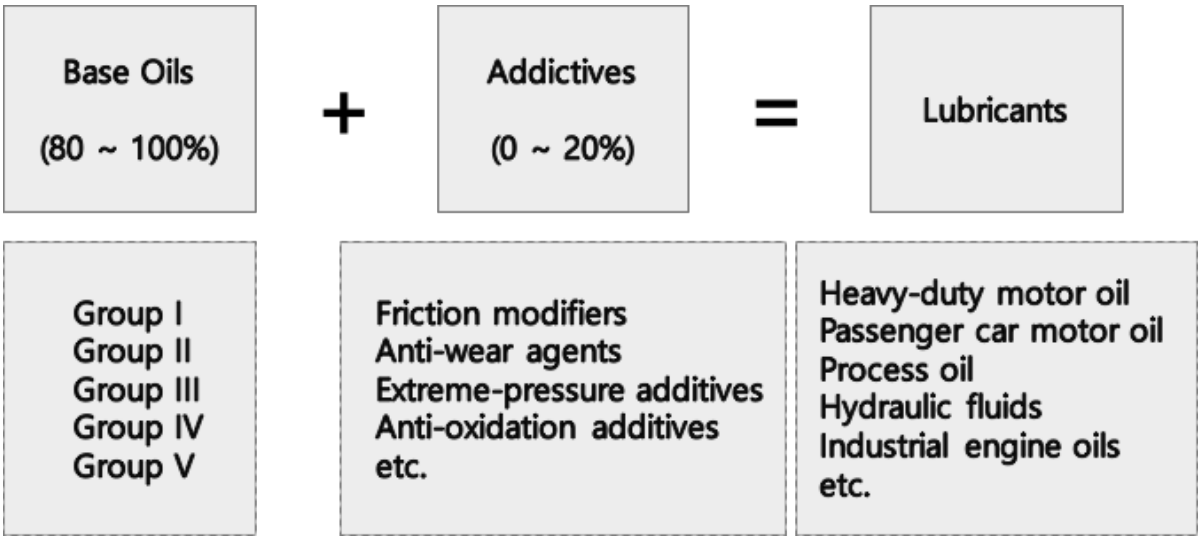
Part 2. Background of the Study

In Part 2, I will introduce the basic information, the market situation, and the price methodology for base oil.

2.1 Overview of Base Oil

Lubricating oil is a liquid substance that minimizes the frictional heat that occurs from friction between machines. For example, lubricating oil products protect the engines of cars and improve fuel efficiency. Base oil is a raw material of lubricating oil, and the final lubricating oil product is completed by mixing it with additives, as shown in Graph 1. Base oil is produced from unconverted oil that is residue of the atmospheric distillation of crude oil.

[Graph 1] Lubricant contents



(Source: SK Innovation, 2016)

According to the API, base oil is classified into five groups: I, II, III, IV, and V. Such classification includes a viscosity index (VI), the proportion of sulfur and saturates, and the manufacturing methods. The VI indicates the “the effect of temperature changes on the viscosity of the oil” (GS Caltex, 2011). For example, a base oil with a low VI is very thin in a high-temperature environment and very thick in a low-temperature environment. In addition, the proportion of sulfur and saturates usually refers to the purity of oil; for example, with less sulfur content and more saturates, a base oil will be of a higher class.

Each of the base oil categories have a different VI, sulfur and saturate percentage, and characteristics of product methods. Referring to the API base oil categories, Group I base oil is produced using a traditional process of solvent extraction (refer to Graph 2). This group contains a high portion of sulfur that is greater than 0.03% and low saturates (<90%). In addition, it has a low-grade VI feature (80 to 120), which means that changes in base oil very intensely occur through temperature changes. Group II base oil goes through the hydrocracking production process and has less than 0.03% of sulfur content. The group has a saturate content more than 90% and a VI range of 80 to less than 120. Group III is

experiencing a similar production process to that of Group II, but it adds a stronger hydrocracking aspect. This group contains less than 0.03% sulfur and has high saturate content and a VI of more than 120, which means that Group III represents an upper-class base oil compared with Group I and Group II. Group IV is characterized by polyalphaolefins (PAOs); this group represents traditional synthetic stocks, and “the use of this oil is severely limited by the cost and availability of feedstock” (Brown, 2015). Finally, Group V contains all base oil that is excluded from the other groups (Kline, 2016).

[Graph 2]

API BASE OIL CATEGORIES

Base Oil Category	Sulfur (%)		Saturates (%)	Viscosity Index
Group I (solvent refined)	>0.03	and/or	<90	80 to 120
Group II (hydrotreated)	<0.03	and	>90	80 to 120
Group III (hydrocracked)	<0.03	and	>90	>120
Group IV	PAO Synthetic Lubricants			
Group V	All other base oils not included in Groups I, II, III or IV			

(Source: Machinerylubrication.com)

2.2 Characteristics of the Base Oil Market

2.2.1 Global Base Oil Supply and Demand

According to Kline (a consulting and research firm), the current tendency of supply and demand of base oil is very strongly related to the market demand for automobile and industrial lubricants. This organization explains details of the base oil market through its report “Global Lubricant Basestocks 2015.” In section 2.2.1 Global Base Oil Supply and Demand and section 2.2.2 Asia-Pacific Base Oil Supply and Demand, the paper will explain the base oil market by referring to Kline’s 2016 report.

Kline mentions that it is very predictable for the base oil supply to follow the trend of finished lubricant demand since base oil is a raw material of lubricants. From 2007 to 2015, the global supply of base oil has decreased, with 787.7 KBD (Kilobarrels per day) in 2007 and 742.2 KBD in 2015. In 2009, the degree of reduction in the amount of base oil was severe because there was a decline in finished lubricant demand as a result of the global financial crisis. As the global economy slowly returned to a regular path, the industrial growth also made a recovery that induced a slight increase in the supply of base oil in 2015.

