Informative mobile application, search costs, and spatial price competition in the Korean retail gasoline market*

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Abstract

This paper empirically evaluates the effects of informative mobile applications ("apps") on spatial price competition and price dispersion in the Korean retail gasoline market. On May 23, 2010, the Korea National Oil Corporation distributed a mobile application—the so-called "Opinet"—to stabilize gasoline prices and intensify competition among gasoline stations. Using the spatial econometric method, I arrive at various interesting results. First, increased transparency makes the market less competitive because producers have more information than do consumers. Second, as the ratio of informed consumers crosses a threshold level, the market becomes more competitive because informed consumers weaken market punishments. Third, there is an inverted-U relationship between the ratio of informed consumers and price dispersion, which is consistent with Stahl's view (AER, 1989). Therefore, I conclude that the penetration rate of informative mobile apps intensifies price competition among gasoline stations and reduces the price dispersion of gasoline.

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1. Introduction

When are search costs, is a market less competitive? According to Stahl's (1989) view, when informed consumers increase, market competition changes from "monopoly pricing" to "marginal cost pricing" through reduced search costs. This paper analyses whether market competition is intensified by a government policy to reduce consumer search costs in the Korean retail gasoline market.

In April 15, 2008, the Korean government introduced the "Oil Price Information Network" (the so-called "Opinet") to stabilize gasoline prices and intensify competition among stations (Kim and Kim, 2010). Opinet is a website that provides information about both gasoline prices and gasoline station locations. Therefore, the introduction of Opinet should make the market more transparent and reduce consumer search costs. To access Opinet, consumers need a computer with access to the Internet. Due to that restriction, if consumers are on a road where the Internet is unavailable, then the effects of Opinet disappear due to difficulties in obtaining the information. Kim and Kim (2010), who analysed the effects of the introduction of Opinet on price dispersion and price-cost margins, suggested as an energy policy that the Korean government develop and distribute instruments that can provide information about roads and are operated using mobile phones to make the market more competitive. It is unknown whether the Korean government has accepted the policy suggestion of Kim and Kim (2010), but the Korea National Oil Corporation released the smartphone application Opinet as freeware on May 23, 2010. If consumers have smartphones, this application can provide information on gasoline prices and gasoline station locations to consumers everywhere. Thus, we can posit that mobile Opinet may reduce consumers' considerable search costs, thus potentially tightening market competition.

Most of the literature related to search costs has estimated a relationship between search costs and price dispersion.[1] For instance, Brown and Goolsbee (2002), who have analysed the relationship between Internet use and the price of term life insurance, have found that increased Internet use significantly reduces both price and price dispersion. Kim and Kim (2010) have concluded that the introduction of Internet service providing information about gasoline prices contributes to reducing gasoline price dispersion and margins.[2] Similar to this paper but taking a different approach, Hong (2014) has shown that the introduction of smartphones has dramatically reduced both price dispersion and the average price-cost margin in the Korean retail gasoline market because smartphones provide the consumers with direct access to Opinet.[3]

The literature on price dispersion explains its relationship to search costs. However, these approaches to price dispersion focus only on the consumer side. The diffusion of price information not only reduces consumer search costs but also makes the market more transparent on the producer side. According to Schultz (2005), information on transparency has two types of effects. If producers have more information than consumers or if the ratio of informed consumers is very low, then market competition becomes weak due to collusive pricing behaviour, but if the ratio of informed consumers is increased, then market

[1] In terms of frequency, Sorensen (2000), who has analyzed the prescription-drug retail market, has found that the price dispersion of repeatedly purchased prescription drugs is significantly low.

[2] Kim and Kim (2010) have approached the Korean retail gasoline market at the provincial level due to data limitations.

[3] Aker (2008), who has analyzed the impact of mobile phones on grain markets in Niger, also has found that the introduction of mobile phones reduces grain price dispersion by approximately 10-16%.

competition tightens because of increased demand elasticity. Therefore, to detect the different effects of information, we must measure the market competition that can capture effects on both the producer and the consumer sides.

In the study of Schultz (2005), for information to have an impact on market competition, goods must be differentiated because homogeneous goods are not affected by transparency. From this perspective, the retail gasoline market is a good example to use to analyse the effects of market transparency on both the producer and the consumer sides. The retail gasoline markets are well known and are defined as the locally competitive market because consumers prefer nearby stations if the quality of service and price are same as other stations (Shepard, 1991), i.e., gasoline markets are horizontally differentiated. Gasoline stations also can establish differentiated prices by offering differentiated service, i.e., gasoline markets are vertically differentiated.

The previous literature seemed to consider price dispersion the proxy of price competition. However, price dispersion not only is reduced if all stations engage in monopoly pricing (Stahl, 1989) but also can be determined by various factors, such as seller type and spatial competition factors (Lewis, 2008). Therefore, it is difficult to conclude whether the market is competitive through price dispersion alone. In this paper, unlike in the previous literature, I focus on the relationship between information and price competition instead of between information and price dispersion.

In this paper, I attempt to evaluate the effect of mobile application on price competition, particularly spatial price competition, using the structural model of Pinkse, Slade and Brett (2002). The empirical strategies and primary findings of this paper are as follows. First, I estimate an indicator of spatial price competition using the spatial econometric method. From this work, I find that the indicator of spatial price competition varies over time and shows declining trends following the release of mobile Opinet. This result means that the information makes the market more transparent and therefore, competition among retail gasoline stations becomes weak. Second, to check whether the competition indicator explains market competition, I compare retail gasoline stations' average margins to the competition indicator. The result shows that when the ratio of informed consumers is low competition and therefore the price-cost margin increase, but as the ratio of informed consumers crosses a threshold, the market becomes more competitive and therefore the margins are reduced. Finally, I test the relationship between the ratio of informed consumers and price dispersion and find that the penetration rate of the mobile Opinet creates an inverted-U relationship with price dispersion. From these results, I conclude that government policies such as developing the mobile Opinet cause market competition to intensify.

The remainder of this paper is as follows. Section 2 introduces Opinet. In section 3, I explain the empirical strategies and data. The estimation results are reported in section 4, and section 5 summarizes this paper.

2. What is Opinet?

The Oil Price Information Network—the so-called "Opinet"—is a website that provides information

about gasoline prices and gasoline station locations. On April 15, 2008, Opinet was launched by the government-owned Korea National Oil Corporation to stabilize gasoline prices and intensify market competition. Before Opinet, consumers either shared the information on gasoline prices in their online communities or individually recorded their purchase histories. Therefore, we can imagine that consumers' search costs were very high. However, since April 15, 2008, consumers have been able to compare gasoline station prices by accessing the website.

[Insert Figure 1]

Opinet's price-collecting process and operating system are shown in Figure 1 and works as follows. First, if a consumer puts gasoline in his/her car at any gasoline station and pays by credit card, information about that gasoline station—such as address and price per litre—is collected through the credit card payment system and stored in a database. Second, the Korea National Oil Corporation distributes the collected data through an online map for consumers to consult. Third, consumers can browse and find gasoline prices through the Opinet website.

