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台北市連鎖便利商店展店行為的動態分析

An Entry Analysis of Convenience Stores in Taipei

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摘要

臺灣的連鎖式便利商店密度居世界之冠，為數眾多的門市使得便利商店與臺灣人民的生活息息相關，就直覺來說，便利商店門市的數量也影響了廠商設立新門市的決策。本研究建構了一離散選擇的動態賽局，分析臺北市各個行政區便利商店門市數量對不同廠商設立新門市的影響。實證結果顯示當競爭對手門市數量剛開始增加時，門市數量對便利商店的利潤有正向的影響，但是當對手門市數量太多時，此數量的增加對便利商店的利潤產生負向影響。這結果表示一開始門市之間的互補效果大於替代效果，但是門市數量太多造成過度競爭，此時門市之間的替代效果大於互補效果。而同品牌的門市數量對於廠商的總利潤也有類似的影響。另外，本研究也估計便利商店歷年來在臺北市各行政區展店的機率，其中大安區和中山區是便利商店廠商最想展店的行政區，相對而言，南港區、大同區和萬華區則是展店機率較低的行政區。

關鍵詞：便利商店，離散選擇動態賽局，巢式擬態概似函數(Nested Pseudo Likelihood)，互補效果，替代效果，市場進入決策

Abstract

The density of convenience stores (CVS) in Taiwan is ranked as number one in the world. The highly concentrated market of convenience stores has dramatically changed the lifestyle of Taiwanese people. The number of existing outlets in a region is also an important factor in regard to the entry decisions of new outlets. In this study, we construct a model of the dynamic discrete game, and examine the influence of the rival outlet number on CVS entry decisions in Taipei, Taiwan. The empirical evidence we find is that the CVS profits first rise and then decline as the own or rival outlet number increases. This result implies that the complement and substitution effects vary with the number of the CVS outlets in a specific region. Furthermore, we estimate the probabilities that the CVS companies will set up additional outlets in any district of Taipei during the data period. The results show that it is most likely for the companies to enter the Da’an and Zhongshan districts, while Nangang, Datong and Wanhua are districts with low entry probabilities.

Keywords: Entry, Convenience Store, Dynamic Discrete Game, Complement Effect, Substitution Effect, Nested Pseudo Likelihood

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1. Introduction

The convenience store (CVS) industry in Taiwan is unique. It seems that there are CVSs almost everywhere in Taiwan. The Taiwanese CVS outlet density is ranked as number one in the world[1]; on average, there is a CVS outlet for every 2322 people. The large store count gives the CVS companies a great influence on Taiwanese people's lifestyle. For example, the Taiwanese eating habits have changed dramatically due to the rise of CVSs. The fresh food and beverages of CVSs are currently remarkably popular in Taiwan. For example, the revenue from fresh food of the leading CVS company, 7-11, even surpasses the total revenue of McDonalds, the largest fast-food company in Taiwan.[2]

The other distinct feature of this industry is that the CVS companies are now offering a variety of services such as parcel delivery, train ticket sales, etc. Consumers are willing to use the convenient services which are provided, and the services are likely to be successful because they are widely used. These positive influences on the expansion of CVSs are called "complement effects." However, there are also negative influences. The large number of outlets increases the degree of competition, and consequently reduces the CVS companies' motivation to set up new branches or outlets.[3] The negative effects are referred to as "substitution effects."

In this discussion, it is interesting to explore how the number of existing CVS outlets affects the entry decisions of new outlets. This analysis will help us to answer the following questions: Why is there a massive expansion of the CVS outlets? Are the CVS markets currently severely competitive? Will the number of CVS outlets continue to increase in the future? In order to answer these questions, we construct a dynamic discrete choice model to analyze how the CVS entry decisions are influenced by the number of existing outlets with the uniquely collected CVS data in Taipei from 1987 to 2013.

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1 Most of the CVSs in the U.S. sell motor fuel. Their retail formats are closer to filling stations than to CVSs in other countries. Thus, the CVSs selling motor fuels are excluded from the U.S. CVS density calculation.

2 The sales of McDonald's and the fresh food sales of 7-11 are estimated in the WEALTH MAGAZINE, Taiwan (2013, July), retrieved from https://www.wealth.com.tw/index2.aspx?f=201&id=3376

3 To avoid confusion, we use the word "outlet" instead of "store" in this literature to represent the branches of CVS.

The empirical evidence shows that the CVS profits first rise and then decline as rival outlets increase in number. The number of own CVS outlets has similar influences on the profitability. It implies that the complement effect is larger when the number of outlets is low, while the substitution effect is larger when the number of outlets is high. In addition, we estimate the probabilities that the CVS companies set up an additional outlet in any district of Taipei during the data period. The analysis indicates that it is most likely that companies will enter the Da'an and Zhongshan districts, while Nangang, Datong and Wanhua are districts with low entry probabilities.

This study is organized as follows. In Section 2 we review the related CVS literature. In Section 3, we briefly discuss the CVS industry and our unique dataset. Section 4 illustrates the empirical model and estimation procedure. In Section 5, we present the details of the empirical results. We conclude in Section 6 with a summary and directions for future work.

2. Literature Review

There are many theses and studies on Taiwan’s CVS industry. Some of the studies investigate how CVS companies set up new outlets. Li (1991) and Luo (2002) analyzed the CVS location strategies by interviewing managers of CVS and experts in the CVS industry. Jung (2005) found the most common CVS location characteristics by data mining with SPSS and GIS (geographic software).

In addition, research on public health also discusses the influence of CVSs. For example, Wang et al. (2013) examined the relation between alcohol use of teenagers and the distance of their schools to CVSs; the way that the CVS market is defined in their paper provides a good reference for us. The Taiwanese research on CVS can be seen in many fields, including management, geography, psychology, etc. However, most of these researches focus on the factors that affect the operations of CVS companies, such as the management, marketing and consumer behavior of CVS companies. Furthermore, few of them apply quantitative methods. In order to fill this gap, we conduct research with rigorous econometric methods to shed some new light in this area.

Next, we reviewed some studies on other retailing industries related to the CVSs, such as the fast food and supermarket industries. The influence of the CVS store count is a key factor in the current study. The increased store count not only brings benefits, but also causes intense competition. We will next discuss some literature on competition in the retail industry. Retailers are likely to change the way they operate when encountering competition, such as pricing and positioning differentiation. Netz and Taylor (2002) found evidence that the gasoline stations in Los Angeles attempt to locate separately as the competition increases. Mazzeo (2002) suggests that U.S. hotels located at highway exits tend to offer differentiated products when facing competition. Thomadsen (2007) analyzed outlet location strategies under competition in the U.S. fast food industry. He indicates that both McDonalds and Burger King prefer to differentiate their locations in large markets. However, McDonalds would like to locate next to Burger King when the markets are small. Smith (2004) uses a more precise way to measure the effects of competition. He estimates the cross elasticity among firms in the U.K. supermarket industry, and thus evaluates the proportion of customers switching to other firms when a certain firm raises its price.

Literature on entry decisions often includes investigations based on the data on the number of outlets, because price and quantity data in retailing industries are usually difficult to obtain. Yang (2012), Nishida (2012) and Toivanen (2005) all explored the entry decisions by setting up the firms' profit functions influenced by the number of outlets. In our study, we adopt a dynamic model that fits the real situation better.

The dynamic discrete games in oligopoly markets have been developed in some studies, such as Aguirregabiria and Mira (2007) and Bajari et al. (2007). Empirically, dynamic discrete games are applied in different industries. Aguirregabiria and Ho (2010) use dynamic models to explain the cause of hub-and-spoke networks in the U.S. airline industry. Beresteanu and Ellickson (2006) examined competition in the U.S. supermarket industry with a dynamic strategic investment model.

The Nested Pseudo Likelihood (NPL) adopted in Aguirregabiria and Mira (2007), among other studies, has been widely used in various areas. Yang (2012) examined the spillover effects of fast food chains in the U.K., and Nishida (2012) investigated the location strategies of convenience stores in Okinawa, Japan. However, they apply static rather than dynamic models in their studies. The structure of dynamic discrete models combined with the NPL are suitable for analyzing the entry decisions in the oligopoly markets (e.g. Aguirregabiria and Mira, 2007; Aguirregabiria, 2009) As a result, we employ a dynamic discrete model and apply the NPL method from the basic structure of Aguirregabiria (2009) to estimate the influence of competition on outlet location strategies in Taiwan's CVS industry.

