

Spatial Differentiation and Entry: Evidence from Retail Gasoline Market in Taiwan

Jian-Da Zhu^{*}

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Abstract

This paper investigates how a gasoline station chooses the location for entry, especially for spatial differentiation. Two measures of spatial differentiation are directly calculated for each gasoline station: (1) the distance from the nearest incumbent, and (2) the number of incumbents inside 2-kilometer radius. The result shows that Formosa dealer-owned gasoline stations has 332.1 meters more close to the nearest station, compared with the distance choice of CPC dealer-owned stations. In addition, Formosa company-operated stations tend to locate at the point with more competitors inside 2-kilometer radius. Compared with CPC dealer-owned stations, Formosa company-operated stations on average has 1.9 more competitors within 2 kilometers.

^{*}Department of Economics, National Taiwan University. Email: jdzhu@ntu.edu.tw

1 Introduction

Since Hotelling (1929), a stream of literature started to analyze spatial differentiation between firms in a market. To make a decision on location, firms have to face two opposing incentives: one is the market share effect, and the other one is the market power effect. Based on the market share effect, firms tend to minimize spatial differentiation to steal customers from the competitors. However, firms might also want to locate farther from their competitors to avoid price competition, according to the market power effect. This paper aims to study how the gasoline stations in Taiwan choose the location to maximize or to minimize spatial differentiation, especially when a new gasoline brand entering into the market.

In Taiwan, gasoline prices are regulated by the government¹, so the location of gasoline stations becomes the most important decision for firms to compete against their competitors. In addition, there are only two gasoline brands in the market, CPC and Formosa. CPC is operated by the government, and Formosa entered into the market after 2000, which provides a good opportunity to study how entrants decide spatial differentiation to compete against incumbents.

Theoretical literature has addressed the multiple dimensions of product differentiation for a long time (Irmen and Thisse, 1998; Tabuchi, 1994; Ansari, Economides, and Steckel, 1998). If a firm has two or more dimensions to implement product differentiation, it maximizes differentiation in one dimension, and minimizes differentiation in the others. It is so called min-max equilibrium or max-min equilibrium. For instance, if the first dimension is location, and the second dimension is product differentiation. In the movie theater industry, Elizalde (2013) finds that closer movie theaters are likely to choose a higher proportion of different movies. Therefore, using the same logic in the gasoline retail market, different branded gasoline stations might have incentives to locate close to each other.

Instead of minimizing spatial differentiation, some literature finds that the location is a major source of product differentiation, especially for those almost homogeneous products. For instance, Seim (2006) finds this result by using the video retail industry to estimate an entry model with endogenous location of firm. In addition, Netz and Taylor (2002) find that gasoline stations tend to increase spatial differentiation as market competition increases. The decision of spatial differentiation is always

¹More details about regulation will be described in section 2

combined with the entry decision; however, in this draft of research, I only consider spatial differentiation conditional on entry.

This paper uses a novel data from Economic Development Department, New Taipei City Government, containing all the attributes for gasoline stations when they entered into the market. To measure the degree of spatial differentiation, I construct two straightforward measures: (1) the distance from the nearest incumbent, and (2) the number of incumbents located within a 2-kilometer radius of a new entrant. Compared with CPC dealer-owned gasoline stations, the result shows that Formosa dealer-owned gasoline stations has 332.1 meters more close to the nearest station. In addition, Formosa company-operated stations tend to locate at the point with more competitors inside 2-kilometer radius. Compared with CPC dealer-owned stations, Formosa company-operated stations on average has 1.9 more competitors within 2 kilometers.

The remainder of this paper is organized as follows. Section 2 presents the background for gasoline retailing in Taiwan. Section 3 describes the data details and the measures of spatial differentiation. The empirical models are introduced in section 4. The preliminary results are reported and discussed in Section 5. Section 6 concludes the paper so far and addresses the future research.

