World Review of Business Research
Vol. 2. No. 5. September 2012. Pp. 160 – 177

Korea's Petroleum Refinery Industry: Its International Competitiveness and Policy Implications for Future Directions

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Korea, a non-oil producing country, entirely relies on imports to meet its crude oil needs. But, Korea is, nevertheless, known as a big exporter of petroleum products. Korea possesses an advanced refining technology and reprocesses crude oil, imported from foreign countries, into value-added products such as gasoline, diesel and kerosene and exports them. Korean oil refining companies, due to continuous investment in upgrading facilities over the past decade, are today amongst the most competitive players of the global petroleum processing market. Their focus on light oils has been also a contributing factor to their strong export performance in recent years. Thus, Korean companies need to further step up their facilities investment, to meet new challenges from the changed market landscape since the global economic crisis. The upgrading ratio among Korean refineries is still less than 30%, which is below corresponding figures in other major countries in the developed world. In conclusion, in industries like petroleum refinery and chemicals manufacturing, which depend vitally on economies of scale, the capacity and efficiency of a production facility are crucial to ensuring competitiveness. Capacity being equal, newer production lines is better and dramatically more efficient than older ones, as the speed of technological progress is such that obsolescence is just around the corner. Accordingly, continuous investment in upgrading facilities is an absolute must.

JEL Codes: A11, D24 and O25

1. Introduction

Korea, a non-oil producing country, entirely relies on imports to meet its crude oil needs. But, Korea is, nevertheless, known as a big exporter of petroleum products. Korea possesses an advanced refining technology and reprocesses crude oil, imported from foreign countries, into value-added products such as gasoline, diesel and kerosene and exports them.

The Korean export of petroleum products began in 1966(Kim Saeng-gi 2008). The Korean Oil Corporation (current SK Corporation) started its operation of atmospheric distillation unit #1 (an installation enabling evaporation of oil into different boiling point ranges, called 'fractions,' from which products such as gasoline, diesel fuel, heating oil and bunker-C oil and naphtha are derived) in 1964, with a 35,000 b/d (barrel per day) capacity. Two years later, in 1966, Korea shipped out its first export batch of petroleum products.

The Korean exports in petroleum products sharply increased once into the 1980s, helped by on-the-spot export deals, arrangements whereby crude oil is imported and is re-exported in processed forms. Korean petroleum product exports have been particularly brisk since 2004, as the demand for gasoline and diesel fuel started to surge dramatically in China and worldwide, around this time. This export buoyancy was also a result of the

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improving quality and increasing international competitiveness of Korean petroleum products, thanks to the continuous investment by oil refining firms in advance refining facilities and the growing share of high value-added products in their product mix. There is a rising demand for petroleum products in Asia, and Chinese refining capacity can currently meet only a third of the overall regional demand, the rest of which can be tapped by the Korean refinery industry. As a result of this supply-demand imbalance, price differentials between crude oil and petroleum products in Singapore's spot market are steadily widening, and refinery margins are expanding. These favorable export conditions coupled with the expansion of upgrading facilities in Korean refining firms, their increasing production capacity and continuously enlarging share of exports in their overall sales, has resulted in a noticeable growth in the contribution of exported petroleum products in their overall refinery revenue, from 36.7% in 2003 to 51.3% in 2011.

In 2011, the combined total of export revenues generated by Korea's top four petroleum refining companies hit US$ 51.6 billion, nearly 9.3% of total national exports (US$ 555.2 billion). Given this export share claimed by the Korean refinery industry, its contribution to the national economy is huge as well. The total value of petroleum product exports, after surpassing US$ 10 billion back in 2004, almost 5 times during the subsequent seven-year period. If we include all exports, including both direct and indirect exports, the export revenue generated by petroleum products rises to an estimated US$ 80 billion. Korean oil refiners also helped alleviate the burden from crude oil imports on Korea's struggling national economy in the wake of the global financial crisis, by bringing in much-needed export dollars, corresponding to almost 51.3% of US$ 100.1 billion (estimation) spent to buy crude oil in 2011.

This upturn in petroleum product exports has clearly to do with the competitiveness of the Korean refinery industry. The contribution of the Korean petroleum refinery industry to the national economy is even more impressive, if we consider oil-producing countries like Indonesia or Vietnam, that are forced to re-import processed petroleum products at high prices, due to a lack of domestic refining facilities.

Meanwhile, Korea's export competitiveness of the refinery industry can be seen by looking at the Revealed Comparative Advantage (RCA) (Korea Energy Economics Institute 2010).[i] Currently being expanded due to market liberalization such as FTA (Free Trade Agreement) were more positive influence on the expanding competitiveness of refinery industry (Changsuh Park & Hojeong Park 2004)

However, the deterioration of global economic conditions and enforcement of environmental regulations in the refining industry has a crisis factor (Hee Jun Kwon & Yongsung Cho 2007; Tae Han Kim & Yoon Gih Ahn 2011).

Meanwhile, The Korean refinery industry has been faced with several problems. The industry, the high dependence on exports, is vulnerable to exterior circumstances like world economy fluctuations. Because upgrading ratio and process technology are still low compared to other developed countries, there are limit to produce high value added products. Because world-widely, the supply capacity in refinery industry is growing, there might be supply surplus problem. Refinery is an equipment industry and is required to huge investment for long term.

Many of Korean companies suffered serious crisis during the 2008 global financial crisis. As mentioned earlier, Korean refinery industry responds sharply to global economy fluctuations because it depends highly on export. Rapid world economy fluctuations can

happen again like in 2008. Therefore, examining issues about the competitiveness in the industry and solution for those issues are required

Even though the influence of refinery industry in Korea is quite enormous, concerned studies are not enough. Especially, studies on factors for export competitiveness in the industry and strategies for securing sustainable competitiveness are required.