However, if consumers are on the road and unable to access the Internet, Opinet's search-cost-reduction effect can disappear. Consequently, Kim and Kim (2010) suggest that to further reduce consumers' search costs, the government must create an additional instrument, such as a mobile application for smartphones. Following that policy suggestion, the mobile version of Opinet was released as freeware by the Korea National Oil Corporation on May 23, 2010, and distributed in app stores. Thus, consumers with smartphones can freely download mobile Opinet in app stores for use everywhere.

[Insert Figure 2]

Figure 2 shows screen shots of mobile Opinet, which provides rich information. If a consumer wants to know whether there are gasoline stations within a 3 kilometre (km) radius of his/her location, he or she can find that information by searching mobile Opinet[4] (see Figure 2.B); mobile Opinet also provides information about gasoline stations on the consumer's route (see Figure 2.C). Therefore, mobile Opinet is a powerful and convenient instrument for consumers to reduce their search costs.

3. Empirical Model and Data

3.1. Estimation model

To estimate the price competition indicator, my empirical analysis begins with the model of Pinkse *et al.* (2002). They theoretically establish the Bertrand competition model in the gasoline market and derive a

[4] Mobile Opinet provides information about gasoline stations within a 1km, 3km, 5km and 10km radius.

reaction function for each seller as follows:

$$p_i = R_i(p_{-i}) = \frac{1}{-2b_{ii}^A}\left(a_i - b_{ii}^A \gamma^T c_i + \sum_{j \neq i} b_{ij}^A p_j + \sum_j b_{ij}^B y_j\right) \quad (1)$$

where γ^T and c_i are the vector of coefficients of the cost sides and cost factors of gasoline station i: $-a_i/2b_{ii}^A$ and y_j, respectively, represent an individual station's characteristics and spatial factors that affect demand for gasoline, and p_j is competitors' regular gasoline prices. The slope of the reaction function, $-b_{ij}^A/2b_{ii}^A \geq 0$, is the diversion ratio between stations i and j, which is a fraction of the lost customers of i who would switch to j as i's prices rise (Pinkse *et al*., 2002; Pennerstorfer, 2009). Therefore, following Mobley (2003), I define the slope of the reaction function as the price competition indicators because when a rival station's prices decline, station i's gasoline demand decreases. I assume that the diversion ratio depends on the distance between stations i and j (Pinkse *et al*., 2002) because as the distance between stations i and j increase, the impact of station j on station i decreases. This assumption allows equation (1) to represent the spatial econometric form as follows:

$$P = R(P) = \rho WP + X\beta + \varepsilon \quad (2)$$

where ρ is a slope of the reaction function, W is a spatial weighting matrix, P is a price vector, X is a vector of control variables and ε is an error term. I set up each element of the spatial weighting matrix as the normalized inverse distance, as in the previous literature (Pinkse *et al*., 2002; Pennerstorfer, 2009), and restrict the distance to a 3.5 km radius because the minimum longest distance to at least one competitor is 3.15 km. Gasoline prices are determined by various factors such as the station's characteristics, cost, spatial competition and demand. I consider car wash, auto mechanic, convenience store, premium gasoline station and brand dummies as the station's characteristics, with the self-service station as the cost factor (Kim and Kim, 2011); the number of competitors within a 3.5 km radius (Barron *et al*., 2004; Lewis, 2008), the spatially weighted share of unbranded stations within a 3.5 km radius (Pennerstorfer, 2009) and distance to the closest competitor as the spatial competition factors; and the number of cars per household in each district as the demand factor.

Because the spatial weighting matrix depends on the distance between stations i and j and frequent entries to/ exits from the retail gasoline market, the spatial weighing matrix will be changed and time varying. Thus, the coefficients of each variable and the slope of reaction function, ρ, are also time varying because they depend on the spatial weighting matrix. To apply this context to the market, I assume that each gasoline station determines its prices through the repeated simultaneous move game. Using this assumption, I can estimate equation (2) at each time.

This paper's primary objective is to detect the effects of informative mobile apps on both the producer side and the consumer side. As mentioned, when the market becomes transparent, if the ratio of informed consumers is very low, then this market environment renders the market less competitive. However, if the ratio of informed consumers crosses a threshold, the market becomes more competitive. The indicator of

spatial price competition, therefore, has a non-linear relationship with the ratio of informed consumers. To estimate the relationship between information and competition, I use the estimated slopes of reaction functions and price-cost margins as the dependent variable to test the hypothesis. The estimation model is as follows:

$$y_t = y_0 + \beta_1 \mu_t + \beta_2 \mu_t^2 + \varepsilon_t \tag{3}$$

where y_t denotes either the estimated ρ_t or the price-cost margins, μ_t is the ratio of informed consumers and ε_t is the i.i.d. error term. The ratio of informed consumers is defined as follows[5]:

$$\mu_t = \frac{\text{the number of installed mobile Opinet apps in week t}}{\text{the number of cars in Seoul in month m}} \tag{4}$$

Therefore, when the ratio of informed consumers increases, if price competition among stations is intensified then ρ_t increases and price-cost margins decrease.

3.2. Data

The data used in this paper were collected from various sources. The data on mobile applications come from the Korea National Oil Corporation, other data such as gasoline prices and the characteristics of gasoline stations come from the Opinet website (www.opinet.co.kr), and data on the number of cars come from Statistics Korea. I count the number of installed mobile Opinet apps operating on the Android system only. Although the first version of mobile Opinet was released for the iPhone on May 23, 2010, I only have data for the Android version, which has been distributed through Google Play since November 27, 2011[6] (see Figure A.1, Appendix). In the case of Korea, the smartphone penetration rate has increased since the release of the iPhone on November 28, 2009 (Hong, 2014); however, the iPhone's market share is dominated by the Android system (See Figure A.2 in Appendix). Considering the iPhone's market share, iPhone users downloading mobile Opinet would have comprised a very small portion of all consumers using the application. The cumulative number of installed mobile Opinet applications operating in the Android system was 2,692 as of November 27, 2011. This number represents a very small portion—approximately 0.11%—of the 2,449,925 cars in Seoul as of November 2011. Therefore, considering all of the circumstances, the ratio of informed consumers from May 23, 2010, to November 27, 2011 is either very low or close to zero.

As mentioned in section 2, the Opinet website provides key information such as each gasoline station's address. Using those addresses, I calculated the distance between gasoline stations by collecting the latitude and longitude from Google Geocoding API and then measured the distance between gasoline stations using the Haversine formula. The descriptive statistics are reported in Table 1.

[5] Pennerstorfer *et al.* (2014) measure the ratio of informed consumers using commuting data.

[6] The data on the mobile Opinet were obtained by request to the Korea National Oil Corporation, which informed me that the distribution of the Android version of the mobile Opinet through Google Play began on November 27, 2011.