2 Background

Before 1987, there was only one refiner and one retailer, which are owned by CPC Corporation Taiwan (CPC, 台灣中油). All the gasoline stations are company-operated stations and there is only one brand, CPC, in the market. In 1987, the government announced a new law (加油站管理規則) to encourage the entries of private gasoline stations. Those private gasoline stations are all dealer-owned stations, which acted as retailers to sell the gasoline for CPC, but they can choose their own locations to provide the services.

Formosa Petrochemical Corporation (FPCC) was established in 1992, and a subsidiary, Formosa Oil (Formosa) was founded in 1999. They entered into the upstream and downstream (retailing) markets, respectively. Some of dealer-owned stations switched the contract from CPC to FPCC after 2000. For instance, one of the famous dealer-owned gasoline station chains, National Petroleum Corporation (NPC, 全國加油站), became Formosa dealer-owned stations after the entry of Formosa.

[Figure 1 about here]

Figure 1 shows the number of gasoline stations after 1998 in Taiwan. The number of gasoline stations increases until 2010, the peak of era, and decreases after 2010. As more gasoline stations in the market, the average provided quantity per gasoline station is decreasing over time.

Gasoline stations in Taiwan can be categorized as four groups: CPC company-operated stations (中油直營站), CPC dealer-owned stations (中油加盟站), Formosa company-operated stations (台亞石油直營站), and Formosa dealer-owned stations (台亞石油加盟站). Some of those dealer-owned stations are operated by those big chain companies, such as National Petroleum Corporation (NPC, 全國加油站) with 107 stations, Formosa Taffeta Corporation (FTC, 福懋興業) with 105 stations, and Mech Smile (統一精工) with 87 stations. Most of the gasoline station chains have the contracts with only one upstream firm (CPC or FPCC), but one gasoline station chain, Shan-Long Transportation (山隆通運) has the contract with both CPC and FPCC. The numbers of different types of gasoline stations are listed in Table 1.

[Table 1 about here]

Besides the entry restriction for gasoline stations in the early time, gasoline wholesale and retail prices are regulated in Taiwan. Actually all the regulations are only for CPC, but it seems that the best response of Formosa is to follow what CPC makes in the market. From 2006, the suggested wholesale prices are determined by a combination index of 70% Dubai Crude and 30% Brent Crude, which is called "7D3B". Figure 2 shows the wholesale price and 7D3B crude oil price pattern. Price controls by government were happened twice during the period of high crude oil price (the gray area in Figure 2). Besides the period of price controls, all the wholesale prices just follow the crude oil price pattern.

[Figure 2 about here]

The government also set the suggested retail prices for gasoline stations, and there is a constant markup between suggested wholesale prices and suggested retail prices. This constant markup is around 2.583 NTD per liter for a long time, it was changed to 3.049 NTD per liter after January, 2016. Although there is a suggested retail prices, the gasoline stations can set up their own prices in fact. They usually set up the

retail prices lower than or equal to the suggested retail price, so the suggested retail price can be treated as a price cap. The lower bound of retail prices are the suggested wholesale prices plus some discounts provided by refiners. However, the room for price competition is very limited according to the price regulation in Taiwan, so the location decision becomes much more important than price competition.

3 Data

The data contains a rich attribute set for each gasoline station in New Taipei City, including its opening date, ending date, geographical location, area size, number of pumps, number of nozzles, and size of fuel storage tanks.² This data can provide not only a longer period but also the entry pattern for different types of gasoline stations.

[Figure 3 about here]

Based on the opening date, we can obtain the earliest record of entry from 1962. The black line in Figure 3 shows the total number of gasoline stations in New Taipei City. This entry pattern is very similar to that in Figure 1, but we can observe those entries before 1999. After the government allowed private gasoline stations to enter into the market, CPC only increases few company-operated stations (blue dash line). From 1988 to 2000, most of the entries are CPC dealer-owned stations (navy dotted line). After 2000, the other two types of gasoline stations, Formosa company-operated (red line) and dealer-owned (orange line) stations, started to enter into the market.

[Figure 4 about here]

Figure 4 shows the map of gasoline stations in different periods. Red squared and blue diamond marks represent CPC and Formosa company-operated stations respectively. The dealer-owned stations operated by chain store are marked as circle, and those operated by small independent firms are marked as stars. Red is the color for CPC brand; blue is the color for Formosa brand. Overall, the number of gasoline stations increase quickly in some urban districts.