In this paper, we examine the competitive and risk factors of the Korean refinery industry and look at how this industry has coped with and overcome economic pressures triggered by the global financial crisis. Implications for its future development directions are derived.

This study has examined the main issues on the competitiveness of Korean refinery industry and the literature review for the issues in the second chapter. The research methodology and statistic data usage were dealt in third chapter. In fourth chapter, the current trends in Korean refinery industry were reviewed. In fifth chapter, the export competitiveness was dealt. In sixth chapter, factors for crisis in Korean refinery industry and the strategies for the crisis were dealt. Lastly, the conclusions and implications are dealt in seventh chapter.

2. Literature Review

Korean refinery industry has grown as main export industry by government-leading investment. The economy contribution of refinery industry is 15%, whose role and portion in Korea economy is quite important. In 2010, 53% of its whole sale was exported and was ranked as second export industry following ship-building industry (Cheon Geun Yeon 2010).

The main factors for the industry’s competitiveness are regarded as economy of scale, export increase of refinery product in developing countries, continuing infra investment, etc. Economy of scale which is regarded as a main competitiveness factor tells that Korean infra capacity is 27,220,000 b/d which is sixth in the world following U.S., China, Russia, Japan and India (Korea Energy Economics Institute 2011). The rapid increase of refinery product is regarded as another factor to strengthen Korean refinery industry competitiveness (Korea Energy Economics Institute 2011).

As of upgrading facility, in 2006, 3 Korean refinery companies was only 4300b/d. In 2007, aggressive investment increased to 533000b/d in 2011, which made 3 Korean refinery companies strong (Hyundai Securities 2011). In spite of the world economy recession due to the global financial crisis in 2008, GS Caltex and Hyundai Oilbank never stopped infra investment. And market liberalization and technology progress have contributed productivity improvement (Park Chang Soo & Park Ho Jung 2004).

It can examine Korean refinery industry competitiveness by RCA and Nelson index. RCA index which shows relative competitiveness compared to other countries is measured high as 2.1 in Korea, comparing that Saudi Arabia is 2.0, U.S. is 1.5 and Japan is 0.5. If RCA is higher than 1, it proves the competitiveness (Korea Energy Economics Institute 2011).

As of Nelson index, Korea is in the third following Japan and India in Asia. In 1960, Wilbur L. Nelson devised Nelson index to examine the competitiveness in refinery companies.

As we examined before, Korean refinery industry are assessed as high competitive. But it has several potential crisis possibilities. Current long economy recession has made

refinery product in surplus. Co2 emission reduction is emerging as a big issue (Park Yeoung Hwan 2010). If Co2 emission regulation policy is introduced, burden for reducing expense to be expected to be increased (Hee Jun Kwon &Yong Sung Cho 2007). This hidden crisis possibility is expected to be a negative influence factor (Tae Han Kim & Yoon Gih Ahn 2011).

Another potential crisis possibility is that 75% of Korean refinery products are geologically leaning too much toward Asian-Pacific area which is located close to Korea. Needs for Petroleum products have kept decreasing because of the refinery capacity increase in that area, which caused negative forecast on Korean refinery product export (Cheon Geun Yeon 2010). To secure stable export competitiveness after overcoming crisis, Korean refinery industry needs the diversification of its export which is too focused in Asian Pacific area (Cheon Geun Yeon 2010). It also has to keep continuous facility investment and technology development to boost upgrading ration which is still low compared to developed counties (Choi Gi Ryeon 2007). Moreover, refinery companies have to set up total solution system from developing petroleum to producing refinery product and structurally change to integrated energy company through developing next generation energy (Park Yeoung Hwan 2010).

3. The Methodology and Model

Descriptive method is used in general. This study has tried to drive implications on Korean refinery industry development direction after examining competitiveness factors and crisis factors.

The reason for using descriptive method is like these. When we analyze refinery industry competitiveness, designing an economic model and using statistic method will result in partial analysis without examining overall competitiveness. To examine the competitiveness of refinery industry, overall examining is required rather than examining each various factors respectively. And there are not many studies on Korean refinery industry competitiveness. Most of the current studies on refinery competitiveness are using descriptive method.

This study got the fundamental analysis by overall examining Korean refinery industry. By the analysis of Refinery Company's current status, petroleum production capacity, export level, portion in world market is examined. Analysing these factors, this study has examined export competitiveness factors, crisis factors and counter measures.

The main statistical data for this study, the reliable sources, are mainly from Ministry of Knowledge Economy in Korea, Korea Petroleum Association, Korea Energy Economic Institute, international organization etc. The main research period is from 2008 to 2011 when the global financial crisis occurred.

4. Overview of the Petroleum Refinery Industry in Korea

4.1 Oil Refining Companies

4.1.1 SK Energy

In 1962, the Korean government decided that building petroleum refineries was the number-one priority in its 1st Five-year Economic Development Plan. The Korea Oil

Corporation Act was enacted during the same year, with the Korea Oil Corporation inaugurated in October. The Korea Oil Corporation entered into an agreement with US firm Gulf Oil, on the supply of crude oil shortly afterwards, with the construction of its refinery in Ulsan coming to completion in December 1963.

