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Data-Driven Investigation of Pricing Behaviors in the Retail Gasoline Market

Jin Hyung Lee

samshun76@gmail.com

Korea Fair Trade Mediation Agency https://orcid.org/0000-0001-5784-9599

Research Article

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Data-Driven Investigation of Pricing Behaviors in the Retail Gasoline Market

Jin Hyung Lee*

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Abstract

This study investigates pricing behaviors of retail gasoline markets in two geographically different regions of South Korea. When one market is regarded as competitive and the other market is uncertain about its level of competition, the test method to compare the former with the latter is introduced and the empirical result is suggested here. This test method seems to be simple but powerful since the historical data on prices is only required to proceed this test method. Accordingly, this study contributes to the economic literature in respect of introducing this efficient novel method and suggesting the empirical result.

JEL Classification: C63, C71, C81

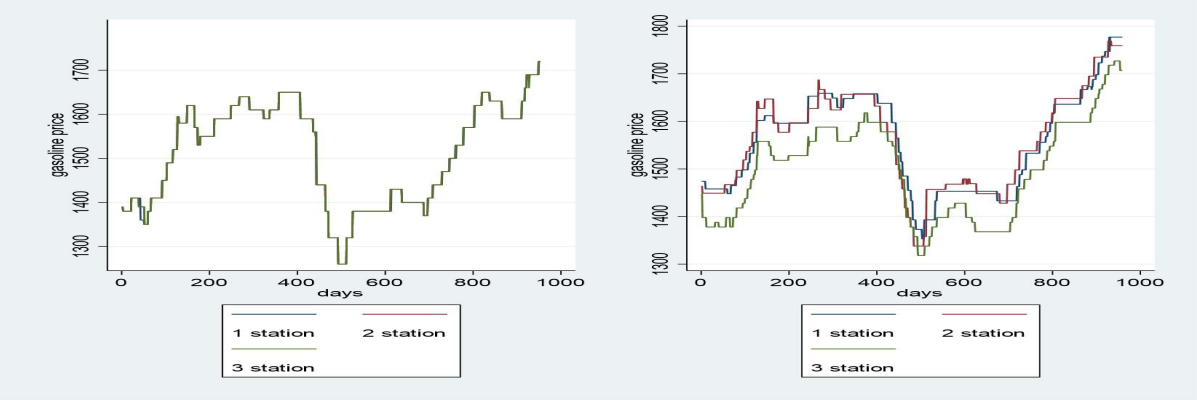
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*I am responsible for all errors.

*Korea Fair Trade Mediation Agency, email: samshun76@gmail.com

1 Introduction

The two figures described below depict the retail gasoline price movement of a few stations in region J (left-side) and region S (right-side) of South Korea from January 1st, 2019 to August 10th, 2021. At least, the three gasoline stations of each figure are not positioned in the same block. In fact, they are far away from each other by distance. Nonetheless, the co-movement of retail gasoline price tends to be more distinct in region J, compared to region S. In more detail, the horizontal line indicates the number of days (days) from January 1st, 2019 to August 10th, 2021. The vertical line implies the gasoline retail price measured in the unit, Korea won. In both figures, the retail gasoline price movements seem to be different from each other. More specifically, in region S (right-sided figure), the retail gasoline price appears to move more smoothly, compared to region J (left-sided figure). More importantly, the retail gasoline prices in region J seem to be exactly overlapped to each other in contrast with prices widely dispersed in region S. In a sense of meaning that price dispersion occurs when each economic operator or player independently acts on its own scheme, the retail gasoline market appears to be competitive in region S.



Source: opinet (period: from January 1st, 2019 to August 10th, 2021)

Figure 1: Comparison between a few gasoline stations in region J and region S

However, daily retail gasoline prices which every gasoline station all over South Korea imposes are open to the public, where such information is provided through the Opinet. Thus, consumers easily get access to the cheapest gasoline price in a certain region, and each gasoline station has

strong incentive to suggest a lower daily price, compared to its competitors. Accordingly, it is difficult to imagine that the retail gasoline market in region J seems to be either collusive or anti-competitive. In spite of that, the two retail gasoline markets indicated earlier appear to be quite different. Therefore, the method to decide whether or not a market is competitive would be suggested in this study. In particular, a questionable market would be compared with a reference market which is firmly regarded as competitive with respect to pricing decision of players.