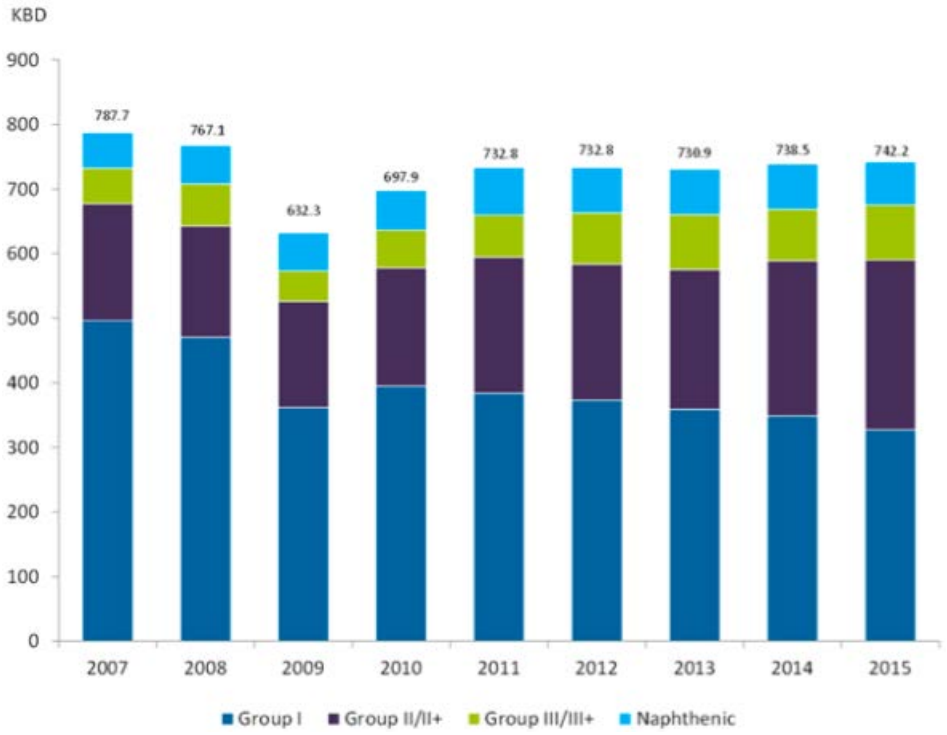
Kline also mentions that Group I is responsible for 44% of the world's oil supply. However, the amount of Group I continues to decrease. For example, in 2007, Group I was responsible for 63% of the total supply. The reduction in the distribution of the Group I oil supply has resulted for the following reasons: technical obsolescence and the oversupply of the Group II and Group III base oils.

"Global Lubricant Basestocks 2015" reports that the base oil supply of Group II steadily increased to more than one-third of the total global supply volume in 2015, from about 23% of the total supply in 2007. Vendors expanded with an increased amount, and Group II manufacturing routes became diversified. A significant portion of the supply is created via hydrocracking and iso-dewaxing or catalytic dewaxing. Group II base oil is also produced by former Group I plants that have undergone a partial upgrade.

Moreover, the report indicates that the global base oil demand (including Groups IV and V) in 2015 was an estimated 690.8 KBD. Group I remains the largest product category, with 47% of the total demand, and Group II follows, with close to 30% of the total demand. Demand patterns for base oil have changed significantly compared with five to ten years ago. The share of Group I has decreased by nearly 20% from the overall demand, and this drop in Group I is supplemented by the increase in the consumption of Group II.

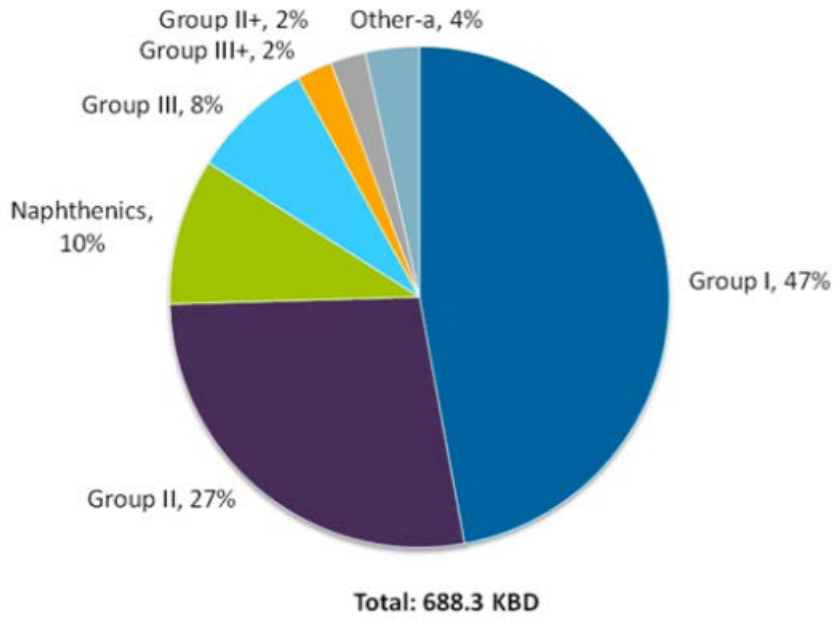
Kline insists that the development of newer engines and machinery increased the demand for high-performance lubricating oil, which is hard to mix with Group I, and this thus led to shifts in request from Group I. “This demand shift has been fueled by the narrowing price differential between Group I and other higher grade base oils. [The] Group I share of global base oils demand has sharply declined from two-thirds in 2007 to just under half in 2015. Following [the] above situation, [the] consumption of Group II has increased rapidly due to [the] increased motor vehicle oil and Group III, almost ten years ago[,] which had little demand[…], [and it] now occupies nearly 10% of the global demand for oil in 2015” (Kline, 2016).