In the late 1960s, to tap the rapidly growing domestic demand for petrochemical products, the Korea Oil Corporation expanded its production facilities and forayed into the petrochemical business. To finance these new super-sized projects, Gulf Oil's shareholding in the Korea Oil Corporation was increased, giving the latter eventually a controlling interest. In 1970, the Korean government ceded management rights over the Korea Oil Corporation to Gulf Oil. However, with the 1st and 2nd oil crises, amid a dwindling supply of crude oil and darkening prospects for the Korea Oil Corporation, Gulf Oil folded its tent and left Korea, selling its shares in the company (50% interest) to the Korean government.

In subsequent years, the Korean government decided to privatize the Korea Oil Corporation and sold the company to Seongyeong (today's SK group). In 1982, Seongyeong renamed the company "Yugong," and in 1997, renamed it again, this time to a more international-sounding name of "SK Corporation," in line with the dawning trend of globalization. In July 2007, SK Corporation was renamed "SK Energy," and was merged with its subsidiary SK Incheon Oil Refinery (the former Gyeongin Energy Company, created in 1969) in February 2008.

Table1: Major Oil Refining Companies in Korea (Year 2011)

	SK	GS-Caltex	S-OIL	Hyundai Oilbank
Date established	Oct. 1962	Apr. 1969	Jan. 1976	Nov. 1964
Refinery location	Ulsan	Yeocheon	Ulsan	Daesan
Refining capacity (1,000 BPSD)	1,110	770	580	390
Upgrading ratio (%)	15.4	28.3	25.8	30.8
Largest shareholder	SK C&C	GS Holdings and etc	AOC	Hyundai Heavy Industries
Largest shareholder's stake (%)	33.4%	40.0%	35%	91.13%

Source: You Kun 2012; Oh Jung-il 2012

4.1.2 GS Caltex

GS Caltex is a company spun off from Lucky, the predecessor of today's LG group. In 1966, Lucky carried the day in a public tender issued by the Korean government for a second oil refinery project, planned in the context of the 2nd Economic Development Plan. Honam Oil Refinery was created in a joint venture between Lucky and US firm Caltex, followed by another refinery in Yeosu, opened in 1969. After several rounds of expansion, the company was renamed "LG Caltex Refinery" in 1996. In March 2005, the company was spun off from the LG group, giving itself the new name of GS Caltex, also at this time.

4.1.3 S-OIL

At the outbreak of the oil crisis in the early 1970s, Ssangyong Cement saw its supply of bunker C oil cut, forcing its operations grind to a halt. The Ssangyong group, its parent business group, subsequently entered into an agreement with the National Iranian Oil Company (NIOC) on the construction of a 50:50 joint-venture refinery plant in Korea. The Korea-Iran Petroleum Corporation was inaugurated in 1976, with a refinery plant set up in Onsan. However, before the construction of the refinery plant came to completion, the crude oil supply contract with the Iranian public corporation was voided, in the wake of the Islamic Revolution in Iran. Ssangyong took over the shares owned by the Iranian firm, in their entirety, and renamed the company "Ssangyong Oil Refining Company," in 1980.

In 1991, the refining firm signed a contract with Aramco, Saudi's government-owned oil corporation, to cede a stake of the company to the latter, and constructed a cracking center for heavy oil. Subsequently, in 1999, the company became independent from the Ssangyong Group, and one year later, in 2000, renamed it "S-Oil."

4.1.4 Hyundai Oilbank

Hyundai Oilbank has as its predecessor, Keukdong Petroleum Corporation, whose main product line was upscale lubricants. In 1965, following the conclusion of a joint investment deal with global major Royal Dutch Shell, the company was renamed "Keukdong Shell Oil." A little than a decade later, in 1977, the company again changed its name to "Keukdong Oil Corporation." With the withdrawal of Shell from Korea and the resulting termination of the joint venture agreement between the two firms, the 50% stake owned by the former was transferred to Hyundai, which became Keukdong's new partner.

In 1988, the company was renamed "Keukdong Oil Refinery Co.," and in 1989, it set up new refinery plants in Daesan and elsewhere in Korea. The company, however, ran into serious financial trouble shortly after the construction of its new refinery plants, and it was sold in 1993 to the Hyundai Group, giving birth to the "Hyundai Oil Refinery Co..." Hyundai Oil Refinery changed its name in April 2002, to its current name of Hyundai Oilbank.

4.2 Production and Exports

4.2.1 Production

The production of petroleum products kicked off in earnest in Korea, in 1964 when the Ulsan refinery plant of Yugong (current SK Energy) began operation. The Korean government's successfully-implemented Five-year Economic Development Plan resulted in a surge of demand for petroleum in the country. The production of petroleum products rapidly climbed as well, helped by the lively process of substitution of coal by oil. The number and capacity of domestic refinery facilities also increased sharply, with new plants regularly constructed to meet the growing petroleum demand. As a result, the national refining capacity jumped over ten-fold between 1971 and the end of 2011, from 270,000 b/d to 2,835,000 b/d.

As of 2011, the capacity utilization rate among Korean oil refineries stood at 86.5%. Although this means that supply capacity exceeds demand in petroleum products, in reality, there is still a shortage of production facilities. This discrepancy is explained by the fact that the industry is lagging behind structural changes in demand for petroleum products. In order to re-adapt the supply to the changing demand structure in the

petroleum market, oil refineries need to cut back their production of bunker C oil and set up heavy oil upgrading facilities to increase the production of light oils that are in growing demand.