1.1 Related Literature

In relation to dealing with testing competitive market,[1] various studies are provided in order to decide whether a market is collusive or not. Above all, there are abundant studies to analyze both the movement of retail gasoline price (or pricing strategies) and corresponding players' incentive to adjust price except the Bertrand model. In this regard, Maskin and Tirole (1988) present the Edgeworth cycle to account for the movement of retail gasoline prices. In this cycle, a leader rapidly increases price in advance and followers consecutively raises prices at similar level. Then, the crack of tacit collusion occurs which implies that some players begin to gradually lower prices and all eventually participate in this price war until they reach the original starting point of price. This pattern would be consistently repeated which is called the Edgeworth cycle. Meanwhile, the price pattern in region J seems to be more similar to the kinked demand curve suggested by Sweezy (1939) and Maskin and Tirole (1988) rather than the Edgeworth cycle. Regardless of whether the price pattern belongs to the Edgeworth cycle or kinked demand curve, this study detects a method to decide whether or not a market is competitive by comparing it with a benchmark being competitive.

In conjunction with theoretical model, Noel (2007, 2008) provides a series of empirical models to estimate the Edgeworth cycle. He adopts an empirical model with the concept of Markov perfect equilibrium to test how firm behaviors would differentially over the path of a cycle and demonstrates the existence of Edgeworth cycle. However, the price pattern in the retail

[1] One example is the study of Urban, Johnson and Hauser (1984).

gasoline market would not be necessarily limited only to the Edgeworth cycle, and there might be various another patterns. For instance, Byrne and De Roos (2019) collect rich data on daily retail gasoline prices and analyze whether the price cycle described by the Edgeworth cycle shows up or not. Thus, they document that a simultaneous moves setting tends to show the explanatory power to match the data due to the timing of play and pervasiveness of coordination difficulties rather than the adoption of Markov strategies.[2]

Unlike studies stated earlier, Blanckenburg, Kholodilin and Geist (2012), Bertsimas, Gupta and Paschalidis (2015) and Hespanhol and Aswani (2020) propose methods to test the competitive level of market. More specifically, Bertsimas, Gupta and Paschalidis (2015) and Hespanhol and Aswani (2020) suggest statistical methods to estimate the parameters of players' utility or profit functions from observed equilibria and determine whether players are acting in competition according to these equilibria. This study employs their methods to test whether or not the retail stations in both region J and region S are symmetrically acting depending on these equilibria.

1.2 Purpose of This Study

Above all, this study aims to introduce the statistical method suggested by Bertsimas, Gupta and Paschalidis (2015) and Hespanhol and Aswani (2020). In reality, it is common that a regulator with no prior knowledge of either utility or profit function mainly collect information only on the historical data about prices of items traded in a certain market. In this situation, the regulator is faced with its decision about whether it initiates to investigate the relevant market in order to detect collusion or not. This study gives a clue which is helpful in solving the problem of a regulator.

This study is organized as follows. In the Section 2, the empirical method is introduced to decide whether or not the retail gasoline market is competitive in region J in comparison with the market in region S. Furthermore, theoretical analysis is presented to support the result derived from the empirical estimation. Finally, a conclusion is made in the Section 3.

[2]In addition, Cabral et al. (2021) establish that Price Matching Guarantee would enact a tacit collusion.

2 Empirical Approach to Detect Collusion

2.1 Model Description

The model described below is suggested by Bertsimas, Gupta and Paschalidis (2015) and Hespanhol and Aswani (2020). They provide the method such that a regulator without any prior knowledge of either utility function or profit function of players (firms) estimates the function from observing the restricted information only on players' pricing decisions and external shocks. The regulator finally decided if the players are competing against each other or pursuing the collusive scheme based on the estimation.

Now, I assume that two players i=1, 2 compete against each other in the downstream market such as gasoline station, etc. p_i means the price which each player decides (eq: 1).

$$\mathcal{P} = \left\{ (p_1,\ p_2) \in \mathbb{R}^2 :\ 0 \leq p_1 \leq \overline{p},\ 0 \leq p_2 \leq \overline{p} \right\} \tag{2.1}$$

The profit function, $\Pi_i\left(p_1,\ p_2,\ p_w; \theta_i\right)$ of player is designated as follows (eq:2∼3). $D_i\left(p_1,\ p_2,\ p_w; \theta_i\right)$ represents the player's demand function, which depends on price vectors and parameters. In particular, p_1 and p_2 are prices which both players 1, 2 determine, respectively, where $\overline{p}$ means the upper bound. p_w basically indicates a common shock that may affect the demand and be outside of the players' control. In this study, p_w particularly stands for the wholesaler's price in the upstream market. Since the players (retailers) in the downstream market purchase goods from the wholesalers, p_w seems to act as a cost shock. The information on p_1, p_2 and p_w are public to the players and regulator. The parameter vector, θ_i consists of θ_{i0}, θ_{i1}, θ_{i2},θ_{i3}, which are assumed to be the private information of each player. After observing p_1, p_2 and p_w, the regulator needs to estimate the parameter vector in order to decide if the players compete against each other or not.