[Insert Table 1]

4. Estimation Results

4.1. Measure of spatial price competition

Table 2 shows the summary statistics for the cross-sectional estimation results of competition within a 3.5 km radius. On average, the estimated indicator of spatial price competition is 0.75 and statistically significant. Self-service stations that can reduce their operating costs charge a lower price—44.31KRW per litre—than full-service stations. Regular gasoline prices at premium gasoline stations that sell both premium and regular gasoline are an average of 36.94 KRW per litre higher than the prices at regular gasoline stations. This result is because premium gasoline stations engage in salient pricing, which means that consumers experience the quality of salience (Lee, Kim and Park, 2015). Other papers indicate that signifiers other characteristics (i.e., auto mechanics, convenience stores), excluding car washes, are similar but insignificant. Among the spatial factors, the share of unbranded stations within a 3.5 km radius reduces prices through the competition effect (Pennerstorfer, 2009).

[Insert Table 2]

[Insert Figure 3]

Figure 3 shows the time trends for each variable. In the case of ρ, competition was tightening before the release of mobile Opinet (May 23, 2010) but subsequently, competition entered into a period of decline. However, ρ shows an increasing trend after 2013. Why did the market become less competitive after mobile Opinet was released? The answer is that mobile Opinet has a two-way effect in terms of transparency. One effect relates to the producer side and the other relates to the consumer side. When mobile Opinet was initially released, prices information was very low in the consumer side because of the low penetration rate, but it was high on the producer side. This type of market environment can make it possible for stations to engage in collusive behaviour because it is easy to detect price undercutting (Ivaldi *et al*., 2003; García, 2010). However, if the ratio of informed consumers increases, then it is difficult for stations to engage in collusive behaviour of stations because the increased elasticity of demand results in weaker punishment (Schultz, 2005). Therefore, we can conjecture that there is a U-shaped relationship between price competition and informed consumers.

4.2. Information, spatial price competition and gasoline margins

Before we move to the estimation results of the second stage, I must check whether the indicator of spatial price competition explains market competition. First, I distinguish each of the indicator's structural

breaks using the multiple structural change model developed by Bai and Perron (1998, 2003)[7] and second, I compare the average margins between each break point.

Estimation results show that there are three break points: the 10th week in 2010, the 5th week in 2011, and the 18th week in 2013 (see Figure 4 and Table A.1 in the Appendix). Comparing the gasoline margins, the average margin of period A (in which competition is higher) is 179.10 KRW per litre and the margin of period C (in which competition is lower) is 191.87 KRW per litre. In a simple regression, ρ and the average margin of gasoline show a significantly negative relationship (-115.60; t-statistics=-5.34, R^2=0.08). Therefore, we can say that the estimated ρ can represent and explain market competition.

[Insert Table 3]

The estimation results for the second stage are reported in Table 3. In all of the models, the ratio of informed consumers, μ_t, shows an U-shaped relationship with the indicator of spatial price competition and an inverted-U relationship with gasoline margins caused by two-way effects. This means that when the ratio of informed consumers is low, market competition is moderated due to the transparency effect on the producer side, but if the ratio of informed consumers crosses the threshold level, then market competition is intensified because the transparency effect on the consumer side dominates that effect on the producer side. The threshold levels in the spatial price competition and the gasoline margins are 0.22~0.26 and 0.29~0.30, respectively.

4.3. Informed consumers and price dispersion

Finally, I attempt to test the relationship between informed consumers and price dispersion to support the previous analysis. If transparency on the consumer side makes the market more competitive, then the price dispersion will show an inverted-U relationship when the ratio of informed consumers increases (Stahl, 1989; Brown and Goolsbee, 2003).

The existing literature shows that price dispersion is determined not only by search costs but also by product-differentiated and spatial-competition factors (Barron, Taylor and Umbeck, 2004; Lewis, 2008; Jost, 2013; Pennerstorfer, Schmidt-Dengler, Schutz, Weiss and Yontcheva, 2014). According to the literature, the number of competitors decreases price levels and reduces price dispersion (Barron *et al*., 2004), but if we consider the type of seller and the composition of competitors, the relationship between the number of competitors and price dispersion significantly varies (Lewis, 2008). If we control for spatial factors and stations' characteristics, the relationship between the search cost and price dispersion consistently shows the inverted-U shape (Jost, 2013; Pennerstorfer *et al*., 2014). Therefore, price dispersion can be determined not only by search costs but also by various other factors.[8] Thus, if the data are available, it is more suitable to analyse gasoline markets in a manner that considers differentiated factors such as distance or services.

[7] To detect the multiple structural break points, I use the Matlab code of Bai and Perron (2003).

[8] According to Wildenbeest (2011), who has analyzed the United Kingdom grocery market, search costs only explain 25~39% of price variations.

To analyse the effects of transparency on the consumer side, I measure price dispersion using the residual prices obtained from price regression. Lewis (2008) has obtained residual prices from estimating the fixed effects regression model—i.e., $p_{it} = \alpha + \beta_i + Week_t +$, —but Barron *et al.* (2004) directly considered the observed station-specific variables and spatial factors in the price regression. In the case of Lewis (2008), if time-varying characteristics determine the gasoline price, then the simple fixed effects regression may suffer from misspecification bias due to the omitted variables.[9] Therefore, I employ the model of Barron *et al.* (2004) when determining residual prices. The specifications of price regression are same with the spatial model except that the spatial lag is excluded and time effects such as week dummies are included.

When analysing the retail gasoline market, we must consider that the retail gasoline market is locally competitive. Thus, price dispersion must be calculated as localized. Denoting $\hat{\varepsilon}_{it}^{P}$ as the residual price, we can calculate the localized variance of residual prices (Lewis, 2008).

$$\sigma_{it}^2 = \frac{1}{N_J}\sum_{j\in J}\left(\hat{\varepsilon}_{it}^{P} - \frac{1}{N_J}\sum_{j\in J}\hat{\varepsilon}_{jt}^{P}\right)^2 \tag{5}$$

where J is the set of stations within a 3.5 km radius. Using this localized variance, I estimate the relationship between the ratio of informed consumers and price dispersion. The model for price dispersion is as follows:

$$\ln\sigma_{it}^2 = \alpha_0 + \alpha_1\mu_t + \alpha_2\mu_t^2 + X_{it}\beta + \varepsilon_{it}^{\sigma^2} \tag{6}$$

where X_{it} includes the control variables in equation (2).

[Insert Table 4]

The estimated results are reported in Table 4. In the columns for price dispersion, (4) is measured by Lewis's (2008) method and the others are measured by the residual prices in the price equations, respectively. The estimation results from (1) to (3) show the inverted-U relationship between the ratio of informed consumers and price dispersion. This is due to market transition. When μ is very low, market transparency renders the market less competitive due to the effect on the producer side, thus inducing low price dispersion because collusive pricing behaviour generates low price distribution. However, if μ increases, price distribution also increases because stations deviate from collusive pricing behaviour. Because the effects on market transparency on the consumer side dominate on the producer side, price distribution is decreased because informed consumers increase demand elasticity. Therefore, the penetration rate of mobile Opinet eventually will reduce price dispersion. However, (4)'s estimation result fails to capture the inverted-U relationship, which I believe may be due to a misspecification of the price regression model by omitted

[9] Chandra and Tappata (2011), who have analyzed dynamic price dispersion in the U.S. retail gasoline industry, have mentioned that a fixed effect regression is only valid if station fixed effects are additively separable from station costs. They also have failed to measure the relevant price dispersion from the fixed effect regression.

variables such as the time-varying spatial competition factors.