3. Data and Industry

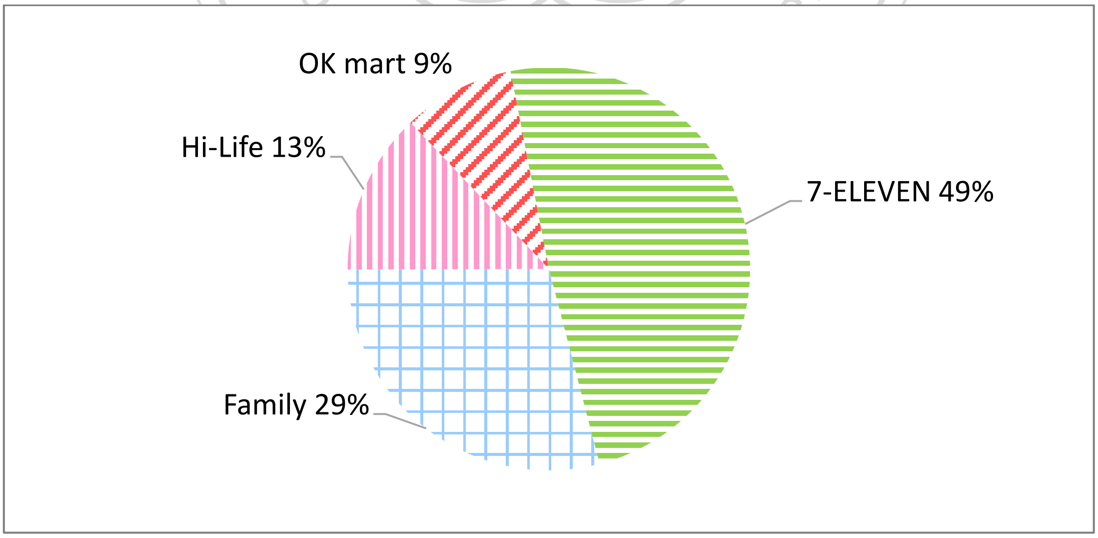
3.1 Industry Background

CVSs play important roles in the everyday life of Taiwanese people. Generally, the Taiwanese CVSs have the following characteristics: small-sized, food-oriented, multi-outlets and long operating hours (most of them are open 24 hours a day). These characteristics enable CVSs to fulfill the needs of the customers anytime and anywhere.

The first convenience store, 7-11, was introduced to Taiwan in 1978. However, the CVS industry did not thrive until the late 1980s. FamilyMart, OKmart and Hi-Life all started their businesses during that period of time. By 2013, there were more than 10,000 convenience stores in Taiwan, on land area of approximately 36,000 square kilometers, i.e. there is on average one outlet for every 3.58 square kilometers.

In 2013, 98.68% of the CVSs were owned by the largest 4 companies: 7-11, FamilyMart, Hi-Life and OKmart. The Herfindahl–Hirschman Index (HHI) of the whole industry is as high as 3454. Eleven other CVS companies that ed are now closed. Thus, the CVS market can be regarded as an oligopoly.

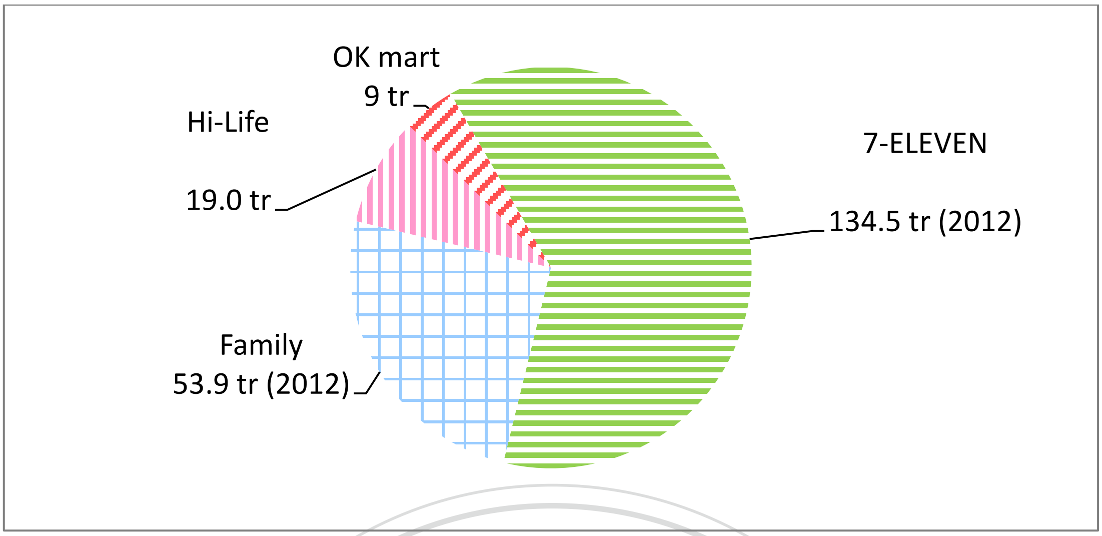
Figure 1: Market share by outlet numbers in 2013



Source: Ministry of Finance

Figure 1 andFigure **2** present the market share of the 4 main CVSs by revenue and by outlet numbers. As we can see, 7-11 is the largest company in terms of outlet numbers and revenue. It earned more than half of the total revenue in this industry.

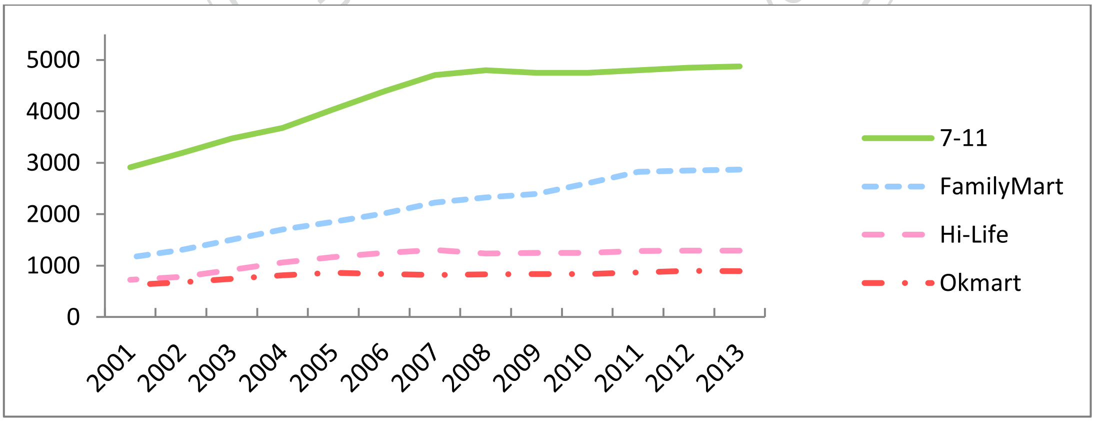
Figure 2: Market share by revenue in 2012



Source: Official Websites of the 4 CVS Companies

7-11 is indeed the most popular CVS company in Taiwan. It is known for its professional services and high-quality products. The goods and services of 7-11 are usually innovative and imitated by other CVS companies. For instance, 7-11 started the wave of CVS fresh-brewed coffee in the 2000s. Moreover, its promotion activities of coupon collecting for exchange of exclusive limited-edition gifts in 2003 were a big success and became common activities among CVSs. In addition, 7-11 was the only CVS company with its own brand mascots and a lot of related products.

Figure 3: Outlet numbers from 2001 to 2013 by company



Source: Ministry of Finance

FamilyMart is ranked number 2 in the Taiwanese CVS industry. It started to catch up by selling soft serve ice cream in 2013. This hot-selling product caused the stock value of FamilyMart to surpass 7-11 for the first time since 2002, when FamilyMart was publicly listed.[4] 7-11 and FamilyMart are fierce rivals of both Hi-Life and OKmart. Thus Hi-Life and OKmart usually provide lower-priced products or differentiate the outlet locations.

Since 7-11 was the first CVS company in Taiwan, it attracted the customers early and took the lead in the Taiwanese market. Figure 3 shows that the outlet number of 7-11 is always much larger than the rest of the CVS companies. The large outlet number offers advantages to 7-11. For example, 7-11 has better facilities and equipment, a better POS system (point of sales, an electronic sales system) and better cooperation with its supply chain partners.

As 7-11's marketing strategies are successful, its goods and services are often imitated by its competitors. In other words, 7-11 acts as a leader, while the others act as followers. For example, 7-11 constructed the first CVS payment and delivery system with an e-commerce company while other three CVS companies built a similar system 3 years later. Such a leader-follower situation implies that the 7-11 location strategies and entry decisions differ from those of other CVS companies. Thus, we divide the 4 companies into two groups in our model: 7-11 belongs to the first group marked as "7-11", while FamilyMart, Hi-life and OKmart are viewed as the second group called the "non 7-11" group.