$$\Pi_i\left(p_1,\ p_2,\ p_w; \theta_i\right) = p_i D_i\left(p_1,\ p_2,\ p_w; \theta_i\right), i \in \{1,\ 2\} \tag{2.2}$$

$$D_i\left(p_1,\ p_2,\ p_w;\theta_i\right)=\theta_{i0}+\theta_{i1}p_1+\theta_{i2}p_2+\theta_{i3}p_w, i\in\{1,\ 2\} \tag{2.3}$$

According to Bertsimas, Gupta and Paschalidis (2015) and Hespanhol and Aswani (2020), since the (pure-strategy) Nash Equilibrium may not be suitable for the Bertrand game under various constrained environments, they will focus on the case where each player plays imperfectly and apply $\epsilon-$approximate Nash equilibrium of the Bertrand game. To formalize this concept of approximate equilibrium, the characterization is presented in the following manner.

(**Definition**) A strategy profile $\mathbf{p}=(p_1,\ p_2)$ is an $\epsilon-$approximate Nash equilibrium if and only if $\mathbf{f}\left(\mathbf{p}\right)^T\left(\overline{\mathbf{p}}-\mathbf{p}\right)\leq\epsilon$, where $\mathbf{f}\left(\mathbf{p}\right)=\begin{bmatrix}\mathrm{f}_1\left(p_1,\ p_2\right)\\ \mathrm{f}_2\left(p_1,\ p_2\right)\end{bmatrix}=\begin{bmatrix}m_1\left(p_1,\ p_2,\ p_w;\theta_i\right)\\ m_2\left(p_1,\ p_2,\ p_w;\theta_i\right)\end{bmatrix}$, $\left(\overline{\mathbf{p}}-\mathbf{p}\right)=\begin{bmatrix}\overline{p}-p_1\\ \overline{p}-p_2\end{bmatrix}$, $\mathbf{p}=(p_1,\ p_2)$, $\overline{\mathbf{p}}=(\overline{p},\ \overline{p})$, $\frac{\partial\Pi_i}{\partial p_i}=\nabla_i\Pi=m_i\left(p_1,\ p_2,\ p_w;\theta_i\right)$.

In the definition, $\overline{\mathbf{p}}$ is basically considered to be an optimal solution to the (pure-strategy) Nash Equilibrium. The meaning of definition is as follows. That is, if $\mathbf{p}$deviates $\overline{\mathbf{p}}$ from in a specific direction and $\mathbf{f}\left(\mathbf{p}\right)^T\left(\overline{\mathbf{p}}-\mathbf{p}\right)$ reaches a negative value, the $\mathbf{p}$ in that direction would decrease either utility or profit of a player. Thus, every movement of $\mathbf{p}$in any direction to put $\mathbf{f}\left(\mathbf{p}\right)^T\left(\overline{\mathbf{p}}-\mathbf{p}\right)<0$ needs to be removed. Furthermore, every movement of $\mathbf{p}$in any direction to make $\mathbf{f}\left(\mathbf{p}\right)^T\left(\overline{\mathbf{p}}-\mathbf{p}\right)>0$ contradicts that $\overline{\mathbf{p}}$ is an optimal solution to the (pure-strategy) Nash Equilibrium. Thus, $\mathbf{f}\left(\mathbf{p}\right)^T\left(\overline{\mathbf{p}}-\mathbf{p}\right)$ goes to zero under the (pure-strategy) Nash Equilibrium. Under the $\epsilon-$approximate Nash equilibrium, there exists an error between $\overline{\mathbf{p}}$ and $\mathbf{p}$, which justifies $\mathbf{f}\left(\mathbf{p}\right)^T\left(\overline{\mathbf{p}}-\mathbf{p}\right)\leq\epsilon$. In their studies mentioned earlier, $\overline{\mathbf{p}}$ is replaced by the upper bound instead of the optimal solution since the optimal value is uncertain.

The theorem below is also suggested by Bertsimas, Gupta and Paschalidis (2015) and Hespanhol and Aswani (2020). The theorem is considered to be another expression of the definition. In other words, $\mathbf{f}\left(\mathbf{p}\right)^T\left(\overline{\mathbf{p}}-\mathbf{p}\right)$ is decomposed into two elements; $\mathbf{f}\left(\mathbf{p}\right)^T\cdot\overline{\mathbf{p}}$ and $\mathbf{f}\left(\mathbf{p}\right)^T\cdot\mathbf{p}$. Furthermore, $\mathbf{f}\left(\mathbf{p}\right)^T$ is assumed to be bounded above, indicating $y_i\geq\mathrm{f_i}\left(p_1,\ p_2\right)$.