Table 2: Capacity of Oil Refining Facilities and Production in Korea (Unit: 1,000 B/D)

	Capacity	Production
1980	640	481
1990	840	834
2000	2,438	2,533
2011	2,928	2,533

Sources: World Oil Gas Review 2011; MKE 2012

This imbalance in the supply structure between different varieties of petroleum is remedied, to a degree, through trade. Excess inventory in a given petroleum product category is reduced through exports, while others, in which there are shortages, are imported from overseas sources. In other words, any unsold stock of petroleum products is shipped out to overseas markets, and demand for other products whose domestic production is insufficient is met through imports. Short-term supply-demand imbalances, frequently occurring due to the sizeable seasonal fluctuation in demand for petroleum products, are also dealt with through import and export operations. These supply-demand imbalances are the main reason why, in spite of the fact that most countries around the world adhere to the refining-in-consuming-area system, international trade in petroleum products remains lively.

4.2.2 Exports

Exports are an important source of revenue for oil refining companies as well, accounting for a substantial share of their total sales. In 2011, exports represented about 51.3% of total sales made by Korean oil refiners.[ii] Even as recently as in 2004, exports in petroleum products amounted to a mere US$ 10.2 billion, representing only 4% of total national exports. Since then, petroleum exports grew rapidly year after year to account for 6.3% of total exports in 2006, and 9.3% in 2011. This export boom in petroleum products is largely due to the surge seen in demand in Asia and South America, since 2004.

Other important contributing factors have been internal factors such as Korean oil refineries' active investment in additional heavy oil upgrading facilities, leading to increased production, and their effort to compensate for the decline in domestic demand through export operations.[iii] In 2009, the combined upgrading capacity of Korea's top four oil refining companies hit 772,000 barrels per day, substantially higher than 683,000 b/d at the end of 2007. Investment in heavy oil upgrading facilities is still going on unabated among Korean oil refining companies. The main export product categories of the Korean refinery industry are light oils such as gasoline, heating oil, diesel fuel and jet fuel, with high value-added petroleum products accounting for 75% of total exports (based on export volumes).[iv]

Table 3: Global Ranking of Korean Refining Industry

(Unit: 1,000 b/d)

Ranking	Oil Import		Oil Consumption		Refinery Capacity	
1	US	12,454	US	19,528	US	17,290
2	China	5,674	China	9,377	China	10,521
3	Japan	4,853	Japan	4,422	Russia	5,555
4	South Korea	3,170	India	3,338	Japan	4,723
5	India	3,078	Russia	3,041	India	3,796
6	Netherlands	3,061	Brazil	2,724	South Korea	2,835
7	Singapore	2,814	Saudi Arabia	2,664	Italy	2,396
8	Germany	2,580	Germany	2,483	Brazil	2,115
9	France	2,128	South Korea	2,249	Germany	2,108
10	Italy	1,857	Canada	2,234	Saudi Arabia	2,100

Sources: World Oil Gas Review 2011; BP Statistics 2011

Table 4: Korea's Import and Export Status by Items (Year 2011)

(Unit: $ million, %)

Ranking	Items	Amount	Growth Rate	Ranking	Items	Amount	Growth Rate
1	Ships	56,524	15.1	6	Wireless Communication	27,327	-1.1
2	Petroleum Products	51,603	63.7	7	Auto Parts	23,088	21.8
3	Semiconductors	50,145	-1.1	8	Steel	21,541	29.9
4	Automobiles	45,329	28	9	Synthetic resin	20,110	17.9
5	Display	30,997	-4.9	10	Computer	9,170	0.6

Source: MKE 2012

As of 2011, gasoline exports by Korean oil refining companies totalled US$ 6.1 billion, representing 12.6% of total petroleum exports, and diesel fuel exports, US$ 19.9 billion or 40.7% of total petroleum exports. Kerosene and heating oil exports, meanwhile, amounted to US$ 3.5 billion, corresponding to 7.5% of total petroleum exports, and jet fuel and naphtha exports, US$ 10.2 billion and US$ 3.5 billion, representing 20.9% and 7.5% of total petroleum exports, respectively. Diesel fuel, accounting for the largest share of Korean petroleum exports, is also the product produced in the largest quantity in Korea, using heavy oil upgrading systems. The demand for jet fuel is rapidly on the rise in the US, where refining facilities for this petroleum product have not been expanded in the last thirty years, as well as in China, where the demand is up for all petroleum products. Korean refining firms have been reducing the share of kerosene and heating oil in their export product mix, which, although similar in characteristics to diesel fuel, has met with a steadily lessening demand, in favour of jet fuel, to improve profitability.

Table 5: Korea's Petroleum Products Exports by Amounts

(Units: $ million)

Products	2011	2010	Growth Rate
Diesel fuel	19,969	11,755	69.9
Jet fuel	10,240	6,384	60.4
Gasoline	6,193	3,479	78.0
Naphtha	3,669	2,579	42.3
Bunker-C	3,500	1,890	85.2
Others	5,449	3,812	42.9
Total	49,020	29,899	64.0

Source: MKE 2012

Export margins on petroleum products have considerably increased over the recent few years. In 2011, the export margin on petroleum products, corresponding to the unit export price of a petroleum product minus the unit import price of crude oil, jumped 3.5-fold from its level in 2000 to US$ 13.4 per barrel. Meanwhile, lighter oils such as gasoline, kerosene, heating oil and diesel fuel account for nearly 70% of all export petroleum products, indicating that the export portfolio of Korean oil refining companies is cantered on high value-added products, rather than low price products such as bunker C fuel.