²The data is obtained from Economic Development Department, New Taipei City Government (新北市政府經濟發展局).

3.1 Summary Statistics

In this subsection, I will show some details about the data. Table 2 shows the summary statistics for all the gasoline stations in New Taipei City. 9 gasoline stations in the original sample do not have the ending date or geographical location, so only 256 gasoline stations are identified in the following analysis. The average area size of gasoline stations is around 1214 squared meters. In addition, each gasoline station on average has 33.53 nozzles, 6.86 pumps, and 4.93 nozzles per pump. From 2009 to 2017, 20 gasoline stations left the market. In 2017, there are 235 gasoline stations in the market.

[Table 2 about here]

Tables 3 shows the number of different types of gasoline stations over time. Because some gasoline stations were switched from CPC dealer-owned stations to Formosa dealer-owned stations when Formosa entered into the market, the exact number of entries and exits can be observed from Table 4. The numbers in brackets represent the number of exits during that period. Formosa gasoline stations only entered into the market after 2000. From 2000-2005, the total number of entries reaches the highest record, and the exits started to show up during 2006-2017. For instance, 7 CPC dealer-owned stations left the market during 2011-2017.

[Table 3 about here]

[Table 4 about here]

3.2 Spatial Differentiation Measure

In this subsection, two different measures of spatial differentiation are introduced: one is the distance from the nearest incumbent, and the other one is to calculate how many incumbents were located within a 2-kilometer radius of a new entrant. These two measures can describe whether the entrant decides to maximize or minimize the spatial differentiation. If a new gasoline station tends to locate far away from the existing gasoline stations, it should enlarge the distance from the opponents and avoid locating in a high-density area.

To consider the degree of spatial differentiation, I ignore all the CPC company-operated gasoline stations based on two reasons. First, the location strategies of

those gasoline stations are made by the government, so the government might have other concerns to decide the location. Second, few CPC company-operated gasoline stations entered into the market after 1987. In the following analysis, I choose the period after 1987 and exclude all the CPC company-operated gasoline stations.

[Table 5 about here]

Because the density of market becomes higher when more gasoline stations enter into the market, the average distance from the nearest incumbent decreases over time. Table 5 summarizes the mean of distances from the nearest incumbent over time across different types of gasoline stations. During 2011-2017, the average distance from the nearest station is around 408 meters, much lower than 1902 in 1993-1999. Within the period from 2000 to 2005, CPC dealer-owned stations have around 700-800 meters from their nearest competitors, which is larger than those of Formosa company-operated and dealer-owned stations, only around 400-650 meters. However, entries of different types of gasoline stations might happen in different districts, so it is necessary to control the district fixed effect in the regression analysis.

[Table 6 about here]

In addition, Table 6 shows the number of incumbents located with a 2-kilometer radius. The average number of incumbents within a 2-kilometer radius increases when more gasoline stations are clustered inside the market. The average number of gasoline stations inside a 2-kilometer radius is about 1.36 in the early period (1993-1999), but it reaches 8.57 during the peak period (2006-2011). Within the same period, such as 2000-2005, 2006-2011, and 2011-2017, the numbers of incumbents within 2 kilometers for Formosa company-operated stations are much larger than those for other types of gasoline stations.

4 Model

To understand the degree of spatial differentiation, the following model is estimated:

$$y_i = \beta_0 + \beta_1 \text{FormosaCO}_i + \beta_2 \text{FormosaDO}_i + \mathbf{D}_i \boldsymbol{\Theta} + \mathbf{X}_i \boldsymbol{\Gamma} + f_i + u_i,$$

where y_i is the measure of spatial differentiation for gasoline i , such as the distance from the nearest incumbent station and the number of incumbent gasoline stations within 2 kilometers. Two dummies, FormosaCO_i and FormosaDO_i , separately indicate Formosa company-operated and dealer-owned gasoline stations. The control group is composed of CPC dealer-owned gasoline stations.