[Graph 3] Global base oil supply by API Groups, 2007 to 2015



(Source: Kline)

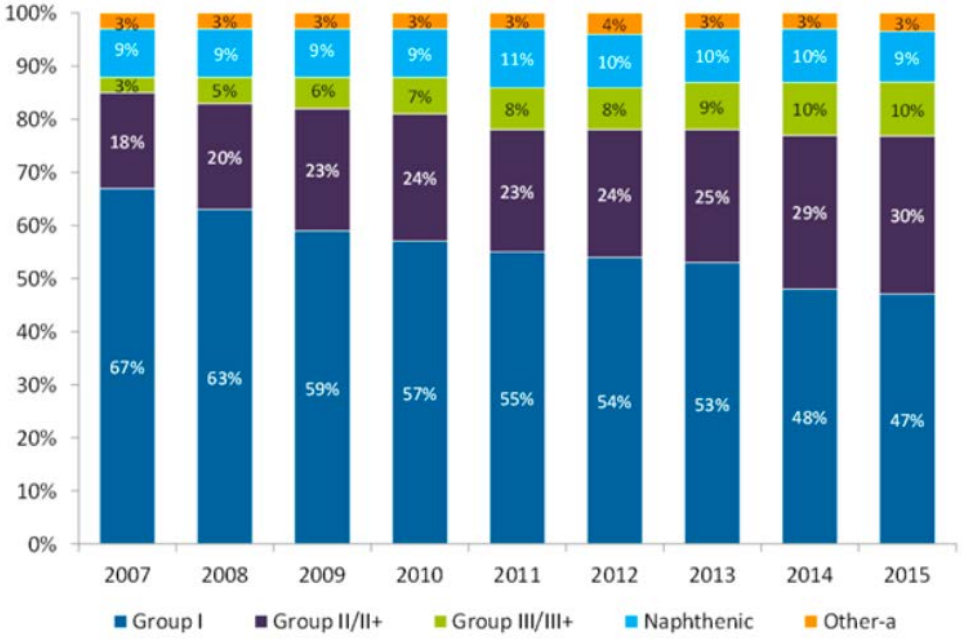
[Graph 4] Global base oil demand by product types, 2015



a- Includes Group IV and Group V basestocks, but excludes naphthenic basestocks.

(Source: Kline)

[Graph 5] Share of API Groups in global base oil demand, 2007 to 2015



a- Includes Group IV and Group V basestocks, except Naphthenic basestocks.

(Source: Kline)

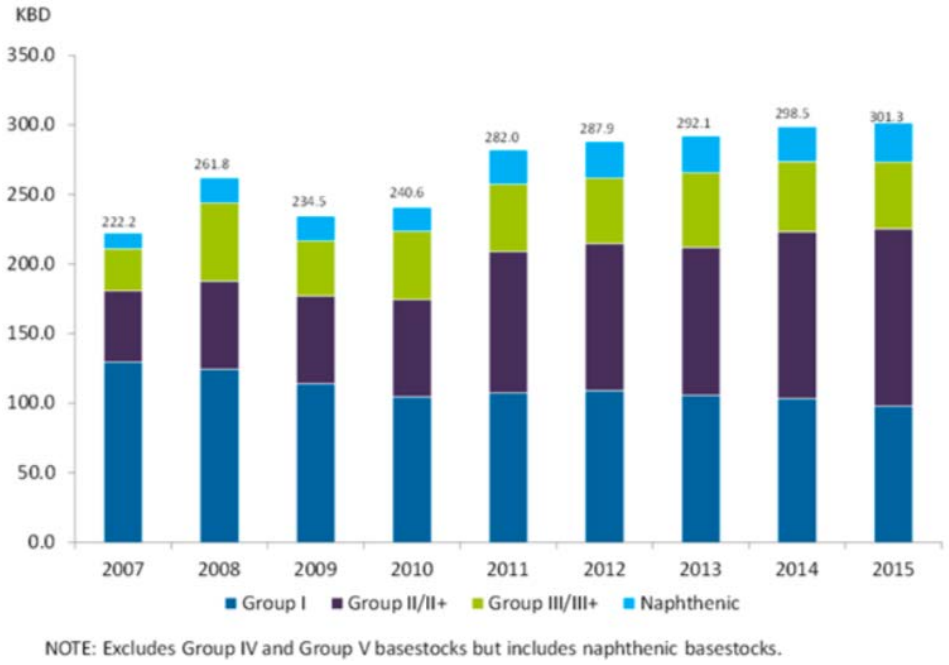
2.2.2 Asia-Pacific Base Oil Supply and Demand

Kline mentions the Asia-Pacific base oil market separately in detail. According to the report, the Asia-Pacific base oil supply in 2015 is estimated at 301.3 KBD. The base oil supplier in the Asia-Pacific region includes “the full spectrum of plants, from national oil companies (NOCs) supplying to both an in-house lubricant business and the domestic market, to large merchant suppliers selling within the region and globally” (Kline, 2016).

The report says that the Asia-Pacific region has added significant quantities of base oil capacity, making it the top producer of base oil in the world. In the report, it describes that “between 2007 and 2015, production in Asia grew from 234.5 KBD to 301.3 KBD, a compound annual growth rate of 3.2%” (Kline, 2016). In 2015, the region produced about 40% of the global supply and specialized in Group II and Group III. In addition, larger producer refineries were located in South Korea, Taiwan, Singapore, and China.

Similar to the global base oil market, Asia-Pacific’s Group I supply continued to decline. According to the Kline report, Group I base oil accounted for about 32% of the total supply in the region. Group II is now the most produced base oil in the Asia-Pacific region, accounting for about 35% of the total base oil production in 2015. Group II is currently widely produced in South Korea, Taiwan, Singapore, China, and India. “While there are a handful of merchant Group II suppliers – including Exxon Mobil in Singapore and GS Caltex and SK in South Korea – most refiners produce for in-house consumption and participate in the merchant market opportunistically” (Kline, 2016). The Asia-Pacific region is the leading hub for Group III oil products. Most of the facilities in the area are located in South Korea, and production companies such as SK and S-Oil operate large-scale factories there. In 2015, the region accounted for 48.0 KBD for Group III, accounting for approximately 56% of the worldwide Group III oil supply.