The development of CVSs in Taiwan is usually divided into three stages. The first stage was from the 1980s to 1990s. At this stage, the CVSs sold everyday items, just as the traditional grocery stores did. In addition, they also sold conventional fresh foods, such as rice balls, hot dogs and steamed buns. What made CVSs different from the traditional grocery stores is that CVSs started to remain open 24 hours a day in 1983. For the Taiwanese who come home late at night, the bright lighting and surveillance system of the CVSs make their way home safer.

The next stage was in the 2000s. At the second stage, the CVSs provided more innovative goods and services. The CVSs began to sell fresh brewed coffee and

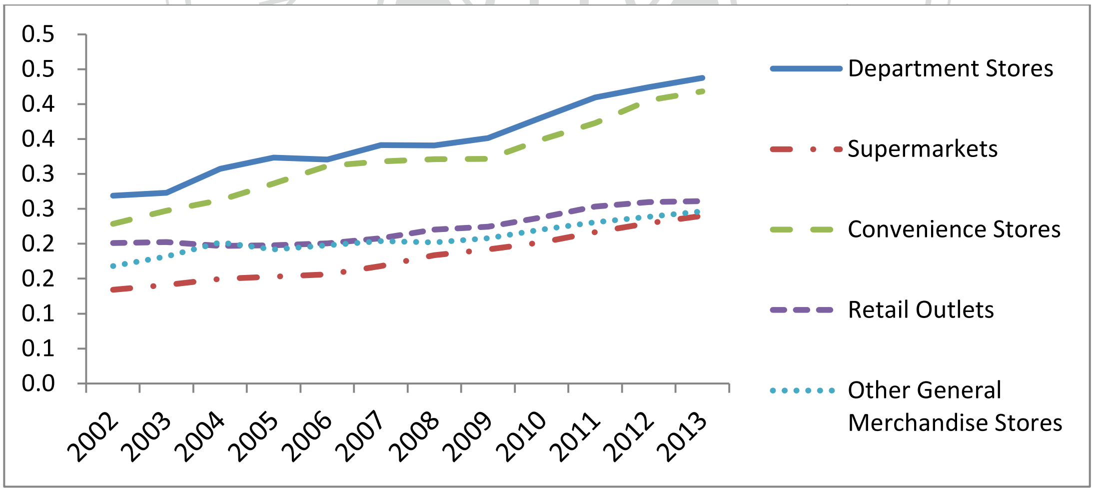
[4] The stock values are revealed in the Commercial Times, Taiwan (2014, February), retrieved from http://ctee.com.tw/Album/Content.aspx?albumid=f671344c-7288-4708-821c-547ee1918b98&newsid=500932

microwaved food. These two kinds of products sold so well that CVSs became a threat to regular restaurants and fair-priced coffee shops. In addition, the CVSs started to offer convenient services. The customers could use the services to simplify their daily routines, such as withdrawing money from ATMs, paying bills, receiving goods from online shopping, buying tickets, pre-ordering holiday gifts, etc.

The last stage is from 2010 to the present time. At this stage, the CVSs are extended by creating a more comfortable shopping environment. They began to offer dining areas, and even restrooms, so customers are willing to stay longer in the stores and end up purchasing more goods. Moreover, the CVSs continue to launch more own-brand products; these are usually inexpensive and special so that they are attractive to customers.

According to the Ministry of Economic Affairs in Taiwan, the CVSs are categorized as General Merchandise Store formats, under which department stores, supermarkets, retail outlets and other general merchandise stores are also included.

Figure 4: Market share by type of retailers



Source: Department of Statistics, MOEA

Figure 4 illustrates the revenue of General Merchandise Stores in Taiwan by category. The CVS industry was ranked in second place with the revenue slightly less than that of department stores. Among these 5 categories, supermarkets are the major competitors of CVSs because their store types are much closer compared to the others. For example, their store sizes, outlet locations and target markets are similar. In Figure 4, the revenue of supermarkets was the lowest, but it grew rapidly during these years. Interestingly, the current chairman of the largest supermarket, PXmart, is the previous general manager of 7-11. The competition among CVSs and supermarkets will certainly become more severe in the future.

After a brief review of Taiwan's CVS industry, we compare the CVSs in Taiwan to those in Japan, the U.S. and China. The relationship between CVSs in Taiwan and Japan is very close. The largest two CVS companies in Taiwan, 7-11 and FamilyMart, are actually franchisees of Japanese parent companies; thus, the CVSs in Japan and in Taiwan are almost the same. However, there are slight differences between them; for instance, fresh brewed coffee and dining areas are not common in the Japanese CVSs.

On the other hand, the United States is the original place of 7-11 and OKmart. However, CVSs are run in different ways in Taiwan and the U.S. The CVSs in the U.S. are usually located near highway exits, and over 80% of them sell motor fuels now.[5] On the contrary, there is only one CVS company in Taiwan selling motor fuels.

Finally, China and Taiwan share similar cultures and languages, yet the CVSs in China are not well-developed compared to those in Taiwan. Over 100 CVS outlets were shut down during 2012 and 2013.[6] More development is still needed for the Chinese CVS industry.

3.2 Data

There are two parts to the data in this study. The first part is the information about CVSs, including their companies, outlet launch dates and outlet locations. The second part consists of the demographic data at the village and district levels. Details of the data collection process are discussed in the following paragraphs.

First, we collected the addresses and launch dates of CVSs from the Ministry of Finance. The data period is from January 1987 to November 2013. Additionally, the village map of Taipei City comes from Data.Taipei, Taipei City Government (TCG).[7] We merged these two datasets with ArcGIS, geographic-related software, to find out

[5] The information comes from NACS, U.S. (National Association of Convenience Stores).
[6] The number of closed outlets comes from Apple Daily, Taiwan (2013 March), retrieved from http://www.appledaily.com.tw/appledaily/article/finance/20130304/34864317/
[7] See more details at http://data.taipei.gov.tw/.

the village in which each outlet is located.[8] Due to the data limitation[9], this study focuses on the entry decisions rather than both the entry and exit. The data on outlets which closed before November 2013 are not included in the current study.

Second, we collect the demographic data at the village level from the Department of Civil Affairs, Taipei City Government. The data include the population and the male to female ratio. The data period is 2002-2013 because the village division was changed in 2002. In addition, three variables are at the district level since no more detailed data are available, including household size, year of schooling and average household disposable income. Moreover, we collected the landmark data within every village from Data.Taipei, TCG. The landmark data contain the number of elementary schools, junior high schools, senior high schools/vocational schools, universities, department stores, hospitals and tourist attractions. These landmark variables are used to capture the impacts of customers who visit CVS outlets but are not residents in that specific region.

Because the demographic data at the village level provide ideal information for us for estimating the demand for CVS goods and services, each village is viewed as a CVS market in our model, similar to Aguirregabiria (2007). There are 456 villages in Taipei City, but as 53 have no CVSs, they were removed from this study. As a result, it turns out that there are 403 defined markets in the dataset.

We then define some associated variables on CVSs, including number of 7-11 and non 7-11 CVS outlets, as well as entry of 7-11 and non 7-11 CVS s. It is worth noting that entries are indicated by a dummy variable, i.e. we assume that any defined group sets up at most one outlet at a time. In our dataset, only 0.97% of the samples have more than one entry at a time; thus, it has no significant influence on the estimation. However, this setting successfully helps to lessen the computation burden.

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[8] According to the autonomous decree of Taipei City Government, the neighborhood divisions are based on the number of households. The crowded areas and the areas with good public transport containing 1000 to 4000 households are categorized into one neighborhood; the suburban areas containing 400 to 1000 households are also categorized into one neighborhood.

[9] The close-down dates of the CVSs are not provided; thus we could not obtain the exit decisions of CVS companies by arranging the data. About 700 CVSs closed down before November, 2013; they are not included in the dataset.

A lot of effort has been made to construct this dataset as it is difficult to find any single data resources that fit our research needs. However, all the hard work has paid off. The current dataset makes a pioneering contribution because it is the first panel dataset on the CVS entry in Taiwan.

4. Model

The model in this study is mainly based on Aguirregabiria (2009). Though the profit function in this model is constructed differently from Aguirregabiria (2009), the technique of the model derivation is similar.

In the following, we will discuss the situation in a hypothetical market. Two players i and j are in the game. $i \in \{s, n\}$ represents a particular CVS company, while $j \in \{s, n\}$ represents its rival. In both sets, s and n represent 7-11 and non 7-11 CVS outlets, respectively. Time is discrete and indexed by $t \in \{1, 2, ..., 12\}$ for 12 years. In each period, the players simultaneously decide whether to set up a new outlet. The discrete choice can be expressed by the entry variable $Y_{it} \in \{0,1\}$, which is unknown to its rival in period t. $Y_{it} = 0$ if company i does not enter the market, while $Y_{it} = 1$ if company i does enter the market.