5. Summary and Conclusions

To reduce consumer search costs and make the retail gasoline market more competitive, the Korean government introduced the Oil Price Information Network—the so-called Opinet. I analysed the effects of mobile Opinet on market competition in the Korean retail gasoline market, particularly in the Seoul retail gasoline market. This paper's primary findings are as follows: First, increased transparency makes the market less competitive because producers have more information than consumers. Second, when the ratio of informed consumers crosses a threshold level, the market becomes more competitive because informed consumers weaken market punishments weak. Third, there is an inverted-U relationship between the ratio of informed consumers and price dispersion, which is consistent with Stahl's view (1989). Therefore, this paper concludes that the penetration rate of informative mobile applications intensifies price competition among gasoline stations, thereby reducing the price dispersion of gasoline.

References

Aker, J. C. (2010). Information from markets near and far: mobile phones and agricultural markets in Niger. *American Economic Journal: Applied Economics* 2: 46~59.

Bai, J. & Perron, P. (1998). Estimating and testing linear models with multiple structural changes. *Econometrica* 66 (1): 47~78.

_____. (2003). Computation and analysis of multiple structural change models. *Journal of Applied Econometrics* 18: 1~22.

Barron, J. M., Taylor, B. A. & Umbeck, J. R. (2000). A theory of quality-related differences in retail margins: why there is a "premium" on premium gasoline. *Economic Inquiry* 38 (4): 550~569.

_____. (2004). Number of sellers, average prices, and price dispersion. *International Journal of Industrial Organization* 22: 1041~1066.

Brown, J. R. & Goolsbee, A. (2003). Does the Internet make markets more competitive? evidence from the life insurance industry. *Journal of Political Economy* 110 (3): 481~507.

Chandra, A. & Tappata, M. (2011). Consumer search and dynamic price dispersion: an application to gasoline markets. *RAND Journal of Economics* 42 (4): 681~704.

García, J. P. (2010). Dynamic pricing in the Spanish gasoline market: a tacit collusion equilibrium. *Energy Policy* 38: 1931~1937.

Hong, W.-H. (2014). Do smartphones spur competition? evidence from the Korean retail gasoline market. Unpublished manuscript.

Ivaldi, M., Jullien, B., Rey, P., Seabright, P. & Tirole, J. (2003). The economics of tacit collusion. Final Report for DG Competition. European Commission.

Jost, B. W. (2012). Price dispersion, search costs and spatial competition: evidence from the Austrian retail gasoline market. Unpublished manuscript.

Kim, D.-W. & Kim, J.-H. (2010). Consumer search activities and price dispersion: evidence from the OPINET (Oil Price Information Network). *Korean Journal of Economic Studies* 58 (1): 37~56.

_____. (2011). The impact of the entry of self-service stations in the Korean retail gasoline market: evidence from the difference-in-differences methods. *Korean Journal of Economic Studies* 59 (2): 77~99.

Lee, S., Kim, H. & Park, M. (2015). Pricing puzzle in a retail gasoline market. Unpublished manuscript.

Mobley, L. R. (2003). Estimating hospital market pricing: an equilibrium approach using spatial econometrics. *Regional Science and Urban Economics* 33: 489~516.

Pennerstorfer, D. (2009). Spatial price competition in retail gasoline market: evidence from Austria. *Annals of Regional Science* 43(1): 133~158.

Pennerstorfer, D., Schmidt-Dengler, P., Schutz, N., Weiss, C. & Yontcheva, B. (2014). Information and price dispersion: evidence from retail gasoline. Unpublished manuscript.

Pinkse, J., Slade, M. E. & Brett, C. (2002). Spatial price competition: a semiparametric approach. *Econometrica* 70 (3): 1111~1153.

Schultz, C. (2005). Transparency on the consumer side and tacit collusion. *European Economic Review* 49: 279~297.

Shepard, A. (1991). Price discrimination and retail configuration. *Journal of Political Economy* 99 (1): 30~53.

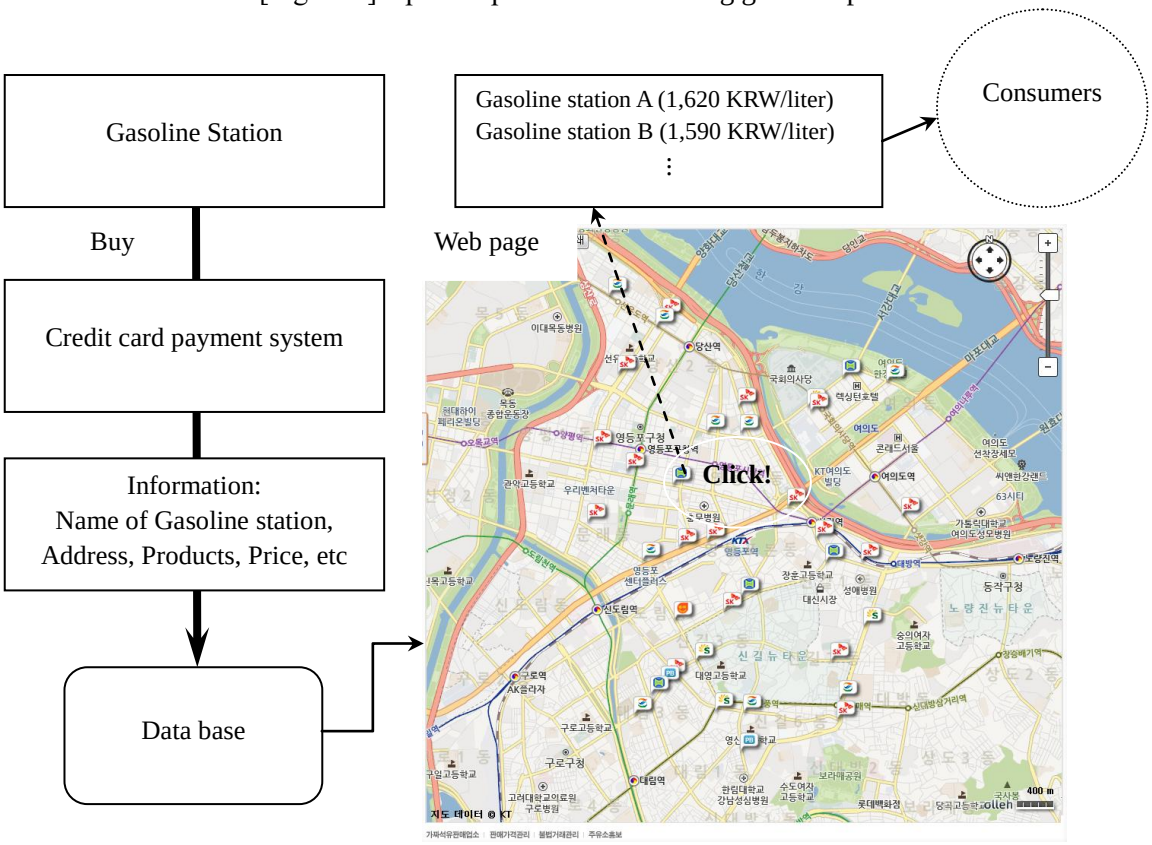
Sorensen, A. T. (2000). Equilibrium price dispersion in retail markets for prescription drugs. *Journal of Political Economy* 108 (4): 833~850.