[Graph 6] Historical Basestock Production in the Asia-Pacific Region, 2007 to 2015



(Source: Kline)

In addition, Kline mentions that the overall demand for base oil did not change significantly in 2015. This is mainly because the economy in China and Japan has declined. Other countries that have witnessed substantial economic growth are currently growing moderately. Despite the decreasing demand for Group I, this is the dominant product in the Asia-Pacific region, and it accounts for approximately 50% of the total demand, where the demand for Group I oil is increasingly being replaced that for by Group II and Group III oil.

In addition, the report explains the increasing demand of Group II and III oil as follows: “Marketing push by suppliers that produce Group II and Group III base oil combined with growing preference among end-users to use better lubricants and OEM recommendations are the prime reasons driving the demand for Group II and Group III base oil. Lubricant blenders are also inclined to [use] higher quality base oil instead of Group I base oil because of [the] narrowing price differential between Group I and Group II base oil. Hence, these base oil[s] are used in blending better quality lubricants even though there are no major technical requirements” (Kline, 2016).

2.3 Base Oil Price Methodology

There are two large pricing firms, ICIS and Argus, which publish the tradable price to the market and help set the reasonable price for the industry. This part of the research will give a brief introduction regarding how each pricing firms decide the right price.

ICIS, one of the base oil pricing companies, announces the base oil price reports on a weekly basis. The report indicates the base oil price that is available for trade through the week starting the next day from publication. Because it is an international price and because the price is set by region, if there are national holidays in several countries, ICIS will indicate the non-publishing date. In the report, a whole week is selected for the range of pricing—for example, from Friday 5:00 pm to the next week Friday 5:00 pm.

The displayed price announced by ICIS is intended to reflect the actual cost of base oil during an entire week. Before the bid and offer price, this price information is preferentially taken in the market.

If the same condition material is on the market with a different price, one is the price displayed by ICIS and another one is confirmed bids and offers; the ICIS-published price will take priory when the prices are suggested concurrently. In an un-active market, “illiquid markets” (ICIS, 2017) will use ICIS-published price and bid-offer price together because there is no base price to assess the market. However, if there is no ICIS-published price, an only the bid-offer price will be used. When the ICIS assesses the market’s price opinion, if the ICIS decides that the information is not trustful, it will reject the information in the assessment.

The ICIS adopts the “week’s rage” price publishing methodology for the base oil pricing. For several decades of observation of the market and feedback, the ICIS realized that the weighted averaging price is not accurate in the random variability market of base oil. In other words, a price distortion phenomenon will arise (ICIS, 2017).

Another organization that publishes a base oil price is Argus. This firm also announces the price on a weekly basis. In this report, global base oil price, market analysis, and crude oil price information are included.

The price team conducts extensive sections on the weekly oil market information from participants through telephone, instant messenger, and e-mail communications. A balance is maintained in surveys between oil sellers, buyers, and trade companies. Market reporters ask market participants whether they purchased the base oil, whether they bought the base oil, or whether they had received a bid or an offer for base oil. Participants are asked where to view the price levels of base oil traded in the international market. In addition, Argus will be contacted by market participants, including market participants and brokers, to receive market data from all trusted market sources. Argus announces the price to view and reflect the general level of open market transactions. The estimated prices are based on the factors of the market participants' surveys and the factors that they were able to qualify from the market. The final price is the middle price between the low and expensive prices. Argus applies editorial judgment to the survey and eliminates untruthful information that appears in the final price evaluation. Argus Base Oil is issued once per week; spot prices are assessed on Thursday, and the report is produced and published on Friday. After such publication, the reporter monitors the market every week, and the valuation includes all related transactions reported during the week (Argus, 2017).

Part 3. Literature Review

Many studies have researched the impact of the crude oil price with a firm’s financial performance or stock market changes. Over the past 2 years during 2016~2017, the annual fluctuation of international crude oil prices has surpassed $40 per barrel, and international oil markets have seen frequent spikes and sudden drops. For example, Korea, with annual

imports exceeding 10% of gross domestic product, the economic ripple effect on oil prices expected along with short-term oil market forecasts has also become an important concern. Therefore, many studies have been conducted to establish a macroeconomic analysis model and input output model of oil price fluctuations and to commercialize them in the future.

Darko and Kruger (2017) examine the relationship between the crude oil price and the profitability performance measures of oil and gas companies. This research found that the crude oil price influences oil and gas companies, listed on Forbes 2016 top 20, positively on their accounting returns, such as return on assets, return on equity, and earnings per share. However, a firm's size and leverage level negatively affected such accounting profitability values.

The crude oil price affects the sales and net income of not only petroleum companies but also various industries related to price changes. Basha (2014) examined the effectiveness of the crude oil prices on Jordan pharmaceutical companies' financial statements. Pharmaceutical industries use petroleum products directly or indirectly. Thus, the study used Jordanian Al-Hikma Pharmaceutical to acquire typical data to determine the relationship of financial statements with crude prices. The researchers found substantial evidence that "the increase in the crude oil prices influence on the Return on Assets, Return on Equity, and Net Profit Margin of the pharmaceutical company."

FTI Consulting (2016) held a forum with experts to discuss the effectiveness of oil prices in the oil and gas sector. The expert forum was assembled at the Securities and Exchange Commission (SEC) Historical Society in Washington, D.C. The forum mentioned the variability of oil prices, and a panel of professionals discussed the important accounting changes and issues.

First, the history of oil price changes was described mainly from the decreasing oil price starting from the OPEC's "oil embargo." The OPEC was in an opposite position with

the US and Western Europe in 1973 because they were helping Israel economically. This event engendered the first oil shock; the oil price increased by $6 within six months (from $4 a barrel to $10 a barrel).