5. Export Competitiveness of the Korean Refinery Industry

5.1 Growing Demand

The upturn in petroleum product exports, seen since 2004, is mainly due to the rapidly rising demand worldwide for light fuel oils, with demand surging particularly sharply in China and other emerging Asian countries. China, the source of one-third of total demand from Asia, is still not self-sufficient in terms of refining capacity. The lack of refining capacity explains the spiralling prices of light oils (diesel fuel, jet fuel and gasoline) in the international petroleum market of Singapore, widening their price differentials between petroleum products and crude oil as well as the price differentials between light and heavy oils; ultimately expanding refining margins on light fuel oils.

5.2 Diversification of Export Destinations and Product Categories

Export destinations of Korean oil refining companies are increasingly diversifying. In addition to regional countries like Singapore, Japan and China, Korean refining firms are today exporting to far-flung destinations such as the US, Chile, Brazil, UK, the United Arab Emirates and Australia. As of 2011, Korean oil refining companies exported petroleum products to 40 countries worldwide. By export volume, China was the largest export destination for Korean refining companies (28.9%, including Hong Kong), followed by Japan (15.9), Singapore (14.9%), Indonesia (12.5%) and the US (4.0%).

The same trend toward diversification is also observed in their export product mix, which now includes bunker-C oil, naphtha, jet fuel, asphalt and lubricants, in addition to gasoline and diesel fuel.

5.3 Economy of Scale

The strong export performance of Korean oil refining companies is explained by their competitiveness, underpinned by high production efficiency. The Korean refinery industry boasts the world's highest competitiveness, in terms of economy of scale at the level of single refining facilities. The Korean refining companies operate five refining facilities for a daily production capacity of 29 million barrels. This production capacity, although it ranks sixth globally in terms of total national capacity, is number one globally in terms of single facility capacity (EBN 2009).[v]

The world's top refining capacity possessed by all of these five refineries, combined with aggressive investment in high value-added facilities such as heavy oil upgrading facilities, have helped arm the Korean refinery industry with a formidable export competitiveness.

5.4 Stepped-up Investment in Upgrading Facilities[vi]

When crude oil is heated in a refinery, depending on the temperature (boiling point), different petroleum oils are produced, from gasoline to kerosene, diesel fuel and heavy oil. About 40% of the oil produced through the refining process consists in low-quality heavy oils such as bunker-C oil, which is cheaper than crude. However, bunker-C oil can be upgraded by adding hydrogen or other types of catalysts, to obtain high value-added petroleum products such as gasoline, naphtha and lubricant oils. These heavy oil upgrading facilities are often called "aboveground oil fields," insofar as they transform cheap heavy oil into upscale petroleum products, generating large profits for refiners. When crude oil is processed through a single refining process, the resulting products yield about US$ 1 per barrel. Meanwhile, crude oil processed through upgrading facilities can yield over US$ 10 per barrel in refining margin.

However, the so-called aboveground oil fields, as opposed to underground oil fields, require colossal amounts of investment. The investment requirement for upgrading facilities is four to six times greater than that for basic refining facilities. But in spite of the huge investment cost, construction of upgrading facilities is rapidly becoming an imperative, as they are indispensable for sustained growth of the national economy and stable supply of petroleum products

5.5 Processing Technology

Advanced processing technology is also an important component of the competitiveness of a petroleum refinery industry. Korean refining companies are currently exceeding the production capacity aimed at by the design of their facilities, thanks to their advanced processing technology (Han kook Ilbo 2009). In the case of GS Caltex, they managed to increase their production capacity through simple improvement of processing techniques, without constructing new facilities. The two consecutive rounds of process revamping lifted GS Caltex's production capacity to 790,000 barrels per day, from the previous 729,000 barrels.

A special type of know-how coming from long experience is transmitted by senior workers to junior refinery staff, ensuring the continuity of an excellent technical standard in the production process. Senior refinery workers, for example, can detect anomalies in refining units that are not detected by high-precision calibration equipment, by simply hitting them with a hammer a few times.

5.6 Flexibility of Production Planning

Price competitiveness is the overriding consideration among all Korean petroleum exporters. They further have a flexible operation structure, allowing them to export their products anywhere in the world, as long as the transaction is profitable. This flexibility of production planning helps Korean refining companies continuously strengthen their cost competitiveness and expand their export markets.

Korean refining companies are also expanding their offering of customized production, whereby petroleum products are produced according to specifications provided by a buyer country. Only refining firms disposing of advanced processing technology can accommodate customized orders.

6. The Risk Facing the Refinery Industry and Response Strategies

6.1 Risk Factors

6.1.1 Global Economic Slowdown Suppressing Demand for Petroleum

The financial crisis of 2008 which originated in the US had global ripple effects, causing the world economy to grind to a halt. One of the consequences of the global economic slowdown is the declining demand for petroleum and petroleum products (EBN 2009). The global petroleum demand hit a high during the 1st quarter of 2008 of 86,580,000 b/d, and quickly tumbled since then, to 83,020,000 b/d in the 2nd quarter of 2009; which corresponds to 3,550,000 barrels less every day. In the US, accounting for 22% of the global petroleum demand, the demand fell over the same period, by 1,580,000 barrels a day. The erosion of petroleum demand in Europe during this period stood at 990,000 barrels a day.

6.1.2 Increased Supply Due to Expansion of Refining Facilities in China, India and Other Emerging Asian Countries

In 2009, new or expanded oil refineries began production in Asia, including India's Reliance (580,000 b/d)[vii viii], China's CNOCC (240,000 b/d) and SINOPEC (160,000 b/d), and Petro Vietnam (120,000 b/d). The increased supply, resulting from the construction of new refining facilities in China, India and elsewhere in Asia, is likely to dampen Korean export performance in petroleum products within this region.