Stahl, D. O. (1989). Oligopolistic pricing with sequential consumer search. *American Economic Review* 79 (4): 700~712.

Wildenbeest, M. R. (2011). An empirical model of search with vertically differentiated products. *RAND Journal of Economics* 42 (4): 729~757.

Figures and Tables

[Figure 1] Opinet's process of collecting gasoline prices



Source: Kim and Kim (2010).

[Figure 2] Screen shots of the mobile version of Opinet

A. Main screen

B. Search screen within a 3 km radius

C. Search screen in driving root

D. Specific information about gasoline stations

Source: Opinet.

[Table 1] Descriptive statistics

Variables	Mean	S.D.
Regular gasoline prices	1,884.51	196.73
Self-service stations	0.14	0.34
Premium gasoline stations	0.38	0.49
Car wash	0.63	0.48
Auto mechanic	0.27	0.44
Convenience store	0.10	0.30
SK Energy	0.42	0.49
GS Caltex	0.28	0.45
Hyundai Oilbank	0.14	0.34
S-Oil	0.12	0.32
Unbranded stations	0.04	0.20
Number of competitors within a 3.5 km radius	44.41	14.47
Share of unbranded stations within a 3.5 km radius	0.04	0.05
Distance to closest competitor	0.41	0.28
Number of cars per household in district	0.73	0.18
Observations	194,705	

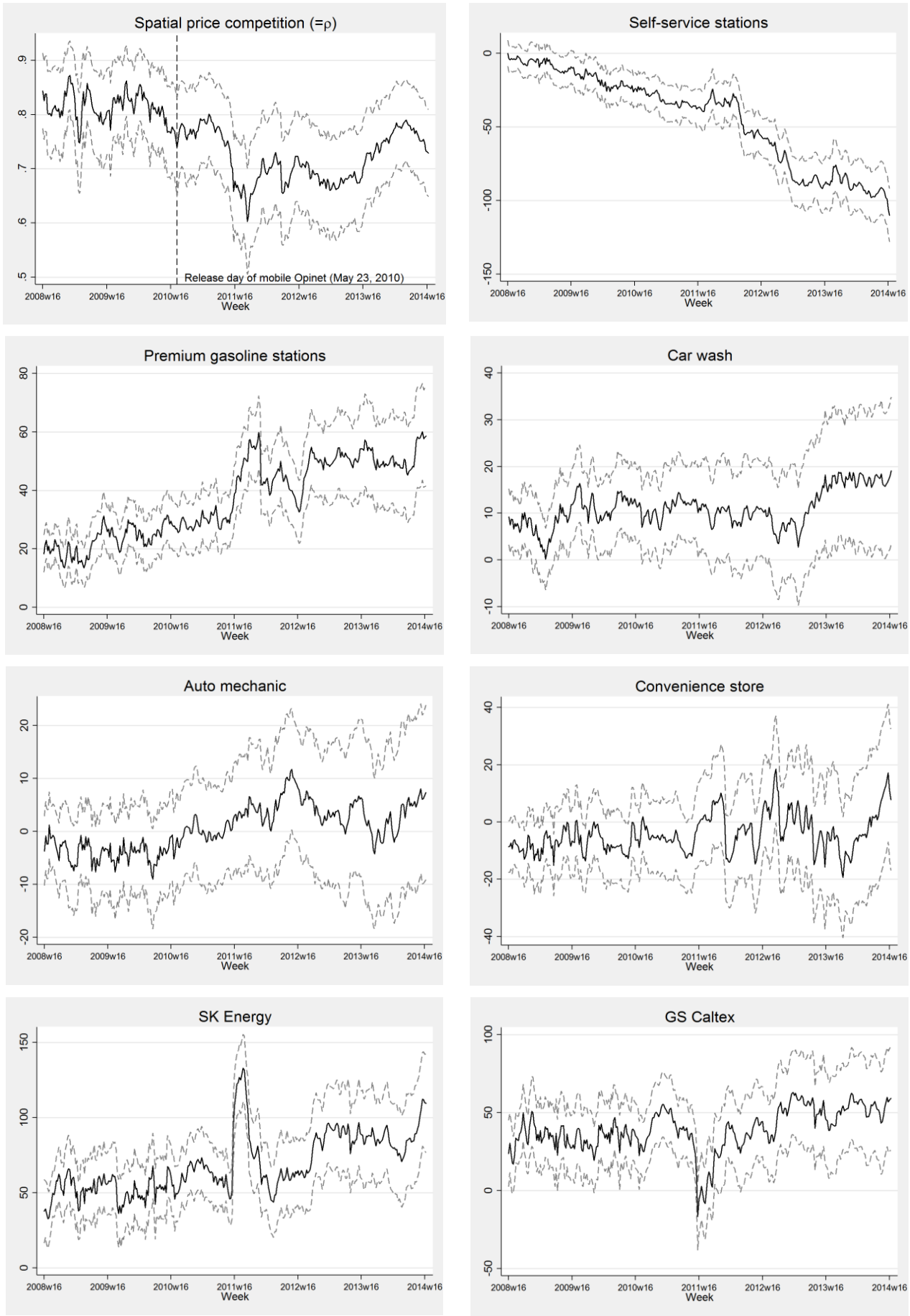
Source: Korea National Oil Corporation.

[Table 2] Summary statistics of cross-sectional estimation results

Variables	Coef.	t-stat.		S.D.
Spatial price competition (=ρ) within a 3.5 km radius	0.75	15.19	***	0.06
Self-service stations	-44.31	-5.00	***	31.21
Premium gasoline stations	36.93	5.56	***	13.13
Car wash	11.06	1.84	*	3.89
Auto mechanic	0.57	-0.02		4.33
Convenience store	-4.21	-0.56		6.57
SK Energy	68.66	4.82	***	19.82
GS Caltex	39.36	2.72	***	13.68
Hyundai Oilbank	19.29	1.36		10.78
S-Oil	33.63	2.13	**	14.58
Number of competitors within a 3.5 km radius	0.05	0.27		0.07
Share of unbranded stations within a 3.5 km radius	-138.89	-2.22	**	44.03
Distance to closest competitor	11.06	1.08		5.95
Number of cars per household in district	0.30	0.07		11.84
Constant	413.23	4.34	***	139.44
Pseudo-R^2	0.59			0.07