In 1980, during the Iran-Iraq war, Iran stopped its oil production, and this resulted in a price increase to $40 a barrel; however, because of overproduction in other countries, the price dropped to $13 in 1986. When Iraqi invaded Kuwait in 1990, the price went up $18 within three months (from $18 to $36). Afterward, the Asian financial crisis decreased the price from $25 a barrel to $12 a barrel in 1999. After the 2000s, the prices repeated downwards and upwards between a strengthening global economy and the world financial crisis; variability in prices occurred from $134 a barrel to $37 a barrel.

Then, the discussion led the subject to how decreasing oil prices would be effective in financial reporting. There are many different results related to decreasing oil prices, such as shutdown; however, damaged asset valuation mostly occurs with respect to accounting. When the oil industry is flourishing, the goodwill and fixed asset values are increasing. However, in a downward condition, the situation is very differently. For example, in the upstream and downstream part of the US, goodwill impairments are increasing because the oil and gas prices and the asset values have a very intimate relationship. In addition, exploration and production companies are responsible for disclosing proved undeveloped reserves (PUD) in their financial statements. However, to keep PUD on the books, companies must show the intent to develop proved undeveloped reserves. It is very difficult to invest such reserves as assets when oil prices are decreasing. As mentioned above, the market environment affects entities, and this also appears in companies' financial statements.

Part 4. Research Question

4.1 Research Objective

This research is undertaken to analyze how the base oil price, which is announced by the ICIS, affects South Korea's oil and gas entities, particularly through their financial statements. In other words, this international base oil price effectively applies the current market situation, and this then appears in entities' financial statements. As mentioned in the Literature Review, the profit of oil and gas entities has positive relationship with the crude oil price, and I show in Part 5 that there is strong positive correlation between the base oil price and the crude oil price; therefore, it is meaningful to examine the positive relationship between the performance of oil and gas entities and the base oil price trend.

4.2 Research Question

The research question addressed in the present study concerns whether the international base oil price (Group II 150N and 500N) is related to changes in oil and gas entities' financial ratios, such as their operating profit ratio. Six independent variables are selected related to base oil price to compare how much the price influences measurement of financial profitability. The independent variables are the interest coverage ratio, current ratio, asset turnover ratio, intangible asset growth rate, rate of increase in long-term debt, and foreign exchange growth rate (KRW/USD).

4.3 Research Hypothesis

The main objective of this study is to determine whether there is a positive relationship between the base oil price and performance in terms of profitability in South Korea oil and gas entities.

H1: Base oil price and operating profit ratio have a positive relationship.

In addition, I divide the firms into two groups: (1) firms that produce entirely refinery products and (2) firms that produce only base oil products. I then analyze this relationship between firms with only a base oil business and other firms.

H2: Firms that have only a base oil business show a stronger positive relationship than other forms.

Finally, the crude oil price hit a bottom in 2016, and the situation for base oil was similar; therefore, I will show the trend of firms' performances in 2016.

H3: Firms' profitability performance is negatively affected by the base oil price during the year 2016.

[Grape 7] Dubai oil price (Unit: Dollar/Barrel)

(Source: NYMEX)

Part 5. Quantitative Research

5.1 Research Methodology

In this research, a quantitative method is used to verify how the fluctuation in the 150N and 500N base oil ICIS price is related to the financial ratios of the three leading producers of 150N and 500N in the South Korea region. Since the industry is very complex and has various products and production areas, it is necessary to acquire particular goods and areas to address the research subject.

First, in this quantitative study, the core discussion emphasizes the relationship between changes in the ICIS prices and financial ratios of the chosen entities. Three entities have elected to approach the research subject: the G, S, and H companies. Financial information is taken from each entity's annual reports and disclosed financial statements. All financial information is collected from companies' websites and the Securities and Exchange Commission (SEC), and the data reflect six years of quarterly data from the year 2010 to the year 2016. However, since H company was established in 2014 August, the company's data starts from the 3rd quarter of 2014.

Second, the ICIS CFR Asia NE (North East) price is used for 150N and 500N products. Asia NE pricing includes South Korea, Japan, China, and Taiwan. CFR refers to the price containing the freight cost and base oil price.

5.2 Research Sample

The research sample explains the reason why the Group II 150N and 500N base oil price is selected and why the location is limited to South Korea.

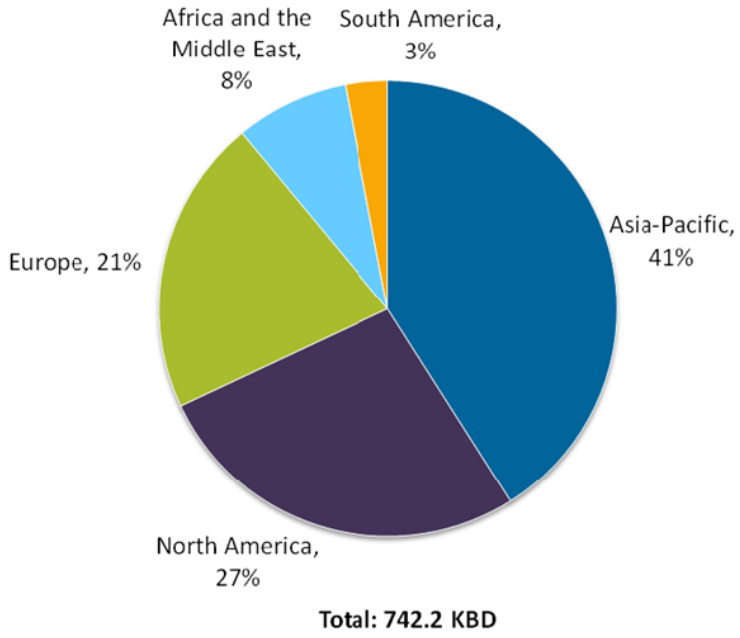
In the study, the base oil market is limited to the Group II 150N and 500N Asia-pacific base oil market. This particular market is selected in the research because Asia-Pacific is a region with largest base oil supply globally in 2015 (refer to Graph 7), and Group II is the most provided product in the area (refer to Graph 8).