(**Theorem**) A strategy profile $\mathbf{p}=(p_1,\ p_2)$ is an $\epsilon-$approximate Nash equilibrium if and only

if there exist $y_1,\ y_2 \in \mathbb{R}$ such that $\begin{cases} y_i \geq \mathrm{f_i}\left(p_1,\ p_2\right), \text{ for } i \in \{1,\ 2\} \\ \sum_{i=1}^{2}\left(\overline{p}y_i - \mathrm{f_i}\left(p_1,\ p_2\right)p_i\right) \leq \epsilon \end{cases}$.

Finally, the theorem above is directly applied to the following yielding named to be the feasibility problem after some arithmetic. That is, given a sequence of observed prices and shocks $\left\{\left(p_1^j,\ p_2^j,\ p_w^j\right)\right\}_{j=1}^{N}$, the regulator would like to ascertain whether players act according to $\epsilon-$approximate Nash equilibrium or not. To that end, the regulator will construct estimates $\hat{\theta}_1,\ \hat{\theta}_2$ of the private information vectors and shocks. Then, the regulator also estimates $\hat{\epsilon}_j$ for each observation tuple, $j\in\{1, 2, \cdots, N\}$.

$$min_{y_1,y_2,\theta_1,\theta_2} \left\|\hat{\epsilon}\right\|, where \left\|\hat{\epsilon}\right\| = \sum_{j=1}^{N}\hat{\epsilon}_j^2 \tag{2.4}$$

$$\begin{aligned} \text{s.t. } y^j=&\left(y_1^j,\ y_2^j\right)\geq 0, \text{ for } \forall j\in\{1, 2, \cdots, N\} \\ y_i^j\geq& m_i\left(p_1^j,\ p_2^j,\ p_w;\theta_i\right), \text{ for } i \in \{1,\ 2\},\ j\in\{1, 2, \cdots, N\} \\ \sum_{i=1}^{2}&\left(\overline{p}y_i^j - p_i^j m_i\left(p_1^j,\ p_2^j,\ p_w^j;\theta_i\right)\right) = \hat{\epsilon}_j, \text{ for } j\in\{1, 2, \cdots, N\} \end{aligned}$$

The regulator applies the method above to one market which is firmly regarded as competitive and computes the estimated residuals, $\hat{\epsilon_1}, \cdots,\ \hat{\epsilon}_N$. Moreover, the regulator also applies this method to another market which is assumed to be anti-competitive or collusive and derives the estimated residuals. Thus, the regulator constructs two types of empirical distributions corresponding to two kinds of estimated residuals, respectively. Then, the regulator uses those residuals and distributions to perform a Kolmogorov-Smirnov test in order to determine whether the latter market is competitive or not. Likewise, Blanckenburg, Kholodilin and Geist (2012) implement the Kolmogorov-Smirnov test in order to make a differentiation between competition and cartel. The empirical cumulative distribution is computed in the following manner.

$$\hat{F_N}\left(d\right) = \frac{1}{N}\sum_{j=1}^{N}\mathbf{I}\left(\hat{\epsilon}_j \leq d\right), \text{ where } \mathbf{I}\left(\cdot\right) \text{ is an indicator function.} \tag{2.5}$$

The test statistic for the Kolmogorov-Smirnov test is also derived as follows.

$$D^* = max_d \left| \hat{F}_N^{com}(d) - \hat{F}_N^{col}(d) \right|, \text{ where "com" means "competitive", and "col" indicates "collusive".} \tag{2.6}$$

$\hat{F}_N^{com}(d)$ means the distribution of estimated residuals, $\hat{\epsilon_1}, \cdots, \hat{\epsilon}_N$ when one market is regarded as competitive, and $\hat{F}_N^{col}(d)$ indicates the distribution of estimated residuals, $\hat{\epsilon_1}, \cdots, \hat{\epsilon}_N$ when the other market is presumed to be anti-competitive. If players in each market compete against each other according to $\epsilon-$approximate equilibrium strategy, the two distributions of estimated residuals, $\hat{\epsilon_1}, \cdots, \hat{\epsilon}_N$ are similar to each other, and $\hat{F}_N^{com}(d)$ would converge to $\hat{F}_N^{col}(d)$. Otherwise, if players act in a dissimilar way, the two distributions of estimated residuals would not converge to each other. Thus, there is the high likelihood such that players in one market are behaving in an $\epsilon-$approximate equilibrium and they are not in the other market.