In order to compare the degree of spatial differentiation within the same period, the model includes a set of period dummies, \mathbf{D}_i , to specify the timing of entry for each gasoline station; otherwise, we might underestimate the coefficients on FormosaCO_i and FormosaDO_i because Formosa gasoline stations were only entering into the market after 2000. \mathbf{X}_i contains all the station-level characteristics, such as the area size, the size of fuel storage tank, the number of pumps, and the number of nozzles. Considering the districts in New Taipei City vary in different sizes, the model also includes the district fixed effects f_i , and all the robust standard error are clustered at the district level.

5 Preliminary Results and Discussion

Tables 7 and 8 report the estimation results using different measures of spatial differentiation. For the second measure, the number of incumbent gasoline stations within 2 kilometers, the results are also robust to other radius size (1 and 3 kilometers).

[Table 7 about here]

In Table 7, without controlling the timing of entry, Formosa company-operated and dealer-owned stations tend to have 401.9 meters and 648.6 meters more close to the nearest station, compared with the decision of CPC dealer-owned stations. However, after controlling the entry time and the district fixed effects, only Formosa dealer-owned stations has 332.1 meters more close to the nearest station, compared with the distance choice of CPC dealer-owned stations. The coefficients on period dummies show that the distance between new entrants and incumbents becomes shorter nowadays. All the characteristics on gasoline stations do not affect the decision of distance.

[Table 8 about here]

The dependent variable in Table 8 is the number of incumbents within 2 kilometers for each gasoline station when they were entering into the market. If the number is large, it means that the entrant tends to decide a location close to more incumbents. However, for those entrants tend to be far away from the incumbents, this number is smaller. In the last column of Table 8 shows that Formosa company-operated stations tend to locate at the point with more competitors inside 2-kilometer radius when those period dummies, characteristics, and district fixed effects are controlled in the model. Compared with CPC dealer-owned stations, Formosa company-operated stations on average has 1.9 more competitors within 2 kilometers. In addition, stations entering into the market during 2006-2011 have most competitors inside the neighborhood, compared with those stations entering in other periods. About the station-level characteristics, the result shows that stations with more number of nozzles or fewer number pumps also have more competitors inside the neighborhood. This could only be interpreted as the correlation not causality because the decisions on those characteristics are combined with the distance choice.

6 Conclusion

In this research, I compare two measures of spatial differentiation across different types of gasoline stations, controlling the timing of entry and the district fixed effects. The result shows that Formosa dealer-owned gasoline stations has 332.1 meters more close to the nearest station, compared with the distance choice of CPC dealer-owned stations. In addition, Formosa company-operated stations tend to locate at the point with more competitors inside 2-kilometer radius. Compared with CPC dealer-owned stations, Formosa company-operated stations on average has 1.9 more competitors within 2 kilometers.

In this paper, I haven't considered the decision of entry and the choice for independent dealer-owned stations between CPC and Formosa brands. In the future, I plan to consider a structural model, similar to Igami and Yang (2016), to endogenize these two decisions.