South Korea, Taiwan, Singapore, China, and India compose Group II. According to Kline, the major suppliers are company E in Singapore and companies G and S in South Korea. The biggest plant is E in Singapore, which occupies 22% of all of Group II's production capacity (106.5 KBD) in the Asia-Pacific region in 2015; the next ranked companies are G 18%, H 9%, and S 6% in South Korea (Kline, 2016). However, company E is excluded from the sample because the company's financial statement includes a downstream business as part of its income, unlike other companies. Therefore, to maintain

the fairness of the sample, E is excluded from the study. Except for company E, most major suppliers of base oil are located in South Korea; therefore, the sample area for the analysis is limited to South Korea.

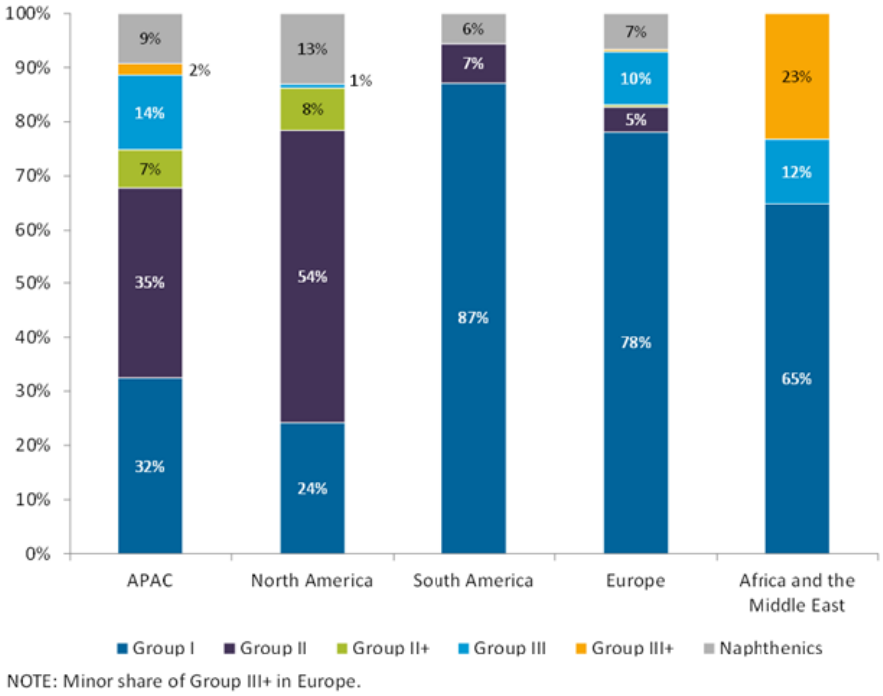
Only company H produces base oil solely; two other entities, G and S, perform total refinery production. These two companies do not disclose financial information publicly only for base oil; therefore, consolidated financial statements are applied to compare changes in base oil prices. Since the income of oil and gas entities depend on crude oil price, this research depicts how the crude oil price and base oil price are connected in advance. In addition, the analysis shows how using base oil data instead of crude oil data is proper for this study. In Asia, the crude oil price in Dubai has been used as a standard from the mid-1980s, and "it is responsible for the pricing of almost 30 million barrels per day of crude oil currently exported to Asia" (Oxford Energy, 2014). Therefore, Dubai crude oil is used as a representative price to compare with the Asia-Pacific base oil market price. The following data explain how this relationship is connected strongly.

[Graph 8] Global Basestocks Supply by Region, 2015



(Source: Kline)

[Graph 9] Share of API Groups in Regional Basestocks Supply, 2015



(Source: Kline)

5.3 Dubai Crude Oil Price vs. Asia-Pacific Region Base Oil Price

This part of the study examines the correlation between the Dubai crude oil price and the Asia-Pacific region base oil price. The quarter-variation of 150N and 500N of the base oil price is compared with the Dubai crude oil price (refer to Table 1). The changes are calculated with the following examples: for the Dubai oil price: [(2010 March Dubai price – 2010 January Dubai price) / (2010 January Dubai price)] x 100 and for 150N/500N base oil: [(2010 March base oil price – 2010 January base oil price) / (2010 January Dubai price)] x 100. With these data, correlation analysis was performed through SPSS, and the result showed that the relationship between the Dubai oil price changes and the 150N/500N base oil price changes. As Tables 2 and 3 show, the Pearson correlations are 0.611 for 150N price fluctuation vs. Dubai crude oil price change and 0.662 for 500N vs. Dubai. This indicates that the base oil price changes and Dubai crude oil price variations are highly correlated.

Therefore, this research uses the entire financial statements of the refinery companies because it is impossible to have information only for the base oil part of financial statements.

[Table 1] Dubai Crude Oil Price and 150N/500N Base Oil Price Correlations

< n=28 >

	Dubai crude oil price
Dubai crude oil price	1
150N price	.611**
500N price	.662**

**Correlation is significant at the 0.01 level

5.4 Financial Performance Indicators

This part explains accounting indicators used in the research and deliberates how the values are used to determine the impact on the financial performance indicators of refinery companies with respect to the base oil price.

Profitability indicators have been analyzed regarding the chosen accounting values of companies from 2010 to 2016 quarterly. The profitability indicator, which is used as the dependent variable, is the operating profit ratio, and the independent variables are the interest coverage ratio, current ratio, asset turnover ratio, intangible asset growth rate, and rate of increase in long-term debt.