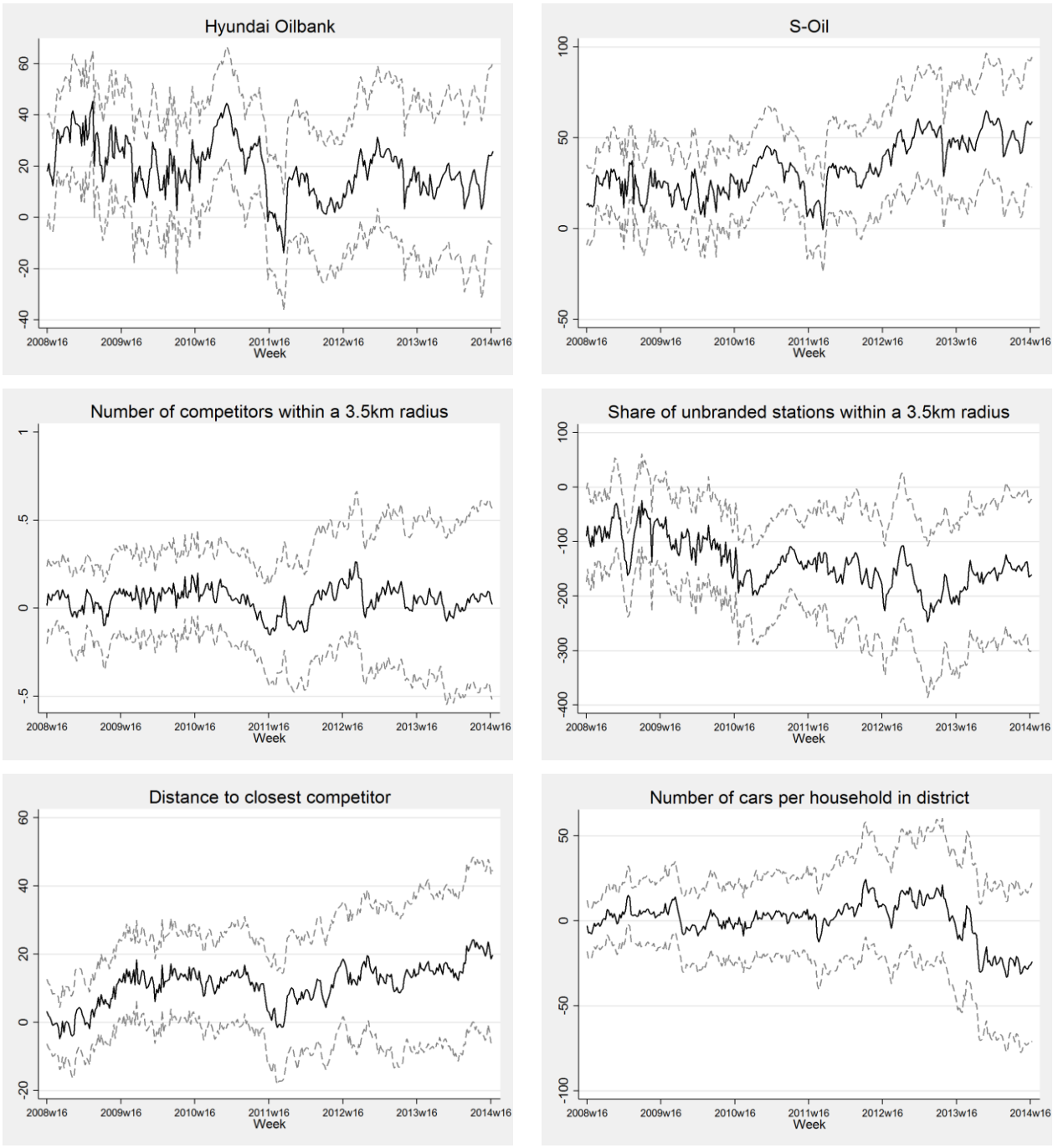
Notes: ***, **, and * represent the statistical significance at 1%, 5% and 10%, respectively. Coef. and t-stat. are the average values of coefficients and t-statistics, respectively.

[Figure 3] Trends of estimation results for competition within a 3.5 km radius



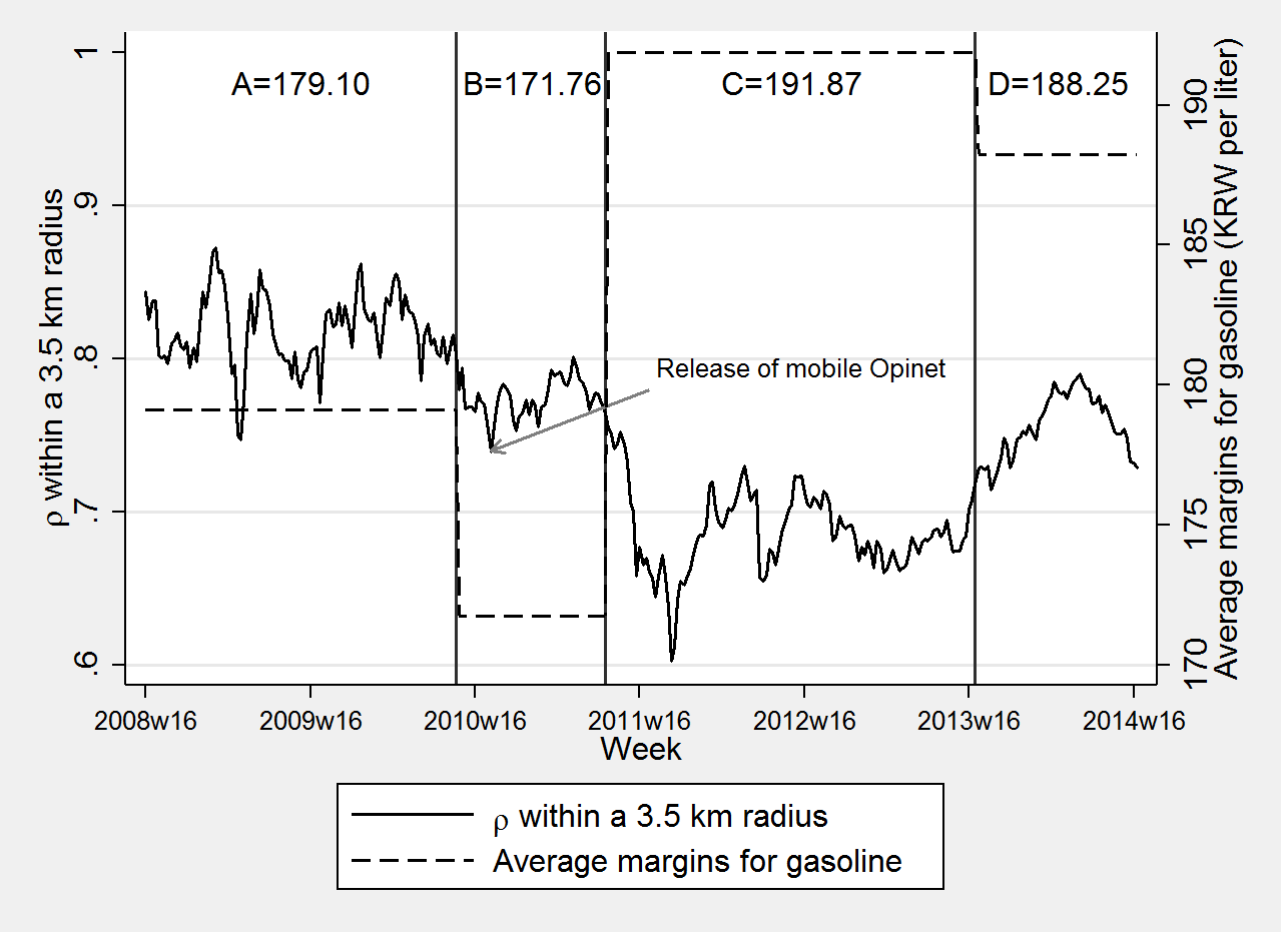
Note: Dashed lines are the 90% confidence interval.