2.2 Data Description

The Opinet provides information on daily gasoline prices of every gasoline station in the Korean Peninsula, including all islands annexed. Thus, the daily gasoline prices of every gasoline station in region J and region S metropolitan area are collected from 1st, January, 2019 to 10th, August, 2021. The method to construct p_1^j, p_2^j, p_w^j is provided as follows.

First of all, p_1^j means the daily gasoline price of a gasoline station located in either region J or region S. p_2^j indicates the daily gasoline price imposed by a corresponding gasoline station the closest to the station for p_1^j with respect to the distance. Therefore, p_1^j and p_2^j are daily gasoline prices charged by gasoline stations which are in competition with each other in distance.

As mentioned earlier, p_w^j particularly stands for the wholesaler's price. The wholesaler is either an oil refinery company or oil refiner's agency. In particular, four main oil refinery companies[3] have been competing against each other in South Korea. They either directly supply gasoline to retail stations or oil refiner's agencies which provide gasoline to retail stations. As indicated below in the table 1, the four companies actually dominate the retail gasoline market across

[3]The four companies are SK Energy, GS Caltex, Hyundai Oilbank, and S-OIL.

region J and region S. However, there exists the difference between region J and region S. There is an alternative method that the retail gasoline stations in region S possibly purchase gasoline instead of the four oil refinery companies. More specifically, they are able to buy gasoline directly from abroad at cheaper price, if some retail stations form cooperative buying group. Accordingly, retail stations in region J are more likely to be subordinate to the four refinery companies in terms of purchasing gasoline. Additionally, p_w seems to be an external shock beyond a retail station's control.

Gasoline Brand	J			S		
	2019	2020	2021	2019	2020	2021
SK Energy	57	56	54	140	132	143
GS Caltex	48	47	47	96	97	129
Hyundai Oilbank	25	27	27	62	61	124
S-OIL	29	28	29	61	63	79
Others	36	36	36	11	10	16
Total	195	194	193	370	363	491

Source: opinet (period: from January 1st, 2019 to August 10th, 2021)

Table 1: The number of gasoline stations in region J and region S

Since $\overline{p}$ is the upper bound of price, it is set up to be the maximum among all daily gasoline prices across region J and region S from 1st, January, 2019 to 10th, August, 2021. Furthermore, every price p_1^j, p_2^j, p_w^j is transformed into $\widetilde{p}_1^j$, $\widetilde{p}_2^j$, $\widetilde{p}_w^j$ through the normalization, where $\widetilde{p}_1^j = \frac{p_1^j}{\overline{p}}$, $\widetilde{p}_2^j = \frac{p_2^j}{\overline{p}}$, $\widetilde{p}_w^j = \frac{p_w^j}{\overline{p}}$. Lastly, θ_{i0}, θ_{i1}, θ_{i2}, and θ_{i3} are estimated for each retail gasoline station. Therefore, about 190 parameters for each θ_{i0}, θ_{i1}, θ_{i2}, and θ_{i3} are estimated for retail stations of region J.

2.3 Results

The two histograms of estimated residuals, $\hat{\epsilon_1}, \cdots, \hat{\epsilon}_N$ are provided as in the figure 2 and 3. The histogram for retail stations in region S widely spreads out in contrast with the histogram for the stations in region J narrowly concentrated. The two cumulative distribution functions (called the cdf) of the estimated residuals are also suggested below the histogram graph. Analogously to the histogram graph, the cdf for the stations in region J more sharply increases compared to the cdf for region S, responding to that the histogram for region J tends to be more dense.

As indicated in the figure 2 and 3, the two distributions do not seem to be overlapped to each other. Thus, I propose a hypothesis test to decide whether players (retail gasoline stations) in both region J and region S are behaving competitively or not. As previously stated, the players in region S are assumed to compete against each other under the dominance of four oil refinery companies and potential purchase source from abroad. In the case that the two cdfs turn out to be indiscernible, the players in region J also seem to be behaving competitively.

The Kolmogorov-Smirnov test result is shown in the table 2. The first line tests the hypothesis that the estimated residual for region J contains smaller values than for region S. The largest difference between the cdfs is 0.180. The approximate asymptotic p-value for this is 0.000, which is statistically significant. The second line tests the hypothesis that the estimated residual for region J contains larger values than for region S. The largest difference between the two cdfs in this direction is 0.267. The approximate asymptotic p-value for this difference is 0.000, which is also significant. Finally, the approximate asymptotic p-value for the combined test is 0.000, indicating the statistical significance. Therefore, the two cdfs seem to be distinct from each other.