To determine financial outcomes, we selected the operating profit ratio as the profitability measurement. The operating profit ratio is a measure of the ratio of operating profit to sales. It is an indicator that captures the operational performance of a company's main business activities, and only the profit or loss of the core business can be compared to the sales amount. It excludes the profit and loss of manufacturing and sales activities. Thus, this ratio is widely used as a measure of the efficiency of a company's main business activities while also being used as an indicator of profitability along with current profit margins. Metharyanasari and Zen (2016) use the operating profit ratio as an indicator to compare the financial performance of PT. Pertamina is an oil and gas company of Indonesia,

with other global entities. The authors selected this ratio as a profitability measurement to evaluate how “effectively and efficiently the company utilize[s] its asset and operat[es] to generat[e] profit” (Metharyanasari and Zen, 2016).

The table below explains what other financial performance indicators mean and shows how the data are used in this research.

[Table 2] Indicators

Indicators	**Explanation**
Operating profit ratio	1) Ratio = Operating income / Sales 2) The financial ratio indicates how the entity will earn from sales. 3) In this research, the ratio shows how the entity will create operating profit from sales, as well as how the ratio changes related with base oil price. The ratio used in the regression data simply divided operating income by sales.
Interest coverage ratio (ICR)	1) Ratio = Operating income / Interest Expense 2) It is a measure of the ability of operating profit to cover interest costs. Because operating profit needs to be greater than interest cost, 1 or more is considered normal, and the bigger the number, the more stable it is.
Current ratio (CR)	1) Ratio = Current Asset / Current Liability 2) The ratio of finance to measure a company's ability to pay short-term debt.
Asset turnover ratio (ATR)	1) Ratio = Sales / Total Asset 2) This is an indicator that shows how efficiently a company can utilize its assets and generate profits.
Intangible asset growth rate (IAGR)	1) PP&E refers to buildings, land, and the like that the company acquired to use for business activities over a relatively extended period of time. 2) In this research, the increment of PP&E indicates how much of PP&E value is changed from the last quarter to the present quarter. 3) Calculation = ex) [(2010 2Q PP&E amount) – (2010 1Q PP&E amount)] / (2010 1Q PP&E amount)

Long-term liability growth rate (LLGR)	1) In general, the payment term is more than one year. 2) In this research, the increment of long-term debt indicates how much of the long-term debt value is changed from the last quarter to the present quarter.

6. Finding

Above, I suggest three hypotheses to verify the main objectives of this research: a positive relationship between the base oil price and the profitability performance in South Korea oil and gas entities.

H1: The base oil price and operating profit ratio have a positive relationship.

H2: A firm that has only a base oil business has stronger positive relationship with base oil price changes than other firms.

H3: Firms' profitability performance will be reduced in 2016.

First, to prove H1, the study tests the operating profit ratio with six dependent variables, including the 150N and 500N price change rate separately. The linear regression model is as follows:

$$\text{H1-1: } OPR_t = \beta_1 + \beta_2 ICR_t + \beta_3 CR_t + \beta_4 ATR_t + \beta_5 IAGR_t + \beta_6 LLGR_t + \beta_7 FERC_t + \beta_8 \underline{BPCR(150N)_t} + \varepsilon_t$$

$$\text{H1-2: } OPR_t = \beta_1 + \beta_2 ICR_t + \beta_3 CR_t + \beta_4 ATR_t + \beta_5 IAGR_t + \beta_6 LLGR_t + \beta_7 FERC_t + \beta_8 \underline{BPCR(500N)_t} + \varepsilon_t$$

[Table 3] Entire companies with a 150N/500N price change

Independent Variables	Dependent variable: Operating profit ratio	
	150N Baseoil (H1-1)	500N Baseoil (H1-2)
Constant	0.000 (0.109)	0.000 (0.097)
ICR	0.001 (0.002)	0.001 (0.002)
CR	0.322 (0.006)	0.154 (0.009)
ATR	0.000 (-0.178)	0.000 (-0.163)
IAGR	0.192 (-0.232)	0.233 (-0.205)
LLGR	0.346 (0.011)	0.260 (0.013)
FERC	0.921 (-0.016)	0.994 (-0.001)
BPCR	0.022 (0.109)	0.002 (0.137)
N	66	66
F	12.990	14.540
Sig.	0.000	0.000
R^2 *(adj.R2)*	0.6111 (0.564)	0.637 (0.593)

Variables are defined as follows: ICR = Interest coverage ratio; CR = Current ratio; ATR = Asset turn over ratio; IAGR = Intangible asset growth rate; LLGR = Long-term liability growth rate; FERC = Foreign exchange rate changes; BPCR = 150N/500N base oil price change rate.

Table 3 represents the results of the main question of the research. For comparison with the 150N base oil price, the R square value 0.6111 indicates that the operating profit ratio can be explained by H1-1 as 61.11%. The F value is 12.990, and the sig. value of F is 0.000 (<0.05); therefore, the model can significantly explain the hypothesis. For the individual independent

variables, the levels for the interest coverage ratio, asset turnover ratio, and 150N base oil price change rate are significant at a level less than 0.05, positive β values (ICR = 0.002, 150 NPCR = 0.109), except for asset turnover ratio (ATR = -0.178). Similarly, in H2-1 model, those independent variables explain the positive relationship with operating profit ratio. Therefore, the above results explain the operating profit ratio, and there is a positive relationship for the Group II base oil price change and the interest coverage ratio.