The goal of each player is to maximize its expected intertemporal profits:

$$E_t(\sum_{s=0}^{T-t} \beta^s \Pi_{i,t+s}), \qquad (1)$$

where $\beta \in (0,1)$ is the discount factor, and Π_{it} is the profit of player i in period t. The profit Π_{it} is affected by ε_{it} and $\mathbf{z}_{it}(Y_{it}, Y_{jt})$:

$$\Pi_{it} = \mathbf{z}_{it}(Y_{it}, Y_{jt})\boldsymbol{\theta}_i - Y_{it}\varepsilon_{it} \ , \qquad (2)$$

where ε_{it} is the private information shock in the investment of company i in period t. ε_{it} has a standard normal distribution, and is independently and identically distributed (i.i.d.) over time. Besides, ε_{it} and ε_{jt} are independent of each other. $\mathbf{z}_{it}(Y_{it}, Y_{jt})$ is a row vector of state variables, while $\boldsymbol{\theta}_i$ is a column vector of structural parameters that we are going to estimate. The structure of the $\mathbf{z}_{it}(Y_{it}, Y_{jt})$ is given by:

$$\mathbf{z}_{it}(Y_{it}, Y_{jt}) = z(X_{it}, X_{jt}, Y_{it}, Y_{jt}) \ , \qquad (3)$$

where $z()$ is a known function with vectors of inputs. X_{it} represents the outlet number of company i in period t. In addition, X_{it} equals the sum of the outlet number in period $t-1$ and the investment in period $t-1$, i.e. $X_{it+1} = X_{it} + Y_{it}$. Note that the maximum outlet number in the dataset is 9,[10] so the set of possible values of X_{it} is considered to be $\{0,1,2,...,9,10\}$.

We assume that the market demand is related to an exogenous market size, which is represented by population S_t. Therefore, the demand function can be expressed as:

$$Q_t = S_t(a - bP_t), \tag{4}$$

where a and b are constant.

Next, we assume the total number of outlets of a company $X_{it} + Y_{it}$ is negatively correlated to its marginal costs. Let the marginal cost of company i MC_{it} be a function of $X_{it} + Y_{it}$:

$$MC_{it} = MC(X_{it} + Y_{it}) \tag{5}$$

The outlet number and the marginal cost are negatively correlated for two reasons. The first is that the marginal shipping costs for an extra outlet are lower. The other is that the advertisement of CVSs may bring external benefits, which make other outlets in the same market better off.

According to (4) and (5), the total profit function is expressed by proposition 1.[11]

Proposition 1: The total profit function can be given by Eq. (6):

$$\begin{aligned}\Pi_{it} = {} & \theta_{0i} S_t 1\{X_{it}+Y_{it} > 0\} + \theta_{1i} S_t (X_{it}+Y_{it}) + \theta_{2i} S_t (X_{jt}+Y_{jt}) + \theta_{3i} S_t (X_{it}+Y_{it})^2 \\ & + \theta_{4i} S_t (X_{jt}+Y_{jt})^2 + \theta_{5i} S_t (X_{it}+Y_{it})(X_{jt}+Y_{jt}) - Y_{it}\varepsilon_{it}\end{aligned} \tag{6}$$

where $1\{.\}$ is an indicator function. Consequently, the vector of state variables $\mathbf{Z}_{it}(Y_{it}, Y_{jt})$ follows:

$$\begin{aligned}\mathbf{Z}_{it}(Y_{it}, Y_{jt}) \equiv \{ & S_t 1\{X_{it} + Y_{it} > 0\},\ S_t(X_{it} + Y_{it}),\ S_t(X_{jt} + Y_{jt}), \\ & S_t(X_{it} + Y_{it})^2,\ S_t(X_{jt} + Y_{jt})^2,\ S_t(X_{it} + Y_{it})(X_{jt} + Y_{jt}) \}\end{aligned} \tag{7}$$

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[10] See Table 1 in Section 5.1 .
[11] See Proposition 1 in the Appendix.

The vector of structural parameters for company i is:

$$\boldsymbol{\theta}_i \equiv (\theta_{0i}, \theta_{1i}, \theta_{2i}, \theta_{3i}, \theta_{4i}, \theta_{5i})' \qquad (8)$$

Next, we are going to introduce Markov Perfect Equilibrium (MPE) and Conditional Choice Probabilities (CCPs). The variables which relate to the profit of company i in period t are $(S_t, X_{1t}, X_{2t}, \varepsilon_{it})$. We use three of the variables to define $\mathbf{X}_t \equiv (S_t, X_{1t}, X_{2t})$, which is the vector of common knowledge state variables.

Let $\boldsymbol{\sigma} \equiv \{\sigma_i(\mathbf{X}_t, \varepsilon_{it}) : i = s, n\}$ be a set of strategy functions. In our model, the strategies indicate whether or not the companies enter the market, given the state $(\mathbf{X}_t, \varepsilon_{it})$. Then the Markov Perfect Equilibrium (MPE) is the $\boldsymbol{\sigma}^*$ that maximizes the expected profit of each player. Since ε_{it} is assumed to follow a certain distribution, we will obtain $P_i(\mathbf{X}_t)$ from the integral of the strategy function over the distribution of ε_{it}:

$$P_i(\mathbf{X}_t) \equiv \int 1\{\sigma_i(\mathbf{X}_t, \varepsilon_{it}) = 1\}\, df(\varepsilon_{it}), \qquad (9)$$

where $P_i(\mathbf{X}_t)$ is the probability that player i set up a new outlet in period t given the state $\mathbf{X}_t$. $P_i(\mathbf{X}_t)$ is called the player's Conditional Choice Probabilities (CCP). In other words, MPE can be expressed as a pair of CCP, $\mathbf{P} \equiv \{P_i(\mathbf{X}_t) : i = s,n \; ; \mathbf{X}_t \in \chi\}$ where the strategy P_i maximizes Company i's expected profit given the rival's strategies P_j, and χ is the set containing all the possible $\mathbf{X}_t$.

In addition to CCP, MPE can also be expressed in terms of the expected profits. When the expected profit of entering the market is larger than not entering, the player will enter. The profit of company i is $\Pi_{it} = \mathbf{Z}_{it}(Y_{it}, Y_{jt})\boldsymbol{\theta}_i - Y_{it}\varepsilon_{it}$; however, as Y_{jt} is unknown, we use P_{jt} to compute the expected profit of firm i:

$$\begin{aligned} \Pi_{it}^{\mathbf{P}}(Y_{it}) &= (1 - P_j(\mathbf{X}_t))\, \mathbf{Z}_{it}(Y_{it}, 0)\boldsymbol{\theta}_i + P_j(\mathbf{X}_t)\, \mathbf{Z}_{it}(Y_{it}, 1)\boldsymbol{\theta}_i - Y_{it}\varepsilon_{it} \\ &= \mathbf{z}_{it}^{\mathbf{P}}(Y_{it})\, \boldsymbol{\theta}_i - Y_i \varepsilon_{it} \end{aligned} \qquad (10)$$

where $\mathbf{z}_{it}^{\mathbf{P}}(Y_{it})$ is specified by:

$$\mathbf{z}_{it}^{\mathbf{P}}(Y_{it}) \equiv (S_t,\ S_t(X_{it}+Y_{it}),\ (1-P_j(\mathbf{X}_t))S_t(X_{jt}+0)+P_j(\mathbf{X}_t)S_t(X_{jt}+1),\ -Y_{it},\ -Y_{it}X_{it}) \tag{11}$$

Because the players' goal is to maximize their profit, the best strategies for company i are as follows:

$$\{Y_{it}=1\} \Leftrightarrow \{\mathbf{z}_{it}^{\mathbf{P}}(1)\,\boldsymbol{\theta}_i - \varepsilon_{it} \geq \mathbf{z}_{it}^{\mathbf{P}}(0)\,\boldsymbol{\theta}_i\} \tag{12}$$

(12) can be expressed as a function of probability distributions:

$$\Pr(Y_{it}=1\,|\,\mathbf{X}_t) = F([\mathbf{z}_{it}^{\mathbf{P}}(1)-\mathbf{z}_{it}^{\mathbf{P}}(0)]\,\boldsymbol{\theta}_i) \tag{13}$$

Thus, the MPE $\boldsymbol{\sigma}^*$ in a Bayesian Nash Equilibrium can be expressed as a pair of Eq. (14):

$$\begin{aligned} P_s(\mathbf{X}_t) &= F([\mathbf{z}_{s\,t}^{\mathbf{P}}(1)-\mathbf{z}_{s\,t}^{\mathbf{P}}(0)]\,\boldsymbol{\theta}_s) \\ P_n(\mathbf{X}_t) &= F([\mathbf{z}_{n\,t}^{\mathbf{P}}(1)-\mathbf{z}_{n\,t}^{\mathbf{P}}(0)]\,\boldsymbol{\theta}_n) \end{aligned} \tag{14}$$

It turns out that we can obtain the expression of CCP in proposition 2.