[Figure 3] Continued



Note: Dashed lines are the 90% confidence interval.

[Figure 4] Structural break points and average margins for gasoline



Notes: Structural break points are calculated by the Matlab code of Bai and Perron (2003). Dashed lines are the average margin for gasoline. The margin for gasoline is the weekly average retail price of gasoline minus the weekly average wholesale supply price of refiners. In the case of spatial competition within a 3.5 km radius, the structural break points are the 10th week in 2010, the 5th week in 2011, and the 18th week in 2013.

[Table 3] Effects of informed consumers on spatial price competition and gasoline margins

Variables	Spatial price competition		Gasoline margins	
	All periods	From 2010w21	All periods	From 2010w21
Ratio of informed consumers	-1.41 ***	-0.73 ***	191.83 ***	144.57 **
	(-12.19)	(-7.43)	(3.51)	(2.31)
Squared ratio of informed consumers	5.37 ***	3.39 ***	-631.09 ***	-494.92 **
	(11.23)	(8.83)	(-2.80)	(-2.01)
Constant	0.77 ***	0.72 ***	180.22 ***	183.57 ***
	(222.60)	(183.59)	(109.33)	(72.54)
Increasing (or decreasing) points	0.26	0.22	0.30	0.29
R^2	0.33	0.32	0.05	0.03
Observations	314	205	311	205

Notes: *** and ** denotes the statistical significance at 1% and 5%, respectively. t-statistics in parentheses. 2010w21 is the 3rd week of May 2010. Mobile Opinet was released on May 23, 2010.

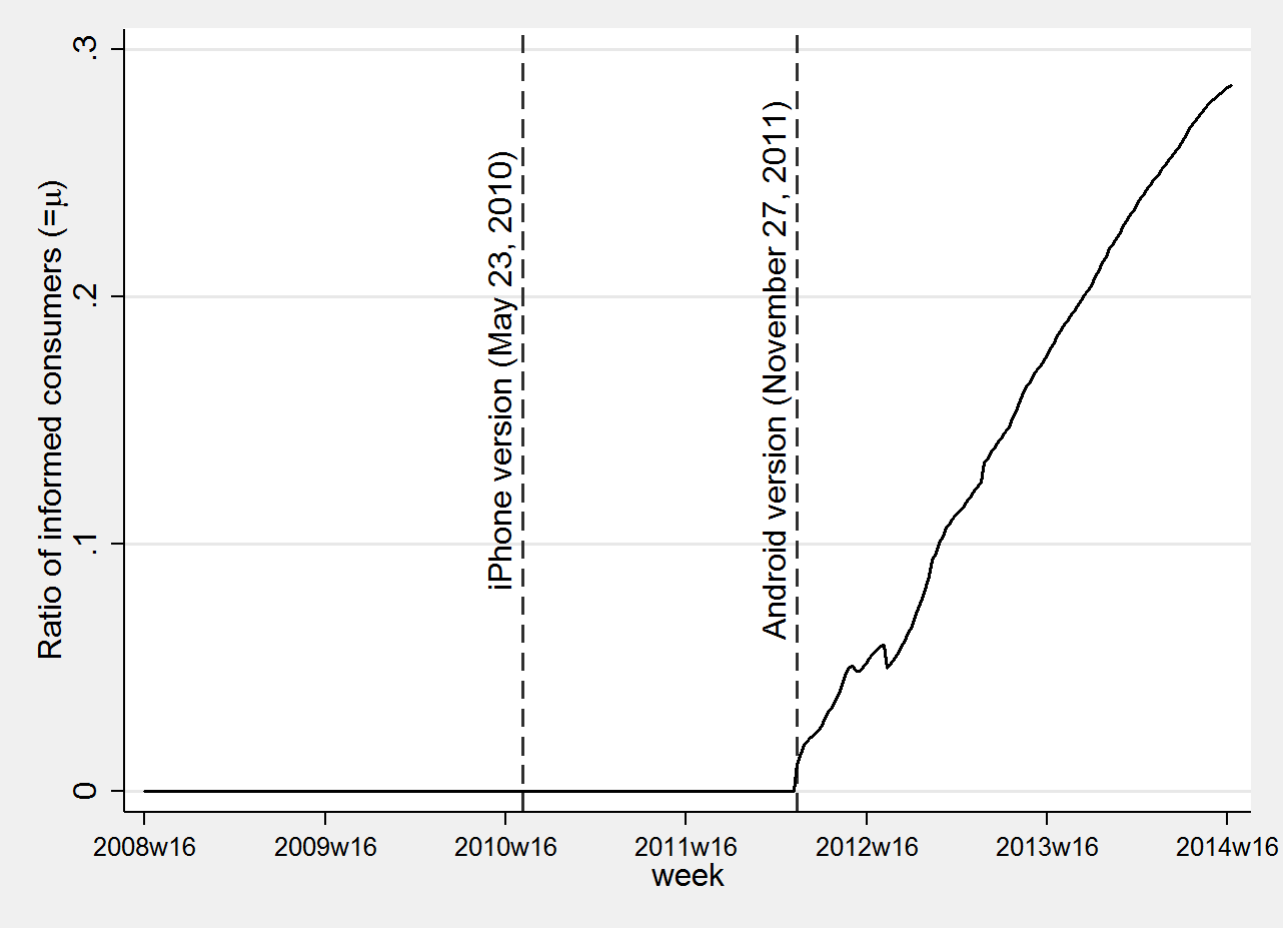
[Table 4] Estimation results of the effects of informed consumers on price dispersion

Variables	Prices	Price dispersion			
		(1)	(2)	(3)	(4)
Ratio of informed consumers (=μ_t)		6.19	6.24	6.49	0.38
		(120.18)	(124.72)	(148.75)	(8.48)
Squared ratio of informed consumers (=μ_t^2)		-10.16	-10.13	-10.64	13.62
		(-47.35)	(-48.66)	(-59.11)	(76.13)
Self-service stations	-58.04		-0.14	-0.06	-0.08
	(-113.12)		(-39.25)	(-18.09)	(-23.00)
Premium gasoline stations	50.95		0.16	0.04	0.03
	(112.45)		(62.87)	(15.36)	(10.48)
Car wash	9.13		-0.03	-0.03	-0.03
	(22.40)		(-12.97)	(-12.43)	(-13.50)
Auto mechanic	1.78		-0.01	-0.04	-0.01
	(3.72)		(-5.25)	(-15.87)	(-4.56)
Convenience store	-5.61		-0.03	0.04	0.05
	(-8.37)		(-8.37)	(11.21)	(12.00)
SK Energy	86.05		0.02	0.03	0.10
	(124.38)		(2.98)	(5.92)	(16.98)
GS Caltex	52.60		0.03	0.04	0.08
	(73.33)		(4.71)	(7.21)	(13.41)
Hyundai Oilbank	34.54		0.06	0.07	0.09
	(47.05)		(9.39)	(12.27)	(13.56)
S-Oil	50.16		0.03	0.05	0.08
	(64.53)		(5.24)	(8.93)	(13.30)
Number of competitors within a 3.5 km radius	-0.04			0.01	0.01
	(-3.18)			(154.91)	(83.11)
Share of unbranded stations within a 3.5 km radius	-408.61			-0.90	-1.72
	(-112.31)			(-36.08)	(-64.55)
Distance to closest competitor	13.40			0.07	0.02
	(19.19)			(15.35)	(4.65)
Number of cars per household in district	94.28			0.72	0.76
	(83.01)			(115.41)	(122.96)
Constant	1602.58	8.17	8.13	7.09	6.53
	(611.60)	(6201.39)	(1,454.90)	(856.80)	(759.16)
R^2	0.83	0.33	0.35	0.47	0.39
Mean of price dispersion		7.59			8.42
S.D. of price dispersions		0.60			0.61
Observations			194,075		