Petroleum refining capacities have also improved in oil-producing countries in the Middle East, such as Saudi Arabia, Iran and Qatar. These countries have now become contenders in the global petroleum processing industry, competing against Korean refining firms for the shares of the US and European markets.

6.1.3 Excess Supply Shrinking Profits

In 2011, the combined total sales of Korea's top four oil refining companies, namely SK Energy, GS Caltex, S-Oil and Hyundai Oilbank, amounted to 114 trillion won, with their operating income standing at 23.4 billion won and operating income-to-sales ratio, 2.1%. As for net profit margin, it below 2%. This is well below the net profit margin of 3%-5% posted in the past.ix The simple refining margin of Korean refiners, corresponding to the price of a petroleum product minus the cost of raw materials, has been steadily negative since the beginning of 2009.[9] Composite refining margins, in other words the sum of

production margins from the conversion of Bunker-C oil to gasoline, diesel fuel and kerosene from heavy oil upgrading facilities, and simple refining margins, have not been eroded as much, but are still in negative territory.

6.2 Risk Response Strategies

Since early 2012, Korean oil refiners have been hit by deteriorating profitability, due to dwindling operating margins. However, this has not affected their investment in facilities expansion and construction of upgrading facilities, which are still going strong. For refining firms to maintain a viable market presence worldwide, they must distribute standardized products in global marketplaces and be price-competitive. Therefore, for refining companies to survive in the global market, it is crucial that they continuously upgrade their facilities and strengthen their cost competitiveness. Korea's top four refining companies are actively preparing for the future, through bold investment in facilities and sustained efforts for technological improvement, in order to gain long-term competitiveness.

6.2.1 Increasing Investment in Upgrading Facilities

In recent years, the Korean refinery industry is focusing their effort on reprocessing cheap bunker C oil into high value-added petroleum products such as gasoline, diesel fuel and heating oil, through their heavy oil upgrading facilities.[x] It is more economical to produce light oils from bunker C oil, than from crude, as the former is cheaper than the latter. Allocating more light oils in their export product mix is also a major trend among Korean refining companies as a strategy to strengthen their competitiveness, as these oils are increasingly more in demand worldwide.

Korean oil refiners, boasting the highest production efficiency on a single facility basis, are doing their utmost to increase their refining margins by constructing additional upgrading facilities.[xi] Due to changes in the structure of the refinery industry, simple refining margins are no longer sufficient to ensure viable operation and competitiveness, forcing refining companies to accelerate their investment in upgrading facilities.

Table 6: Major Investment in Refinery (By the end of September 2011)

(Units: kb/d)

	SK Energy	GS Caltex	S-OIL	Hyundai Oilbank	Total
Crude Distillation Unit(CDU)	1,115	775	580	390	2,860
Residue Fluid Catalytic Cracking(FTCC)	172	215	150	120	657
Integrated Rate	15.4%	27.7%	25.9%	30.8%	21.2%

Source: MKE 2012; KIS 2012

The current focus of Korean oil refining companies is building long-term competitiveness by investing in high value-added production facilities.

Table 7: Korean Oil Refining Upgrading Investments and Expected Benefits

SK Energy		S-OIL
Construction of a heavy oil upgrading facility of 40,000 b/d capacity within the Incheon plant	Company	Construction of a PX production facility of 900,000t capacity and a BTX production facility of 280,000t capacity within the Onsan plant
1.520 trillion won	Description	1.4 trillion won
June 2016	Amount of investment	2011
Improved profitability and export capabilities for the Incheon plant	Expected benefits	Expansion of the petrochemical business line to raise the operating income by more than 20%
GS Caltex		Hyundai Oilbank
Construction of a third desulphurization facility of 113,000 b/d capacity within the Yeosu plant	Company	Construction of a heavy oil upgrading facility of 52,000 b/d capacity within the Daesan plant Construction of a PX manufacturing line of 800,000t in annual production capacity and a benzene production line of 110,000t capacity in a joint venture with Japan's Cosmo Oil
3 trillion won	Description	2.1 trillion won for the heavy oil upgrading facility US$ 1.2 billion investment in kind (estimation) for the petrochemical plant
Late 2010	Amount of investment	1st half of 2011 for the heavy oil upgrading facility 2013 for the petrochemical plant
Lift the upgrading ratio to 38% and gain global competitiveness	Expected benefits	Lift the upgrading ratio to 30% and gain global competitiveness by expanding the petrochemical division

6.2.2 Intensification of Technology Development Efforts

As important for the petroleum refinery industry as facilities investment is technology development. Technological advantages always lead to an increase in production capacity. SK Energy aims higher than using advanced production technology. Under a goal to export not just petroleum products, but also new petroleum processing techniques and technologies, the company is accelerating its R&D efforts. Its various catalyst technologies, used in processing petroleum and petrochemical products, are, as a matter of fact, amongst the world's best. One of the objectives at SK Energy is to develop a low-temperature processing technique for naphtha upgrading with the use of catalysts, to literally revolutionize current petroleum production methods, which have hardly changed since the 1920s.

GS Caltex, meanwhile, has recently increased its atmospheric distillation capacity by 30,000 b/d through simple process improvement, without constructing a single new facility. Process improvement efforts also raised the production capacity of its lubricant oil plant to 23,000 b/d, from 18,000 b/d.

Finally, S-OIL is also investing in production technology research to support the desulphurization process of gasoline and diesel fuel and the processing of lubricant oils and BTX. S-OIL, notably, operates reduced-size pilot plants where each new process is tested to ensure that they make long-term contributions to product quality.