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Figures and Tables

Figure 1: Overview of Gasoline Stations in Taiwan, 1998-2017

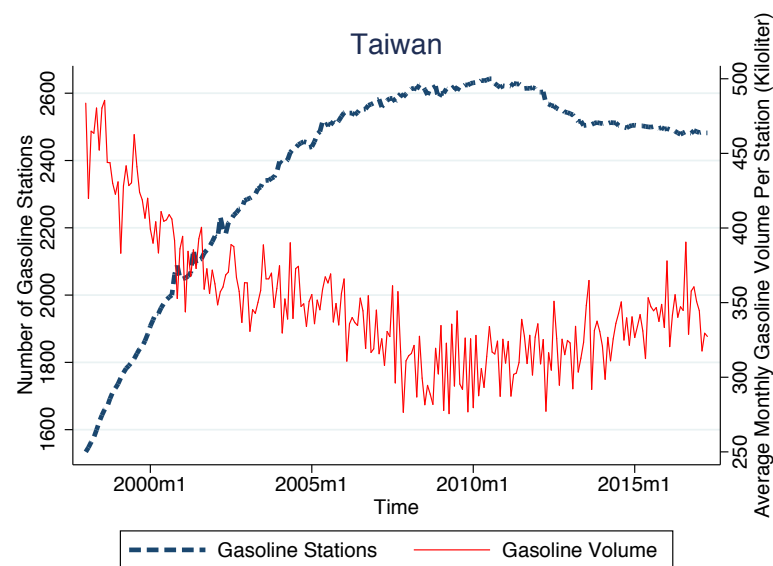


Figure 2: CPC's Wholesale Prices

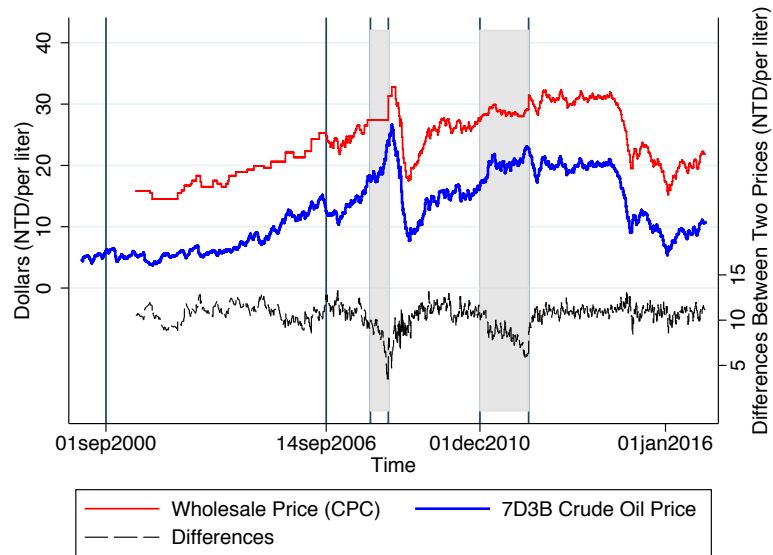


Figure 3: Overview of Gasoline Stations in New Taipei City, 1962-2017

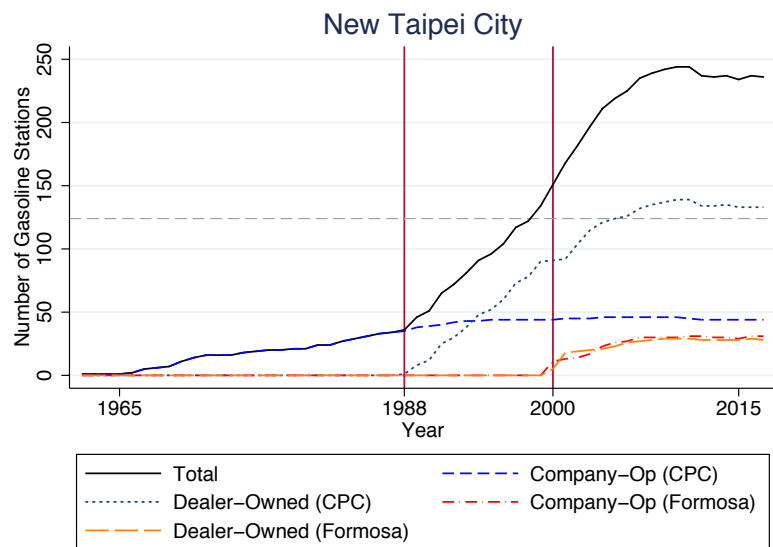


Figure 4: Maps of Gasoline Stations in New Taipei City, 1987-2017

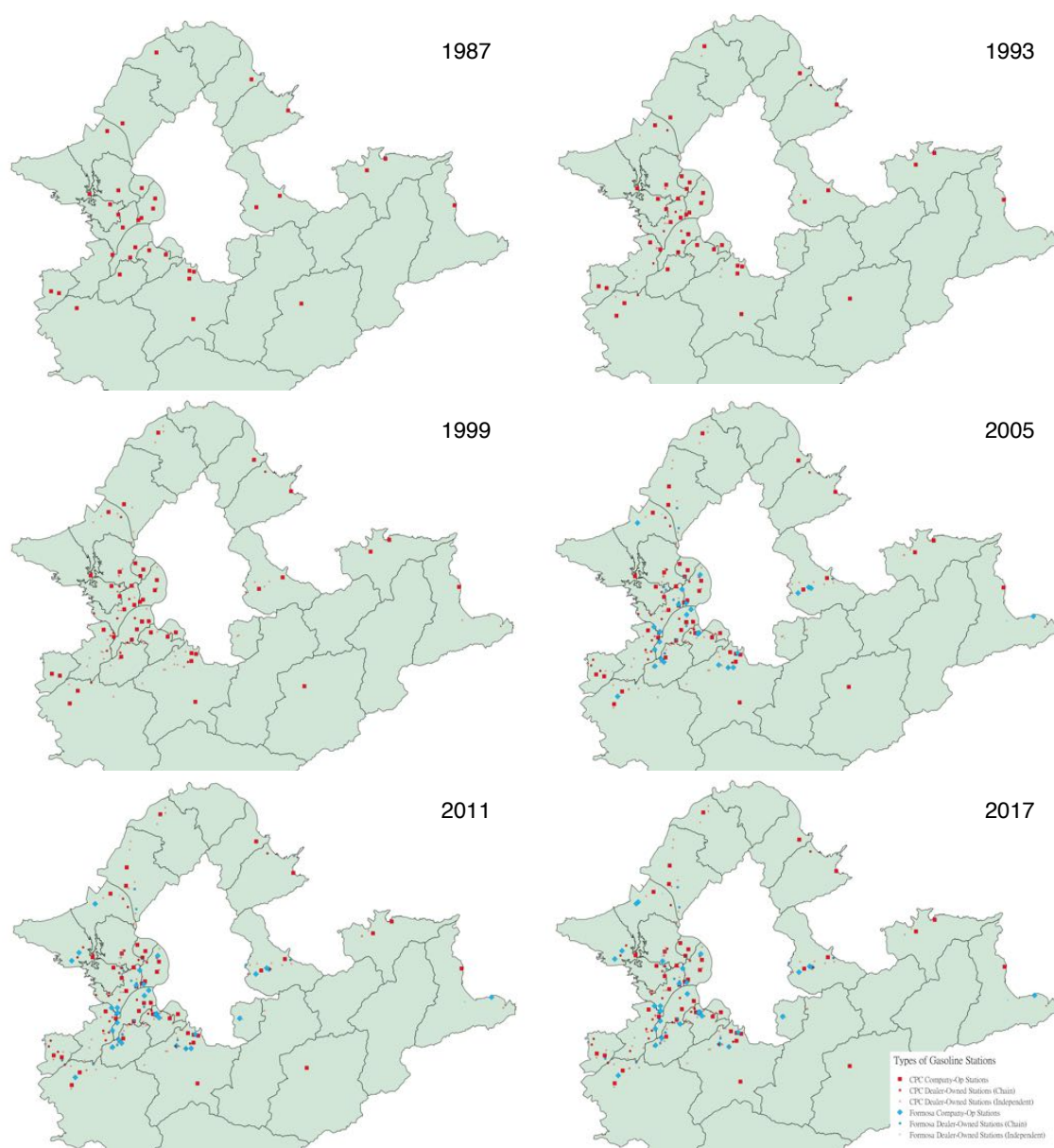


Table 1: Types of Gasoline Stations in Taiwan, 2017

Types of Gasoline Stations	Number of Stations
CPC Company-Operated Stations	598
CPC Dealer-Owned Stations (Chain Stores)	296
CPC Dealer-Owned Stations (Independent Stores)	1045
Formosa Company-Operated Stations	127
Formosa Dealer-Owned Stations (Chain Stores)	263
Formosa Dealer-Owned Stations (Independent Stores)	129
Total	2458

Note: All of the gasoline stations are branded stations. The data is collected on May 2, 2017.