According to the result, the retail gasoline market in region J is more likely to be collusive rather than competitive. Even though the retail market itself in region J appears to be competitive, the competitive level is very limited in the following reason discussed the next.

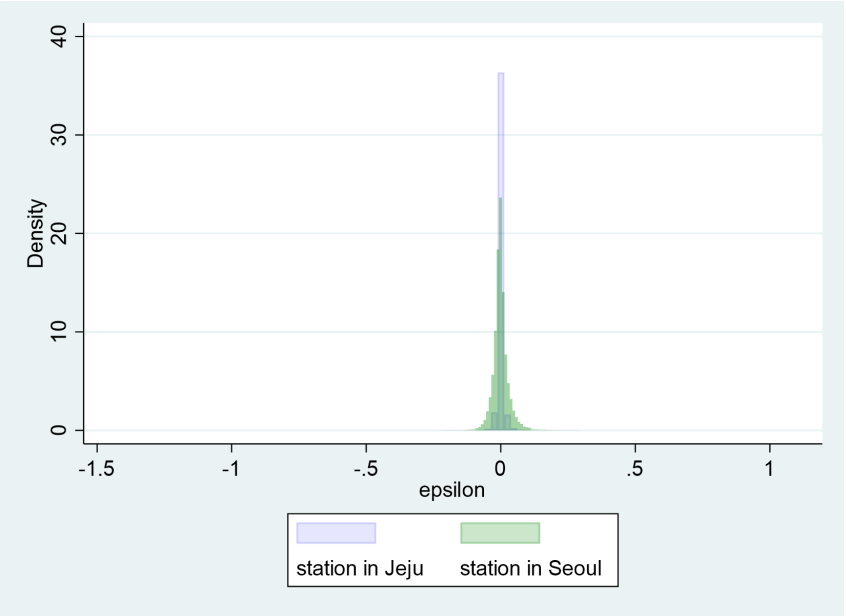


Figure 2: The histogram of estimated epsilons

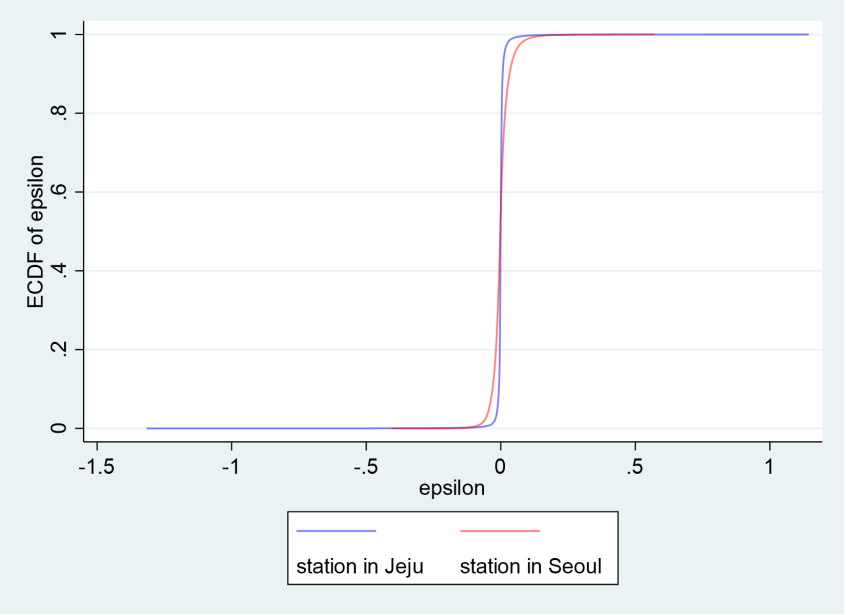


Figure 3: The distributions of estimated epsilons

Smaller group	D	P-value
0	0.180	0.000
1	-0.267	0.000
Combined K-S	0.267	0.000

Table 2: The result of the Kolmogorov-Smirnov test

2.4 Further Discussion on the Likelihood of Collusion

In this section, it is assumed that each oil refinery company is almost vertically integrated with respective oil refiner's agency (wholesale gasoline supplier) in the upstream market. Furthermore, each oil refiner's agency is also assumed to be determinedly connected to a specific retail gasoline station due to the exclusive purchase contract between them. In contrast with the upstream market, it is postulated that a retail gasoline station is competing against each other for attracting consumers in the downstream market. In this situation, it is investigated how a retail gasoline station is behaving with respect to its price strategy.