6.2.3 Production Capacity Improvement and Energy Saving through Process Improvement

If heavy oil upgrading infrastructure is a major determinant of the prospects of a petroleum refinery industry, efficiency improvement efforts to cut costs and energy intensity are as important a determinant ensuring the viability of production operations.

At SK Energy, since 2008, an energy consumption reduction team, led by the head of the production technology division, is hosting organization-wide debates on power saving technologies and policies. Meanwhile, SK Energy started a cost-cutting campaign in April 2009, called “WI_PI.” The campaign is aimed at discovering innovative ideas by hosting small group discussions by engineers and applying these ideas to maximize operation efficiency in SK Energy’s plants (EBN 2009). They selected fifteen concrete tasks from the 1st round of WI_PI, which are expected, when successfully implemented, to save the company over 50 billion won in operating costs.

Expansion of P2P, a task proposed as a way of expanding channels for acquisition of low-cost materials, is particularly promising. The P2P expansion plan consists in trading unused by-products between SK Energy and its subcontracting firms of good standing. By buying excess by-products from a subcontracting firm, at low prices, SK Energy can manufacture finished products at its idle facilities or using its unutilized production capacity.

SK Energy is also noted for using new, innovative technologies for cutting energy consumption at its petrochemical production line as well. A fine example is its R&D project to develop a new technology for catalyst (ACD)-based upgrading of naphtha, instead of the traditional heat-based upgrading. This technology is expected to allow the upgrading process to take place at a temperature below 700 degrees, instead of a temperature over 850 degrees, required in the existing process, drastically cutting the energy intensity for this process.

At GS Caltex, active efforts are under way to improve process efficiency, cut costs and reduce energy consumption. In July 2008, the company updated and expanded its existing crude oil distillation units and lubricant oil production units, at the same time as improving their mode of operation. This round of revamping resulted in an increase of GS Caltex’s production capacity in petrochemicals from 790,000 b/d to 820,000 b/d, and in lubricant oils from 18,000 b/d to 23,000 b/d.

In March 2008, improvements were introduced to the heavy oil upgrading facility and alkylate production line in its Yeosu Plant, set up under a 170 billion-won project #1, which was also thoroughly retuned. This has led to a substantial enhancement of product yield from the heavy oil upgrading process, resulting in a commensurate increase in the

production of high value-added gasoline. The daily handling capacity in related processes also grew by 20 to 30% from the previous level.

Meanwhile, the energy technology team of GS Caltex, in charge of energy-related affairs in the company since 2002, continuously added an 'energy efficiency team.' Thanks to improvement efforts by the new team, energy use at GS Caltex is now over twice as efficient as before. Over the last five-year period, GS Caltex managed to enhance its energy efficiency rate by more than 10%, which, in monetary terms, translates into a whopping annual savings of 100 billion won.

S-OIL is as committed as its three major Korean competitors to slashing energy consumption at its production sites and has been continuously investing in related projects. To reduce energy consumption at its plants, S-OIL is installed 13,000 removable units of heat-insulation apparatus, which are attached to the valves and flanges of refinery equipment, under a project costing 3 billion won. The installation of heat insulation units, S-OIL is expected to be able to reduce its fuel use by as much as 87 barrels daily and shrink its greenhouse gas emissions by 14,000t annually, which represents an annual savings of 2.5 billion won. Before this, under a project begun in late 2008, S-OIL installed close to 30,000 lids on its steam equipment to prevent losses of heat and steam, resulting in a reduction of fuel consumption by 22 barrels daily or an annual savings of 600 million won on fuel costs.

6.2.4 Elimination of Customs Tariffs

Whilst some petroleum exporting countries export petroleum products to Europe tariff-free under a customs tariff agreement, a 4.7% tariff is imposed on export shipments from Korea, weakening the price competitiveness of Korean products.

Meanwhile, the recent Chinese decision to eliminate customs tariffs on asphalt products from ASEAN countries is unfairly discriminating Korean companies, as it undercuts their export competitiveness vis-à-vis China.

The Korean government, given that FTA negotiations between Korea and other nation are likely to last some time before a deal is signed and ratified, is considering engaging in separate customs tariff negotiations with the latter on certain product categories.

7. Summary and Conclusions

Korean oil refining companies, due to continuous investment in upgrading facilities over the past decade, are became the competitive players of the global petroleum processing market. Their focus on light oils has been also a contributing factor to their strong export performance in recent years. Using upgrading facilities enabling the conversion of bunker C oil to light oils, Korean refining companies are expanding their volume of exports in diesel fuel, gasoline and jet fuel, thereby improving their export performance. This was largely due to the fact that Korean companies have been relentlessly investing in facilities, year after year, while other oil-consuming countries have been more reluctant, considering the refinery industry a sunset industry.

Thus, Korean companies need to further step up their facilities investment, to meet new challenges from the changed market landscape since the global economic crisis. The upgrading ratio is still less than 30%, which is below in other major developed countries. Petroleum refining companies in developed countries re-use 100% of bunker C oil

produced from internal processing, as the raw material for producing light oils, at the same time as buying cheap bunker C oil from international markets for conversion into high value-added products. These companies, therefore, have a revenue structure that is more advanced than that of Korean firms.