Notes: All of the variables are significant at 1%. In the price-dispersion columns, the price dispersion of (4) is measured using the fixed effects regression of Lewis (2008). All of the price dispersions are calculated as localized dispersions.

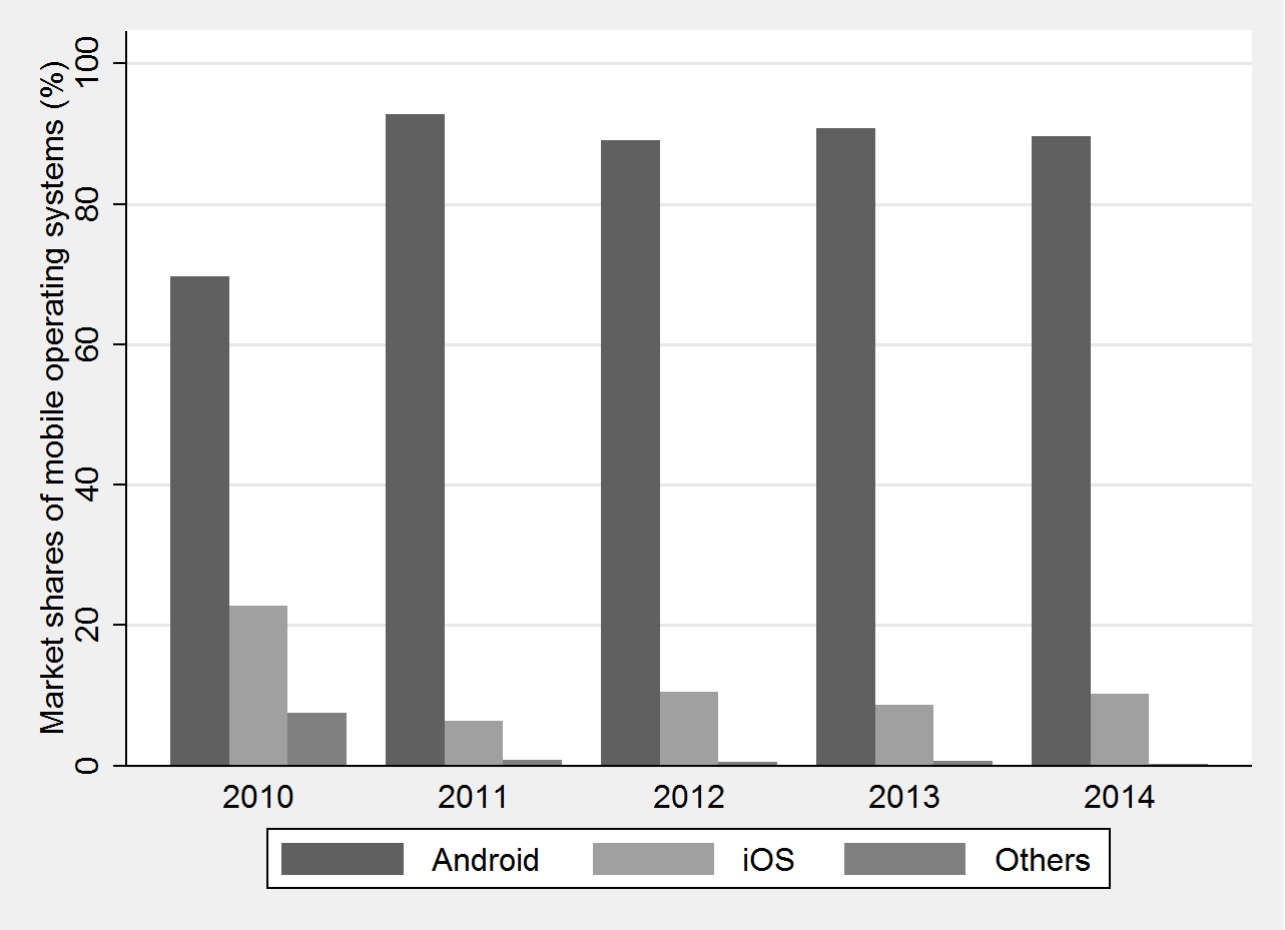
Appendix

[Figure A.1] Release timing of mobile Opinet and trends in the ratio of informed consumers



Notes: The iPhone version of mobile Opinet was released on May 23, 2010, and the Android version was released on November 27, 2011. Before the Android version of mobile Opinet listed in Google Play, it was distributed through the Opinet website (beginning in October 2010). The data installed in the Android system are from Google Play.
Source: Korea National Oil Corporation.

[Figure A.2] Market shares of mobile operating systems in Korea



Sources: Statcounter.

[Table A.1] Estimation results for structural breaks and average gasoline margins

Panel. A Estimates with Three breaks				
$\hat{\rho}_1$		$\hat{\rho}_2$	$\hat{\rho}_3$	$\hat{\rho}_4$
0.82	***	0.77 ***	0.69 ***	0.76 ***
(343.37)		(418.64)	(275.73)	(263.09)
$\hat{T}_1$		$\hat{T}_2$	$\hat{T}_3$	
2010w10		2011w05	2013w18	
[2010w06~2010w39]		[2010w41~2011w08]	[2012w33~2013w42]	
Panel B. Sequential test SupF(T+1|T)				
SupF(2|1)		SupF(3|2)	SupF(4|3)	
29.19	***	24.41 ***	0.97	
Panel C. Average margins				
A. ~$\hat{T}_1$		B. $\hat{T}_1$~$\hat{T}_2$	C. $\hat{T}_2$~$\hat{T}_3$	D. $\hat{T}_3$~
179.10		171.76	191.87	188.25

Notes: ***, ** and * denote statistical significance at 1%, 5% and 10%, respectively. Structural break points are calculated using the Matlab code of Bai and Perron (2003) and selected by sequential procedures at a significance level of 5%. t-statistics are in parentheses and 95% confidence intervals are in square bracket. The model specifications are h=31 (segments) and M=5 (maximum break points). The margin of gasoline is weekly average retail gasoline price minus weekly average wholesale prices of refiners.