Proposition 2: The function of CCP can be written as Eq. (15) considering the future profits:

$$P_i(\mathbf{X}_t) = F([\tilde{\mathbf{z}}_{it}^{\mathbf{P}}(1)-\tilde{\mathbf{z}}_{it}^{\mathbf{P}}(0)]\,\boldsymbol{\theta}_i - [\tilde{e}_{it}^{\mathbf{P}}(1)-\tilde{e}_{it}^{\mathbf{P}}(0)]), \tag{15}$$

where $\tilde{\mathbf{z}}_{it}^{\mathbf{P}}(Y_{it})$ is the sum of expected $\mathbf{z}_{it}^{\mathbf{P}}(Y_{it})$ in each period discounted by the discount factor. The details of derivation of Eq. (15) are provided in the Appendix.

Following this, we obtain the final MPE $\boldsymbol{\sigma}^*$:

$$\begin{aligned} P_s(\mathbf{X}_t) &= F([\tilde{\mathbf{z}}_{st}^{\mathbf{P}}(1)-\tilde{\mathbf{z}}_{st}^{\mathbf{P}}(0)]\,\boldsymbol{\theta}_s - [\tilde{e}_{st}^{\mathbf{P}}(1)-\tilde{e}_{st}^{\mathbf{P}}(0)]) \\ P_n(\mathbf{X}_t) &= F([\tilde{\mathbf{z}}_{nt}^{\mathbf{P}}(1)-\tilde{\mathbf{z}}_{nt}^{\mathbf{P}}(0)]\,\boldsymbol{\theta}_n - [\tilde{e}_{nt}^{\mathbf{P}}(1)-\tilde{e}_{nt}^{\mathbf{P}}(0)]) \end{aligned} \tag{16}$$

After specifying the model, we can use Nested Pseudo Likelihood (NPL) to estimate the results. The model has been expanded to consider all the markets in the following derivations. When $\mathbf{P}$ is the CCP of players to set up a new outlet, the pseudo log-likelihood follows[12]:

$$Q(\boldsymbol{\theta},\mathbf{P}) = \sum_{m=1}^{M}\sum_{i=s,n}\sum_{t=1}^{T}\{ Y_{imt}\ln G_i([\tilde{\mathbf{z}}_{imt}^{\mathbf{P}}(1)-\tilde{\mathbf{z}}_{imt}^{\mathbf{P}}(0)]\boldsymbol{\theta}_i-[\tilde{e}_{imt}^{\mathbf{P}}(1)-\tilde{e}_{imt}^{\mathbf{P}}(0)] \\ + (1-Y_{imt})\ln(1-G_i([\tilde{\mathbf{z}}_{imt}^{\mathbf{P}}(1)-\tilde{\mathbf{z}}_{imt}^{\mathbf{P}}(0)]\boldsymbol{\theta}_i-[\tilde{e}_{imt}^{\mathbf{P}}(1)-\tilde{e}_{imt}^{\mathbf{P}}(0)]))\} \quad (17)$$

where m represents different markets.

We use $P(Y_i=1|\mathbf{X})$ as the initial $\mathbf{P}$, which is calculated by:

$$\hat{P}_i^0(\mathbf{X})=\frac{\sum_{m=1}^{M}\sum_{t=1}^{T}Y_{imt}1\{\mathbf{X}_{mt}=\mathbf{X}\}}{\sum_{m=1}^{M}\sum_{t=1}^{T}1\{\mathbf{X}_{mt}=\mathbf{X}\}} \quad (18)$$

From the initial $\mathbf{P}$, we will get a $\hat{\boldsymbol{\theta}}$ after maximizing pseudo log-likelihood, and $\hat{\boldsymbol{\theta}}$ can be used to obtain a new $\hat{\mathbf{P}}$:

$$\hat{\boldsymbol{\theta}}^K=\arg\max Q(\hat{\boldsymbol{\theta}},\hat{\mathbf{P}}^{K-1}) \\ \hat{P}_i^K(\mathbf{X}_t)=G_i\left(\left[\tilde{\mathbf{z}}_{it}^{\hat{\mathbf{P}}^{K-1}}(1)\text{-}\tilde{\mathbf{z}}_{it}^{\hat{\mathbf{P}}^{K-1}}(0)\right]\hat{\boldsymbol{\theta}}^K-\left[\tilde{e}_{it}^{\hat{\mathbf{P}}^{K-1}}(1)-\tilde{e}_{it}^{\hat{\mathbf{P}}^{K-1}}(0)\right]\right) \quad (19)$$

Through this iteration process, the result will approach $(\hat{\boldsymbol{\theta}}^*,\hat{\mathbf{P}}^*)$ when K reaches infinity; they satisfy:

$$\hat{\boldsymbol{\theta}}^*=\arg\max Q(\hat{\boldsymbol{\theta}},\hat{\mathbf{P}}^*) \\ \hat{P}_i^*(\mathbf{X}_t)=G_i\left(\left[\tilde{\mathbf{z}}_{it}^{\hat{\mathbf{P}}^*}(1)\text{-}\tilde{\mathbf{z}}_{it}^{\hat{\mathbf{P}}^*}(0)\right]\hat{\boldsymbol{\theta}}^*-\left[\tilde{e}_{it}^{\hat{\mathbf{P}}^*}(1)-\tilde{e}_{it}^{\hat{\mathbf{P}}^*}(0)\right]\right) \quad (20)$$

Up to this point, we have constructed the model and illustrated the estimation method and procedure. The next section will report our empirical findings.

[12] The pseudo log-likelihood is similar to the log-likelihood function of Bernoulli distribution. The pdf of a Bernoulli distribution is $f_X(p)=p^x(1-p)^{1-x}$ and the log-likelihood function is $\ln L(p;x)=\sum x\ln p+\sum(1-x)\ln(1-p)$.

5. Estimated Results

5.1 Summary Statistics

We first present some market and demographic factors for our dataset. Table 1 shows the summary statistics of the data used in this study. There are 4836 observations in the current dataset, as there are 403 markets and each market spans 12 years. There are on average 0.78 outlets of 7-11, and 6.4% with a new 7-11 outlet entry in each market. On the other hand, the average number of non 7-11 CVS outlets is 1.08, 8.6% of which are new outlet entries in each market. For the demographic part, there are 5948 residents in each market where the males are less than the females (male 49%). 15.8% of the population are under the age of 15 and 12.2% of the population are over 65. There are 2.76 people in each household. Each household has an average disposable income of 1.25 million NT dollars. Moreover, the average schooling years are 13.6 years. The bottom of Table 1 indicates the information of the landmarks. The landmarks serve to capture the influences of custom traffics beyond those of demographic variables.

Table 1: Summary statistics for the data

Variable	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**
7-11 Outlet	4,836	0.7878	0.8381	0	6
7-11 Entry	4,836	0.0641	0.2450	0	1
Non 7-11 Outlet	4,836	1.0856	1.0468	0	9
Non 7-11 Entry	4,836	0.0866	0.2813	0	1
Population	4,836	5,948	1,926	1,051	14,495
Male	4,836	0.4931	0.0210	0.4244	0.5707
Young	4,836	0.1578	0.0373	0.0781	0.3119
Old	4,836	0.1224	0.0297	0.0425	0.2739
Household size	4,836	2.7596	0.1264	2.4962	2.9464
Year of Schooling	4,836	13.5745	0.6617	12.3928	14.7846
Disposable Income	4,836	1,254,158	115,042	1,017,564	1,460,448
Elementary School	4,836	0.3350	0.5267	0	2
Junior High School	4,836	0.1464	0.3673	0	2
Senior High School and Vocational School	4,836	0.1489	0.3956	0	2
University	4,836	0.0819	0.3462	0	3
Department Store	4,836	0.0471	0.2641	0	3
Hospital	4,836	0.0620	0.2412	0	1
Tourist Attraction	4,836	0.0744	0.2979	0	2

Table 2 shows the distributions of CVS outlets by different companies in each market. Most of the markets contain no more than four 7-11 outlets and five non 7-11 outlets. As we can see in Table 2, the numbers of the 7-11 and non7-11 outlets are highly correlated. It implies that the location strategies of these two groups are dependent on each other.