Table 2: Summay Statistics

VARIABLES	N	mean	sd	min	max
Area size (squared meters)	256	1214	776	307	6641
Number of nozzles	256	33.53	12.45	2	74
Number of pumps	256	6.863	2.377	1	21
Average number of nozzles per pump	256	4.934	1.195	1.2	8
Number of fuel storage tanks	256	4.641	1.163	2	12
Fuel storage tank size (kiloliters)	256	204.5	53.56	40	382
Year started	256	-	-	1962	2016
Year closed	20	-	-	2009	2017

Note: The sample includes 256 gasoline stations in New Taipei City. 9 gasoline stations without the information about address location or exit dates are excluded in the sample.

Table 3: Types of Gasoline Stations in New Taipei City, 1987-2017

	Year					
	1987	1993	1999	2005	2011	2017
CPC Company-Operated Stations	34	43	44	46	45	44
CPC Dealer-Owned Stations (Chain Stores)	0	9	17	24	33	31
CPC Dealer-Owned Stations (Independent Stores)	0	29	73	100	105	100
Formosa Company-Operated Stations	0	0	0	26	31	31
Formosa Dealer-Owned Stations (Chain Stores)	0	0	0	15	19	18
Formosa Dealer-Owned Stations (Independent Stores)	0	0	0	8	11	11
Total	34	81	134	219	244	235

Note: Some gasoline stations were switched from CPC dealer-owned stations to Formosa dealer-owned stations when Formosa entered into the market after 2000.

Table 4: Number of Entries and Exits in New Taipei City Over Time

	Before 1987	1988- 1993	1994- 1999	2000- 2005	2006- 2011	2011- 2017
CPC Company-Operated Stations	34 [0]	9 [0]	1 [0]	2 [0]	0 [1]	0 [1]
CPC Dealer-Owned Stations (Chain Stores)	0 [0]	9 [0]	8 [0]	11 [0]	9 [0]	3 [5]
CPC Dealer-Owned Stations (Independent Stores)	0 [0]	29 [0]	44 [0]	45 [0]	7 [2]	2 [7]
Formosa Company-Operated Stations	0 [0]	0 [0]	0 [0]	17 [0]	5 [0]	3 [3]
Formosa Dealer-Owned Stations (Chain Stores)	0 [0]	0 [0]	0 [0]	7 [0]	4 [0]	0 [1]
Formosa Dealer-Owned Stations (Independent Stores)	0 [0]	0 [0]	0 [0]	3 [0]	3 [0]	1 [1]
Total	34 [0]	47 [0]	53 [0]	85 [0]	28 [3]	9 [18]

Note: The numbers in brackets represent the number of exits during that period.

Table 5: Distance from the Nearest Station (in Meters)

	1988- 1993	1994- 1999	2000- 2005	2006- 2011	2011- 2017
CPC Company-Operated Stations	2398.203 [2047.890]	1795.233 -	1319.236 [1820.068]	- -	- -
CPC Dealer-Owned Stations (Chain Stores)	1578.969 [748.645]	477.912 [334.547]	832.588 [654.300]	508.315 [566.548]	345.327 [391.740]
CPC Dealer-Owned Stations (Independent Stores)	1865.910 [2201.779]	1015.989 [1003.553]	707.345 [841.448]	471.344 [300.924]	301.176 [334.047]
Formosa Company-Operated Stations	- -	- -	470.655 [327.069]	1021.680 [1117.741]	631.999 [242.624]
Formosa Dealer-Owned Stations (Chain Stores)	- -	- -	416.690 [276.411]	207.268 [207.320]	- -
Formosa Dealer-Owned Stations (Independent Stores)	- -	- -	649.568 [338.463]	175.992 [130.575]	139.922 -
Total	1902.342 [1958.041]	949.473 [948.465]	664.637 [719.346]	512.132 [617.410]	408.251 [314.889]

Note: Standard deviations are in brackets. The distances are in meters.