2.4.1 Economic Environment

The region J is an isolated land long distant from the Korean Peninsula. The region J is all surrounded by sea. Either the aircraft or ship is used on the purpose of the transportation and shipping in order to reach the island. The number of wholesale suppliers (oil refiner's agency) who provide gasoline to retail stations in region J has been limited over a few decades. In particular, four wholesale gasoline suppliers (oil refiner's agencies) dominate the relevant market in region J, where the four main wholesalers are directly connected to four oil refinery companies as shown in the table 3. In particular, the wholesaler, A company is subject to SK Energy, B company is subordinate to GS Caltex, C company is with Hyundai Oilbank, and D company is connected to S-OIL, which is similar to the vertical integration between oil refinery companies and wholesalers, even though each company is an independent economic operator. As indicated in the table 3, each wholesaler works for a specific oil refinery company, even though each wholesale gasoline supplier is an independent economic operator. Accordingly, the four wholesalers are more likely to be subordinate to the corresponding oil refinery companies, compared to any wholesaler located in the mainland of South Korea.

Oil Refinery Company	Wholesaler	2021	Rank	Share	2020	Rank	Share	2019	Rank	Share
SK Energy	A company	198,166,555	1	44%	164,482,093	1	47%	202,660,689	1	45%
GS Caltex	B company	101,809,468	2	23%	68,335,753	2	20%	106,999,814	2	24%
Hyundai Oilbank	C company	76,397,076	3	17%	61,877,370	3	18%	76,538,284	3	17%
S-OIL	D company	73,100,222	4	16%	53,786,959	4	15%	60,906,683	4	14%

Source: balance sheet of each wholesaler (unit: 1,000 krw) / (period: from January 1st, 2019 to August 10th, 2021)

Table 3: Gasoline Wholesalers in region J

It is well known in South Korea that exclusive purchase contracts between a wholesale gasoline supplier (oil refiner's agency) and a retail gasoline station are common, where the exclusive purchase contract (or consignment sale) is a legally binding agreement such that a retail gasoline station agrees to purchase goods or services exclusively from a specific wholesale gasoline supplier for a certain period. It is true that exclusive purchase contract seems to be more firmly prevalent in region J compared to region S. For instance, 6 retail gasoline stations in region J altered either oil refinery companies or oil refiner's agencies from January 1st, 2019 to August 10th, 2021. In contrast, 34 retail gasoline stations in region S changed either oil refinery companies or oil refiner's agencies over the same period. Therefore, the vertical relationship in region J appears to be more stable, indicating that a retail gasoline station in region S tends to more freely establish the relationship with either oil refinery company or wholesale gasoline supplier. It implies that the retail gasoline station is more dependent on the wholesalers in region J, and the wholesalers do not tend to compete for depriving rivals of relevant retail stations, which intensifies the exclusive purchase contract between retail stations and wholesalers. Moreover, there is no alternative channel such as abroad purchase resource that each retail gasoline station can afford to buy gasoline except the four oil refiner's agencies in region J.