Table 2: Number of outlets by CVS chains (7-11 vs. non 7-11)

non 7-11 7-11	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	494	904	361	122	22	17	0	0	0	0
1	668	748	416	110	20	2	0	0	0	0
2	186	267	181	73	41	2	0	0	0	0
3	19	52	49	14	16	8	5	0	0	0
4	3	11	3	2	1	5	4	1	1	0
5	0	0	0	0	0	1	0	0	0	4
6	0	0	0	0	0	0	1	0	0	2

5.2 Empirical Results

In this section we turn our attention to a discussion on the empirical results. Table 3 reports the results of the NPL regression. It indicates that all demographic variables except "Disposable Income" have a negative influence on the CVS profits. As for landmark variables, almost all of them have a positive influence on the profits of CVS.

Table 3: Estimated results of the demographic and landmark variables

	Parameter	Estimate	S.E.	t-ratio
Demographic	Male (%)	-0.0696	0.0456	-1.5250
	Household Size	-0.0057	0.0050	-1.1290
	Year of Schooling	-0.0014	0.0021	-0.6875
	Disposable Income	8.50E-09	1.30E-08	0.6546
Landmark	Elementary School	-0.0006	0.0010	-0.6432
	Junior High School	0.0006	0.0015	0.3908
	Senior High School and Vocational School	0.0007	0.0013	0.5047
	University	0.0057	0.0016	3.5660
	Department Store	0.0007	0.0020	0.3758
	Hospital	0.0003	0.0022	0.1219
	Tourist Attraction	0.0028	0.0018	1.5120

The ratio of male population has a negative impact on the CVS profits, i.e. the female population has a positive impact. Indeed, plenty of CVS products target female customers. For example, the CVS food is appealing to females in order to control the calories intake because the CVS food is usually small size and with calories labeled. Also, buying things in a cozy place is more important than a low price for females.

Household size has a negative influence on the profit of CVSs. It may be because larger households are more likely to cook by themselves instead of consuming CVS food as meals. The average years of schooling decreases the profits. It is likely that higher education attainment discourages people from eating microwaved food. Household disposable income has a negative effect on the profits, which implies that CVS products are inferior goods.

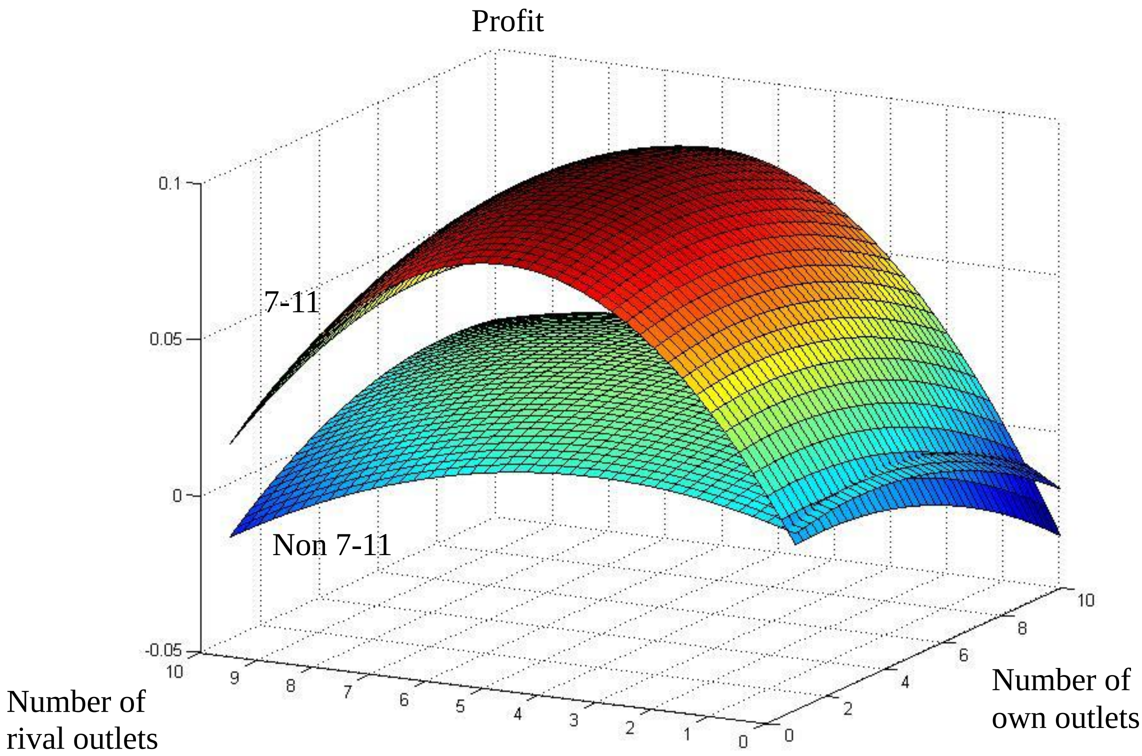
Almost every landmark variable has a positive influence on the profits of CVS. The results are intuitively reasonable. The landmarks bring the crowds to the areas, increasing the potential customers of the CVSs, and end up raising the profits of CVS. However, elementary school has a negative impact on the profits. It may be because students in elementary school generally lack purchasing power. Furthermore, they do not have many opportunities to eat out on their own.

Table 4: Estimated results of the outlet number variables

Parameter	Corresponding State Variable	7-11	Non 7-11
θ_0	$S_t 1\{X_{it}+Y_{it}>0\}$	+	+
θ_1	$S_t(X_{it}+Y_{it})$	+	+
θ_2	$S_t(X_{jt}+Y_{jt})$	+	+
θ_3	$S_t(X_{it}+Y_{it})^2$	-	-
θ_4	$S_t(X_{jt}+Y_{jt})^2$	-	-
θ_5	$S_t(X_{it}+Y_{it})(X_{jt}+Y_{jt})$	+	+

Table 4 shows the influences of outlet numbers and entries on the profits. For both the 7-11 and non 7-11 outlets, the square of the outlet numbers has a negative impact, while all the other variables have positive influences. To illustrate the implications in Table 4, we draw some associated graphs in the following. Figure 5 displays the estimated profits functions of both companies using the 10 coefficients shown in Table 4. Both profit functions are hill-shaped surfaces. The 7-11 profit function is generally higher than that of the non 7-11 CVS.

Figure 5: Impact of the number of outlets on profit of CVS companies



We mentioned above that a company's profit is related to the number of its own and rival outlets. With various ranges of outlet numbers, the numbers may have different effects on profits, called the complement effect and substitution effect.

First, the complement effect is positive. The increase of rival outlets attracts the companies to set up a new outlet because the rival outlets may bring external benefits. On the one hand, the companies achieve economies of agglomeration when the number of CVS outlets increases in a certain market. When the rival outlets enter and stay in the market, it implies that the location is appropriate to operate a CVS.

Second, the substitution effect is negative. The companies have no incentive to set up a new outlet when the number of rival outlets increases because the market is too competitive. Too many CVS outlets in one market are likely to reduce the profit of each outlet.

Figure 6 shows that complement effect is stronger at first; the two profit curves both rise. Then they reach maximum points and fall afterward because the substitution effect starts to surpass the complement effect. The 7-11 profit is overall higher than the non 7-11 CVS's, which implies that 7-11 is a dominant CVS. The optimal numbers of own and rival outlets can be determined by maximizing the profit of CVS outlets. Figure 6 shows that 7-11 is most profitable in a market with four non 7-11 CVS outlets, while the non 7-11 CVSs are the most profitable in a market with two rival (7-11) outlets.

Figure 6: Impact of the number of rival outlets on profit of CVS companies when the number of own outlets equals 1