In conclusion, in industries like petroleum refinery and chemicals manufacturing, which depend vitally on economies of scale, the capacity and efficiency of a production facility are crucial to ensuring competitiveness. Capacity being equal, newer production lines is better and dramatically more efficient than older ones, as the speed of technological progress is such that obsolescence is just around the corner. Accordingly, continuous investment in upgrading facilities is an absolute must. There is, in other words, no competitiveness without investment. This is particularly true for process industries like the petroleum refinery industry. Only larger and better production facilities can guarantee future competitiveness. That is why the wisest way to wait out bad economic times and prepare for better times is to invest actively and early in production facilities. The petroleum industry is also a classical cyclic industry. A period of boom is almost always followed by a period of downturn, and a downturn, followed by a boom, so on and so forth. Only those firms that continuously invest in facilities, through good and bad economic times, can ensure the survival and continued competitiveness of their businesses. Also, cyclic changes in the international market reveal quite a clear pattern. Companies have to stay the course with their investment plans, with foresight and a visionary mindset, and history has repetitively proved that a bearish economic phase is the best time to invest.[xii]

In addition, South Korea is more required to sign on FTA with other major trading countries, which have great demand potential for petroleum products. And it will be expanding the competitiveness of Korea's refinery industry due to increase of petroleum product exports.

This research uses descriptive method to analyse the overall competitiveness of refinery industry and to draw some policy implications. However, the exclusive using this descriptive method can′t prove the co-relation between affecting factors in competitiveness and competitiveness itself. Therefore, econometrical models and sophisticated analytical methods are required to get more exact affecting factors in export competitiveness and to draw more realistic and more accurate implications through proving the co-relation between affecting factors in competitiveness and competitiveness itself.

Endnotes

[i] The RCA is an index used in international economics for calculating the relative advantage or disadvantage of a certain country in a certain class of goods or services as evidenced by trade flows. It is based on the Ricardian comparative advantage concept. It most commonly refers to an index introduced by Béla Balassa (1965). A comparative advantage is “revealed”, if RCA>1. If RCA is less than unity, the country is said to have a comparative disadvantage in the commodity or industry.

[ii] Korea Petroleum Association (http://www.petroleum.or.kr)

[iii] This is because, unlike other oil-consuming countries that have been reluctant to invest in refining facilities, considering refining a sunset industry, Korean companies have relentlessly invested in upgrading facilities year after year, increasing, thereby, their capacity to produce high-quality light oils.

[iv] Korea Petroleum Association, ‘Petroleum Product Exports Hit More than Half of Crude Oil Imports in Value,’ May 22, 2009.

[v] In Japan, for example, where small-scale refining facilities, aimed mostly at meeting the domestic demand, are set up along the country’s coastlines for easier access to imported crude oil shipments, production efficiency in petroleum products is far below the level in Korea.

[vi] Upgrading facilities refer to facilities equipped to reprocess bunker C oil, heavy oil left over from the initial processing of crude oil, into upscale petroleum products such as gasoline, diesel fuel or kerosene or heating fuel.

[vii] Reliance in India is planning to add two more refineries in 2010 and 2012, each providing a 434,000 b/d and a 436,000 b/d capacity. The annual average additional capacity of 230,000 b/d, brought by these new refining facilities, over a period leading up to 2015, is likely to largely exceed the annual increase in petroleum demand in India, over the same period, forecasted at 100,000 to 150,000 b/d. A noteworthy detail about Indian refining facilities is that they possess a high upgrading ratio and are export-oriented. The expansion of domestic refining infrastructure in India is likely not only to cause the dampening of Korean exports to this destination, but also to make this country a new competitor for Korea in the global petroleum process market.

[viii] The new facilities constructed by Reliance (India) boast high upgrading ratios. Upgrading facilities permit refiners to use cheap bunker C oil to produce gasoline, diesel fuel and kerosene, thereby cutting their raw materials costs.

[ix] The manufacturing industry average operating margin is 6.9% in Korea.

[x] The global petroleum product market has been completely restructured around light fuel oils. Today, heavy fuel oils, emitting large quantities of atmospheric pollutants, are shunned, and are sold at cheap prices. Accordingly, petroleum refiners around the globe are resting their hopes on upgrading facilities; the more upgrading facilities, the larger the earnings potential. Constructing an upgrading facility is, however, a hugely costly undertaking, requiring billions of dollars. Also, there are only a handful of engineering firms capable of manufacturing core components for upgrading facilities, which makes any upgrading unit construction project a long haul. The sharply declining worldwide demand for petroleum products, meanwhile, does not make it easy for refining companies to undertake new large investment projects. But, most industry watchers agree with each other in pointing out that this is not the time for slackening investment, given the facility requirements of the future petroleum processing market. On the contrary, this is precisely the time to boldly invest in infrastructure, if Korea wants to edge out its competitors and bring in 'oil dollars' through its refining competitiveness.

[xi] Whilst upgrading ratios in the US and Europe hover above 50%, the corresponding figures among Korean refiners are still below 30%.

[xii] Atmospheric distillation units, still largely in use in Korean refining companies, although they do produce light fuel oils, such as LPG (Liquefied Petroleum Gas), gasoline, naphtha, diesel fuel and kerosene, from crude oil, about 40% of total output is accounted for by bunker C oil. The problem is that the demand for bunker-C oil is rapidly dwindling worldwide, due to toughening environmental regulations. Bunker C oil, currently used only as marine fuel oil, is traded currently at prices that are US$ 10 to 20 lower than crude oil per barrel. In order to compensate for negative margins in the bunker C oil segment, refining companies need to maximize their margins from light fuel oils. Upgrading facilities put an end to this conundrum of the refinery industry. Bunker-C oil by-produced from the atmospheric distillation process can be re-used as raw material to produce light fuel oils such as gasoline and diesel fuel. This is the reason why the refinery industry baptized upgrading facilities "aboveground oil fields."

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