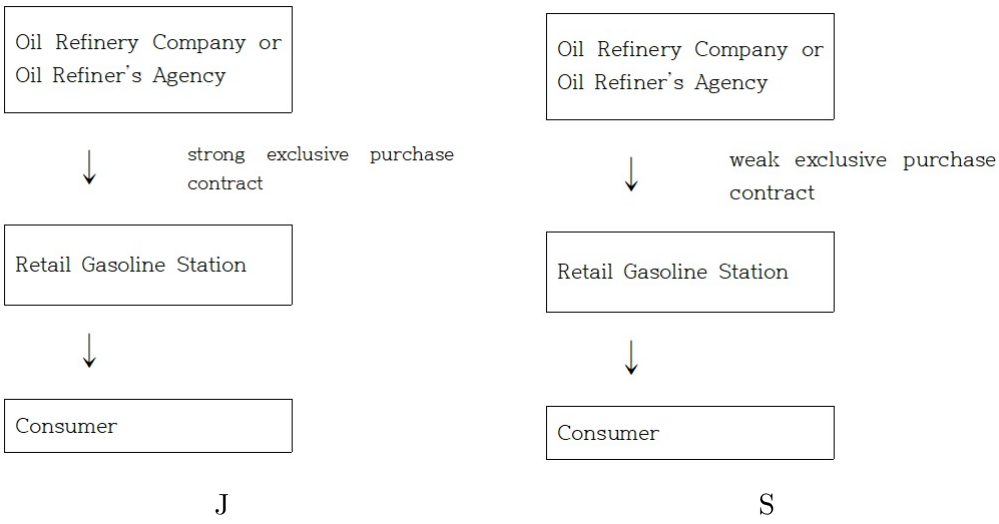


Figure 4: The major market structures in two regions, region J and region S

As mentioned earlier, in contrast with the upstream market in region J, the retail gasoline market is assumed to be competitive for attracting consumers in the downstream market. For instance, a consumer is able to find out daily gasoline prices of every gasoline station in South Korea, since the website[4] named as "Opinet" provides the relevant price information on every gasoline station nationwide. Thus, a consumer is able to figure out the cheapest gasoline price near himself or herself at any time. Accordingly, even though a few gasoline stations in a certain region would attempt to collude with each other, the other gasoline stations in neighboring area have incentive to bring down lower gasoline price compared to the collusion in order to attract consumers in the former region, which makes it difficult to sustain the collusion. Thus, the upstream gasoline market is assumed to be oligopoly, whereas the downstream gasoline market in region J is regarded to be competitive.

2.4.2 Upstream Market

This study employs the concept of a model suggested by Buccirossi (2006) in order to analyze the price strategy in the following manner. First of all, suppose that there are two wholesale gasoline suppliers 1, 2 competing in the upstream market. Moreover, there are numerous retail

[4]Please, refer to the website, https://www.opinet.co.kr/user/main/mainView.do

gasoline stations which buy gasoline from the two wholesalers. For each supplier, i = 1,2, its cost, price and quantity correspond to c_i^u, p_i^u, q_i^u, respectively.[5] c_i^u is common knowledge to the two suppliers. Both demand and profit for each wholesaler are as follows:

$$q_i^u = a_i^u - p_i^u + \gamma p_j^u,\ i,\ j \in \{1,\ 2\},\ i \neq j,\ \gamma \in (0,\ 1) \tag{2.7}$$

$$\pi_i^u = (p_i^u - c_i^u) q_i^u \tag{2.8}$$

γ implies the effect of a rival j's price on i's supply. It is assumed to be between 0 and 1. Furthermore, it indicates that the closer it is to 0, the less the competitor's price affects the quantity of a wholesaler. In general, γ reflects a degree of product differentiation in a differentiated product market. In this study, γ it refers to a degree of exclusive purchase between a wholesaler and gasoline stations. When it converges to 0, a retail gasoline station just purchases gasoline only from one wholesaler mainly due to the exclusive purchase contract and can not buy from the other competing wholesaler.

2.4.3 Downstream Market

The retail gasoline market is assumed to be competitive, and the Bertrand competition acts. The price at which a gasoline station purchases from a specific wholesaler would be cost to the gasoline station. Besides, it is assumed that the other cost is not considered for the model simplification,

2.4.4 Equilibrium Results

Above all, under the economic environment indicated in the upstream market, the Nash equilibrium and collusive equilibrium are shown as follows:

$$p_i^N = \frac{2a_i + 2c_i}{4 - \gamma^2} + \gamma \frac{a_j + c_j}{4 - \gamma^2} \tag{2.9}$$

[5] "u" indicates the upstream.

$$p_i^C = \frac{c_i}{2} + \frac{a_i + \gamma a_j}{2(1-\gamma^2)} \tag{2.10}$$

Here, N stands for the Nash equilibrium, and C represents the collusive equilibrium. As γ goes to 0, $p_i^N \approx p_i^C$. It implies that if retail gasoline stations more severely purchase gasoline from a particular wholesaler mainly due to an exclusive purchase contract, the competitive price will converge to the collusive price.

Next, in the downstream market, the gasoline price imposed by a retail gasoline station would be equal to $p_i^N \approx p_i^C$. Thus, the retail gasoline price is likely to converge toward the collusive price. Accordingly, even though retail gasoline stations compete to attract consumers in the downstream market, their competition is constrained by the market structure in the upstream.

3 Concluding Remarks

This study investigates pricing behaviors of retail gasoline stations in two regions, region S and region J. The two regions seem to be enforced into competition in terms of retail gasoline market since consumers easily find out the cheapest gasoline price nearby themselves through the website named as "Opinet". However, the pricing behaviors in the two regions are observed to be quite different from each other. Thus, the test method to compare the pricing behaviors is introduced to decide whether or not the retail gasoline market is competitive in region J. According to the test result, the observed pricing behaviors in region J are likely to be distant from ones in competitive market. Even though there exists competition in the retail gasoline market, the level of its competition seems to be less intensified in constraint with the price decision in the upstream market where retail stations purchase gasoline from oil refiner's agencies.

Additionally, when there exists controversy over whether a market is competitive or not, a competition authority is able to adopt this test method to decide whether or not the controversial issue is investigated or not. This test method seems to be simple but powerful since the historical data on prices is only required to proceed this test method. Accordingly, this study contributes to the economic literature in respect of introducing this efficient novel method and suggesting the empirical result.

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