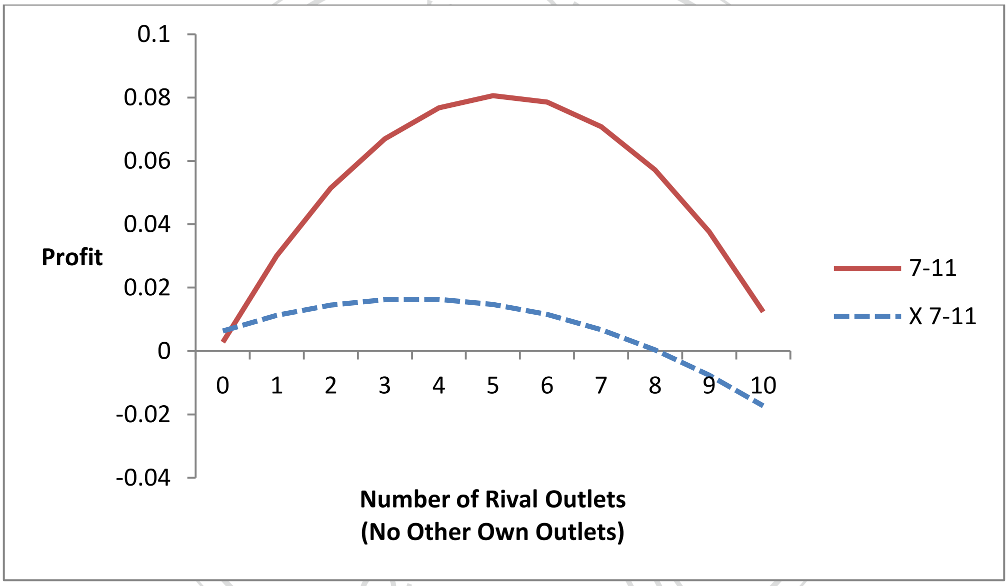
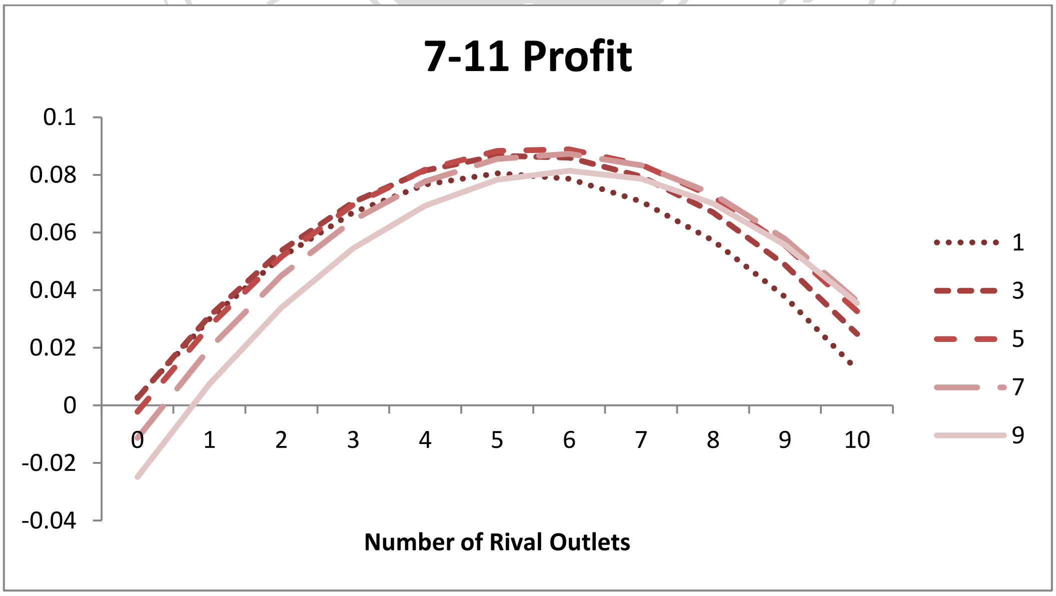


Figure 7 lists the optimal number of rival outlets. 7-11 is able to compete with 5 rival outlets successfully when it has no more than 4 outlets in the market. However, the 7-11 could only beat 6 rival outlets at most as its own outlets increase. When the non 7-11 CVS has no more than 3 outlets in the market, it is able to compete with 4 rival outlets successfully. As the number of outlets increases, the market becomes more competitive and the companies compete with more rival outlets. Figure 7 demonstrates that 6 and 7 are the maximum numbers of rival outlets for the 7-11 and non 7-11 companies, respectively. A company could not earn the maximum profit in any market where the rival outlets exceed the maximum numbers.

Figure 7: The number of rival outlets which maximizes the profit, given the number of own outlets

7-11		Non 7-11	
Number of 7-11 outlets	Rival Outlets at maximum	Number of Non7-11 outlets	Rival Outlets at maximum
1	5	1	4
2	5	2	4
3	5	3	4
4	5	4	5
5	6	5	5
6	6	6	5
7	6	7	6
8	6	8	6
9	6	9	7
10	6	10	7

Figure 8: Impact of the number of rival outlets on profit of 7-11



In Figure **8** and Figure **9**, curves with different colors show the CVS's profits with different numbers of own outlets. These profit curves have similar shapes. As the number of the own outlets increases, the profit curve shifts rightward in the horizontal direction; it first moves upward and then downward in the vertical direction. The horizontal shift is due to the changing positions of the maximum points explained previously. On the other hand, the vertical shift results from the hill-shape profit curve in Figure 10, which is viewed from a different axis.

Figure 9: Impact of the number of rival outlets on profit of non 7-11 CVS

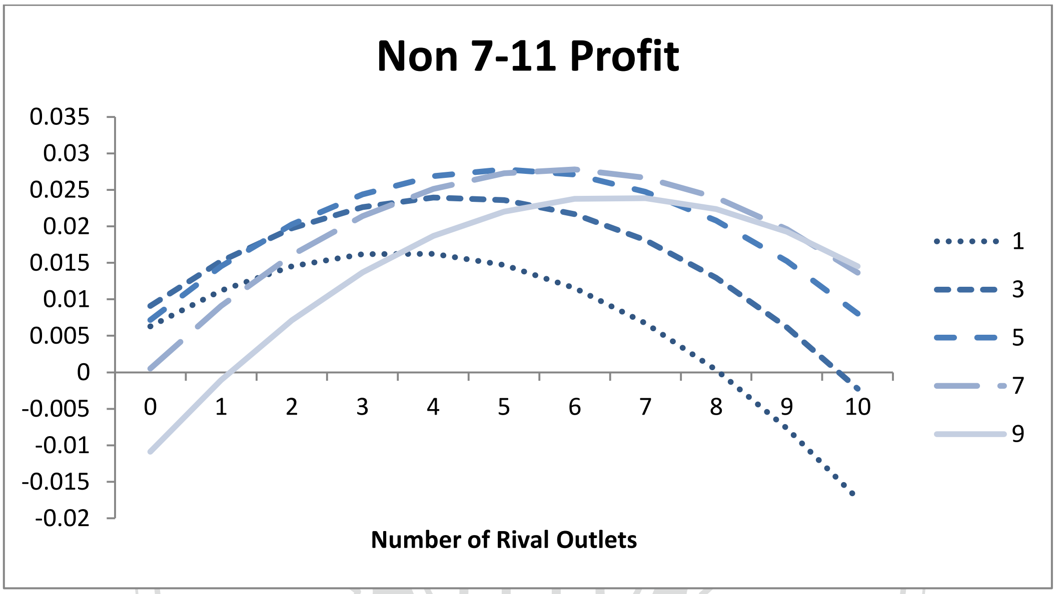
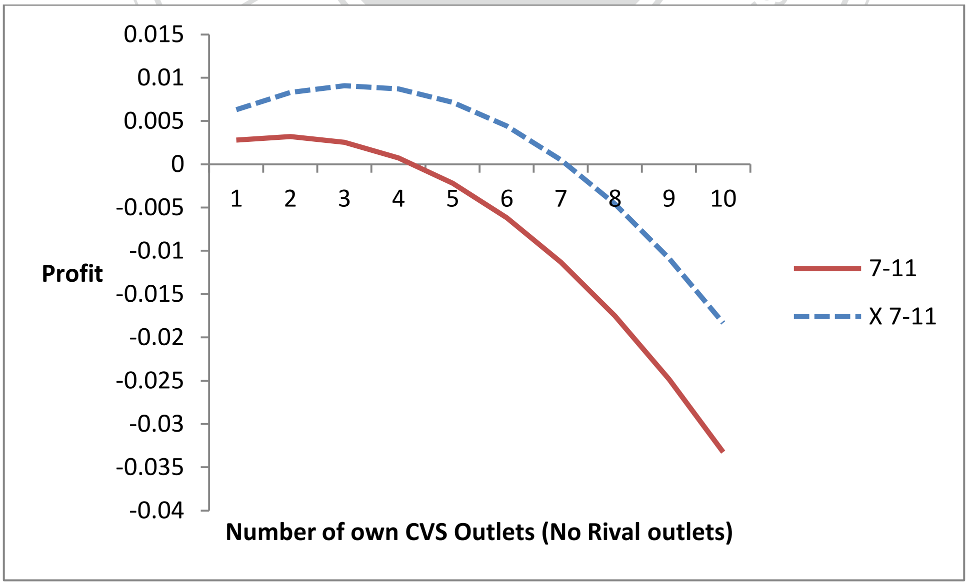


Figure 10: Impact of the number of own outlets on profit of CVS companies



The shape of the curves in Figure 10 is also due to the complement effect and substitution effect. At first, the complement effect is obvious. A CVS company is willing to open new outlets in order to achieve economies of agglomeration. However, the profits decrease when the substitution effect becomes stronger than the complement effect. Diseconomies of scale occur because there are too many outlets. Figure 10 also shows that the 7-11 profits are higher overall than the non 7-11 CVS profits.