Second, this study compares a firm that has only a base oil business with other two firms to determine whether it contains a stronger positive relationship with base oil price changes than other firms. To verify H2, the study tests the operating profit ratio with six dependent variables, including the 150N and 500N price change rate separately. However, this part uses a separate regression, which includes firms that have only a base oil business and firms that have an entire refinery business. The linear regression model is as follows:

H2-1: $\text{Only\_OPR}_t = \beta_1 + \beta_2 \text{Only\_ICR}_t + \beta_3 \text{Only\_CR}_t + \beta_4 \text{Only\_ATR}_t +$

$\beta_5 \text{Only\_IAGR}_t + \beta_6 \text{Only\_LLGR}_t + \beta_7 \text{Only\_FERC}_t + \beta_8 \underline{150\text{NPCR}_t} + \varepsilon_t$

H2-2: $\text{Non\_OPR}_t = \beta_1 + \beta_2 \text{Non\_ICR}_t + \beta_3 \text{Non\_CR}_t + \beta_4 \text{Non\_ATR}_t +$

$\beta_5 \text{Non\_IAGR}_t + \beta_6 \text{Non\_LLGR}_t + \beta_7 \text{Non\_FERC}_t + \beta_8 \underline{150\text{NPCR}_t} + \varepsilon_t$

* Only: a firm that has only a base oil business; Non: and firms that have an entire refinery business

[Table 4] Only base oil business companies a with 150N price change and refinery business companies with a 150N price change

Independent Variables	Dependent variable: Operating profit ratio	
	Only base oil business (H2-1)	Refinery business (H2-2)
Constant	0.271 (0.068)	0.538 (-0.020)
ICR	0.005 (0.001)	0.002 (0.012)
CR	0.318 (0.031)	0.125 (0.006)
ATR	0.003 (-0.161)	0.885 (-0.025)
IAGR	0.214 (-0.214)	0.573 (0.248)
LLGR	0.318 (0.011)	0.125 (-0.643)
FERC	0.851 (0.033)	0.116 (0.225)
BPCR(150N)	0.062 (0.099)	0.053 (-0.104)
N	56	10
F	5.067	131.891
Sig.	0.000	0.008
R^2 *(adj.R2)*	0.424 (0.341)	0.998 (0.990)

Second, this study compares firm that have only a base oil business with other two firms to determine whether they have a stronger relationship than other firms. In Table 4, the β value of BPCR is 0.099 for only base oil business firms and -0.104 for all refinery business firms, which means that only base oil business firms' operating profit ratio has a stronger

positive relationship than other firms. It is noticeable that all refinery business firms have a negative relationship with base oil price changes.

Finally, the third hypothesis is that firms' profitability performance is negatively affected by the base oil price during year 2016. In this research, I insert a dummy variable as 1=Year 2016, 0=Year 2010~2015. The linear regression model is as follows:

H3-1: $OPR_t = \beta_1 + \beta_2 ICR_t + \beta_3 CR_t + \beta_4 ATR_t + \beta_5 IAGR_t + \beta_6 LLGR_t + \beta_7 FERC_t + \beta_8 \underline{BPCR(150N)_t} + \delta_1 Year\ 2016 + \varepsilon_t$

H3-2: $OPR_t = \beta_1 + \beta_2 ICR_t + \beta_3 CR_t + \beta_4 ATR_t + \beta_5 IAGR_t + \beta_6 LLGR_t + \beta_7 FERC_t + \beta_8 \underline{BPCR(500N)_t} + \delta_2 Year\ 2016 + \varepsilon_t$

[Table 5] Entire companies with a 150N/500N price change with a dummy variable

Independent Variables	Dependent variable: Operating profit ratio	
	150N Baseoil (H3-1)	500N Baseoil (H3-2)
Constant	0.001 (0.085)	0.001 (0.077)
ICR	0.000 (0.002)	0.000 (0.002)
CR	0.522 (0.004)	0.290 (0.006)
ATR	0.001 (-0.131)	0.001 (-0.122)
IAGR	0.054 (-0.323)	0.070 (-0.295)
LLGR	0.298 (0.012)	0.215 (0.013)
FERC	0.962 (-0.007)	0.899 (0.018)
Year 2016	0.087	0.010

	(0.077)	(0.109)
BPCR	0.002 (0.044)	0.002 (0.042)
N	66	66
F	14.662	16.164
Sig.	0.000	0.000
R^2 *(adj.R2)*	0.673 (0.627)	0.694 (0.651)

There is no change in the effective independent variables, including the interest coverage ratio, asset turnover ratio, and base oil price, which still have a positive relationship even with the dummy variable Year 2016. However, the influence degree of the base oil price change to the operating profit ratio is reduced: 150N β = 0.109, 150N with dummy β = 0.044 / 500N β = 0.137, 500N with dummy β = 0.042.

Part 7. Conclusion

Base oil is the raw material of lubricating oil that comprises over 80% of oil products, and the final lubricating oil product is completed by using mixing additives. According to the API, the base oil is classified under five groups: I, II, III, IV, and V. In addition, there are differences in its viscosity, the proportion of sulfur and saturates, and manufacturing methods. The material's current tendency of supply and demand of base oil is very strongly related to the market demand for automobile and industrial lubricants. To set the price in the market, two organizations, ICIS and Argus, publish the international price of the base oil. They use their own methodology to determine the right price, and the market follows the price. This research discusses how the market supports the pricing system and the effect of the base oil price on the financial condition of the selected entities. As the regression data show, profitability financial indicators such as the operating profit ratio are significantly influenced

by the fluctuation of the base oil price, as the base oil price increases in a positive direction, with the profit indicator is increasing.

Although this research found meaningful results, there are limitations to the data. This study uses only the ICIS organization price of Group II 150N/500N CFR Asia NE and refers only to three entities' financial statements for the product. Although Group II represents a core market in the Asia region and although selected entities are leading producers in the market, the sample is too narrow to explain the entire relationship between the base oil price fluctuation and the changes of financial indicators. In addition, this study found that the influence in the degree of the base oil price change to the operating profit ratio has been reduced during the 2016 oil price shock.

This study indicates that a base oil producer's certain portion of profit is influenced by the base oil price fluctuation, which could be predictable. Then, a model could be developed to make a financial forecast. The predictor would help base oil producers monitor their profit and control the financial position along with the market changes. Moreover, the ultimate purpose of an entity, enlargement of profit and market share, will be successfully achieved.

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