Table 6: Number of Gasoline Stations in 2 Kilometers

	1988- 1993	1994- 1999	2000- 2005	2006- 2011	2011- 2017
CPC Company-Operated Stations	0.78 [1.09]	1.00 -	4.50 [6.36]	- -	- -
CPC Dealer-Owned Stations (Chain Stores)	1.67 [1.87]	4.75 [1.98]	7.55 [7.15]	7.11 [3.79]	6.00 [1.00]
CPC Dealer-Owned Stations (Independent Stores)	1.45 [1.35]	3.36 [2.67]	5.96 [4.05]	11.14 [5.01]	5.50 [6.36]
Formosa Company-Operated Stations	- -	- -	10.41 [4.27]	7.20 [8.04]	8.00 [6.56]
Formosa Dealer-Owned Stations (Chain Stores)	- -	- -	6.00 [4.20]	8.00 [2.94]	- -
Formosa Dealer-Owned Stations (Independent Stores)	- -	- -	4.33 [2.52]	10.00 [3.00]	2.00 -
Total	1.36 [1.42]	3.53 [2.61]	6.96 [4.85]	8.57 [4.91]	6.11 [4.43]

Note: Standard deviations are in brackets. We calculate how many opponent's gasoline stations were located within a 2-kilometer radius of the entrant. I also use 1, 2, and 3 kilometers as the radius to check the robustness of the result.

Table 7: Empirical Results for Spatial Differentiation I

Variables	(1)	(2)	(3)	(4)
	Dependent variable: Distance			
Compared with CPC dealer-owned stations				
Formosa company-operated stations	-401.9** [168.6]	-43.34 [145.7]	-9.792 [150.8]	16.84 [153.0]
Formosa dealer-owned stations	-648.6*** [131.3]	-286.4** [108.2]	-359.1** [154.7]	-332.1* [162.9]
Compared with 1987-1993				
Period in 1994-1999		-864.7** [327.5]	-675.6** [283.1]	-621.6** [267.4]
Period in 2000-2005		-1,106*** [344.0]	-805.6*** [232.3]	-772.2*** [218.5]
Period in 2006-2011		-1,206*** [369.9]	-925.2*** [304.1]	-881.3*** [280.6]
Period in 2012-2017		-1,343*** [349.1]	-1,177*** [367.7]	-1,163*** [370.6]
Area size (squared meters)				0.0317 [0.0686]
Fuel storage tank size (kiloliters)				-0.242 [2.091]
Number of nozzles				-14.60 [11.46]
Number of pumps				59.08 [61.61]
Constant	1,002*** [123.1]	1,798*** [329.7]	1,859*** [183.2]	1,942*** [491.5]
Observations	210	210	210	210
R-squared	0.033	0.156	0.462	0.466
District fixed effects	No	No	Yes	Yes

Note: Robust standard errors in brackets are clustered at the district (區) level. *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Empirical Results for Spatial Differentiation II

Variables	(1)	(2)	(3)	(4)
	Dependent variable: Number of Stations			
Compared with CPC dealer-owned stations				
Formosa company-operated stations	4.899*** [1.062]	2.784** [1.015]	2.365*** [0.737]	1.924*** [0.682]
Formosa dealer-owned stations	2.030* [1.167]	-0.485 [1.328]	0.264 [0.576]	0.281 [0.531]
Compared with 1987-1993				
Period in 1994-1999		2.077*** [0.657]	1.916* [0.940]	1.406* [0.807]
Period in 2000-2005		5.012*** [1.352]	4.472*** [0.592]	3.821*** [0.542]
Period in 2006-2011		6.695*** [1.587]	6.952*** [0.724]	5.864*** [0.823]
Period in 2012-2017		3.737** [1.405]	4.376*** [1.299]	3.613*** [1.194]
Area size (squared meters)				0.00012 [0.000362]
Fuel storage tank size (kiloliters)				-0.00388 [0.00344]
Number of nozzles				0.100*** [0.0355]
Number of pumps				-0.738** [0.279]
Constant	4.581*** [0.753]	1.500*** [0.347]	-1.013** [0.478]	1.473 [0.930]
Observations	210	210	210	210
R-squared	0.126	0.322	0.703	0.726
District fixed effects	No	No	Yes	Yes

Note: Robust standard errors in brackets are clustered at the district (區) level. *** p<0.01, ** p<0.05, * p<0.1.