The maximum points here imply the best strategies for CVS companies to set up outlets. Figure 10 reveals that when there are no rival outlets, setting up three outlets maximizes the 7-11 profits, while setting up five outlets maximizes the non 7-11 CVS profit.

Figure 11: The number of own outlets maximizing the profit, given the number of rival outlets

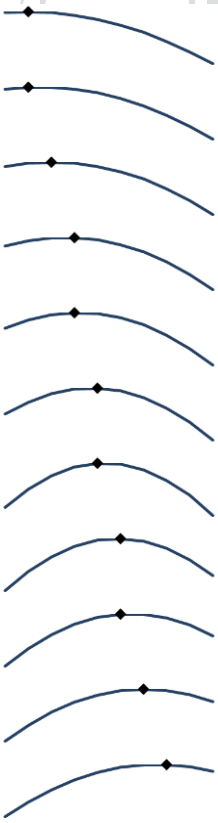
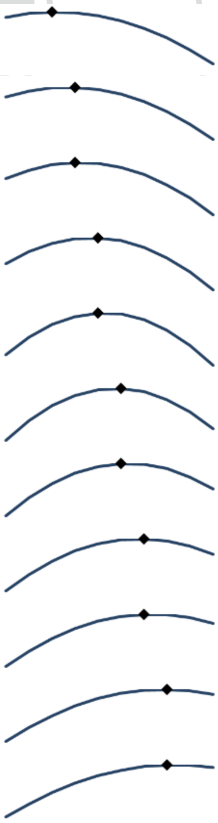
7-11			Non 7-11		
Number of Rival outlets		Own CVS Outlets at maximum	Number of Rival outlets		Own CVS Outlets at maximum
0		2	0		3
1		2	1		4
2		3	2		4
3		4	3		5
4		4	4		5
5		5	5		6
6		5	6		6
7		6	7		7
8		6	8		7
9		7	9		8
10		8	10		8

Figure 11 illustrates the number of the own CVS outlets at maximum points. When there is 1 non 7-11 CVS outlet in the market, the best strategy for the 7-11 is to set up 2 outlets because 2 outlets maximize its profits. As the number of rival outlets increases, it has to set up more outlets to maximize the profit. When there is 1 7-11 outlet in the market, the best strategy for the non 7-11 CVS is to set up 4 outlets. It also has to set up more outlets to maximize the profit as the number of rival outlets increases. Because 7-11 is a dominant company in the market, the best strategy for the 7-11 is to set up fewer outlets than the non 7-11 CVS when facing the same number of rival outlets.

Figure 12: Impact of the number of own outlets on profit of 7-11

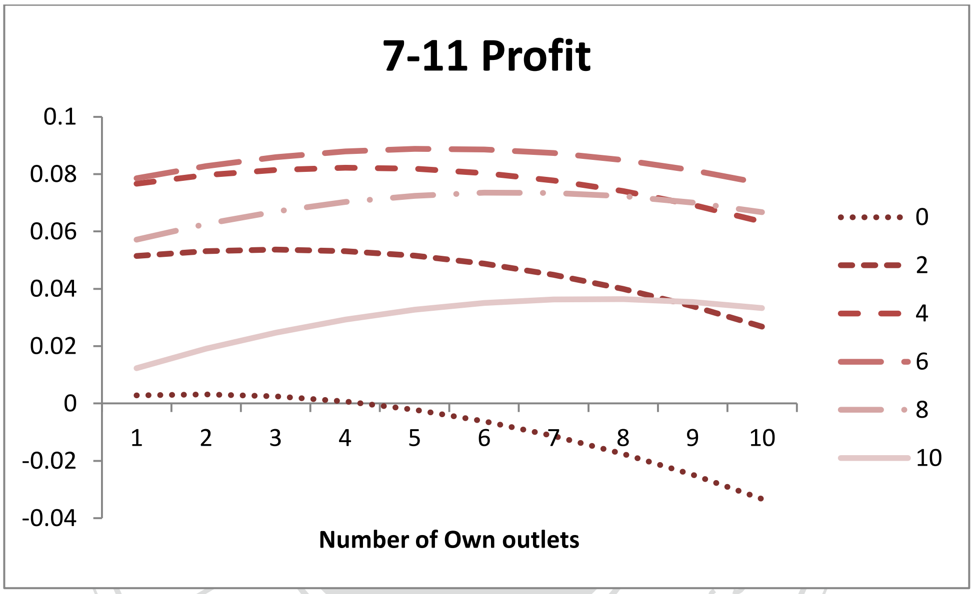
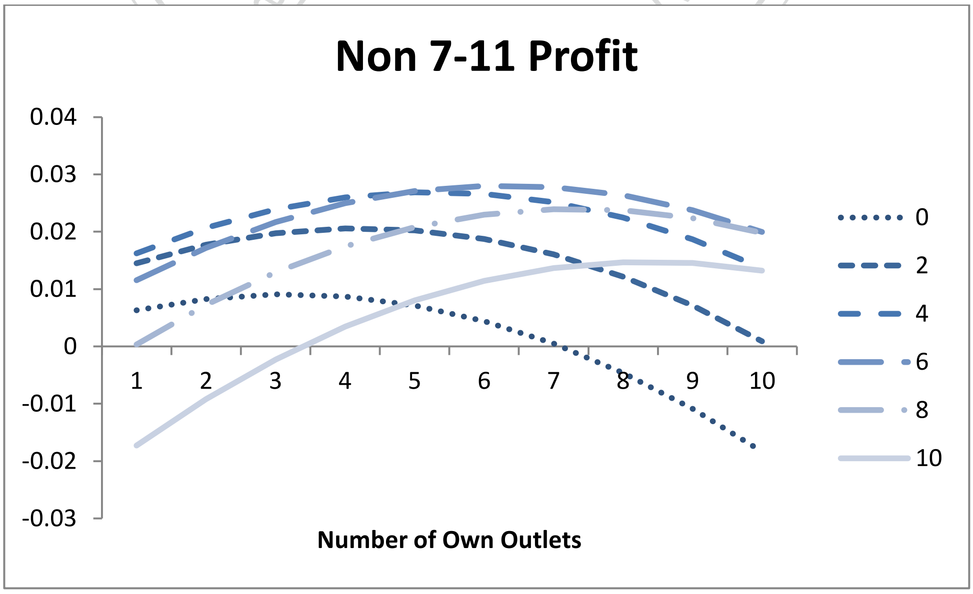


Figure 13: Impact of the number of own outlets on profit of non 7-11 CVS



Similarly, Figure 12 andFigure **13** show CVS's profits given different number of rival outlets. These profit curves have similar shapes. As the number of the own outlets increases, the profit curves shift rightward in the horizontal direction, and first upward and then downward in the vertical direction. The horizontal shift is due to the changing positions of the maximum point explained previously. The vertical shift results from the hill-shape of profit curve in Figure 6, which is viewed from a different axis.

We use the development of the CVS in remote islands (Kinmen, Penghu and Green Island) off Taiwan as an example to explain our results. 7-11 set up the first outlet in Kinmen in 1999. Now, there are sixteen 7-11 outlets. 7-11 is a dominant company, and has operated in the area since 1999. It seems that non 7-11 CVS companies have no incentive to enter Kinmen. However, the first outlet of Hi-Life opened in Kinmen in 2014. In addition, Hi-Life plans to set up 7 to 9 outlets in Kinmen. It implies that the complement effects due to rival outlets are obvious when the number of CVS outlets is not large enough, as shown in our previous estimated results. The situations in Penghu and in Green Island are very similar. 7-11 is the first CVS company to enter these two markets, followed by a non 7-11 CVS company (FamilyMart).

There are 4836 entry opportunities in the dataset. We can estimate the 4836 probabilities of CVS companies entering the markets by using the coefficients in Table 3. In other words, we may compute the corresponding probability that CVS companies will set up new outlets in each market over time. As a result, we can compute the probabilities that CVS companies will set up at least one outlet in the districts over time. The probabilities of entering the districts are calculated with the probabilities to enter the markets (villages):

$$P_{idt} = 1 - \prod_{m=1}^{M_d} (1 - P_{imt}), \qquad (21)$$

where d represents 12 districts in Taipei; $i \in \{s, n\}$ represents the CVS companies; M_d represents the number of markets in district d.

The results are shown in Figure 14 and Figure 15. Figure 14 reports that Zhongshan, Da'an and Xinyi are the top 3 districts that the 7-11 are most eager to enter, while Nangang, Datong and Wanhua are the last 3 districts that the 7-11 wants to enter. In addition, Figure 15 reports that Da'an and Zhongshan are the top 2 districts that the non 7-11 CVSs are most eager to enter, while Nangang, Datong and Wanhua are the last 3 districts that the non 7-11 CVSs want to enter.

Figure 14: Probabilities that 7-11 will enter the districts over time

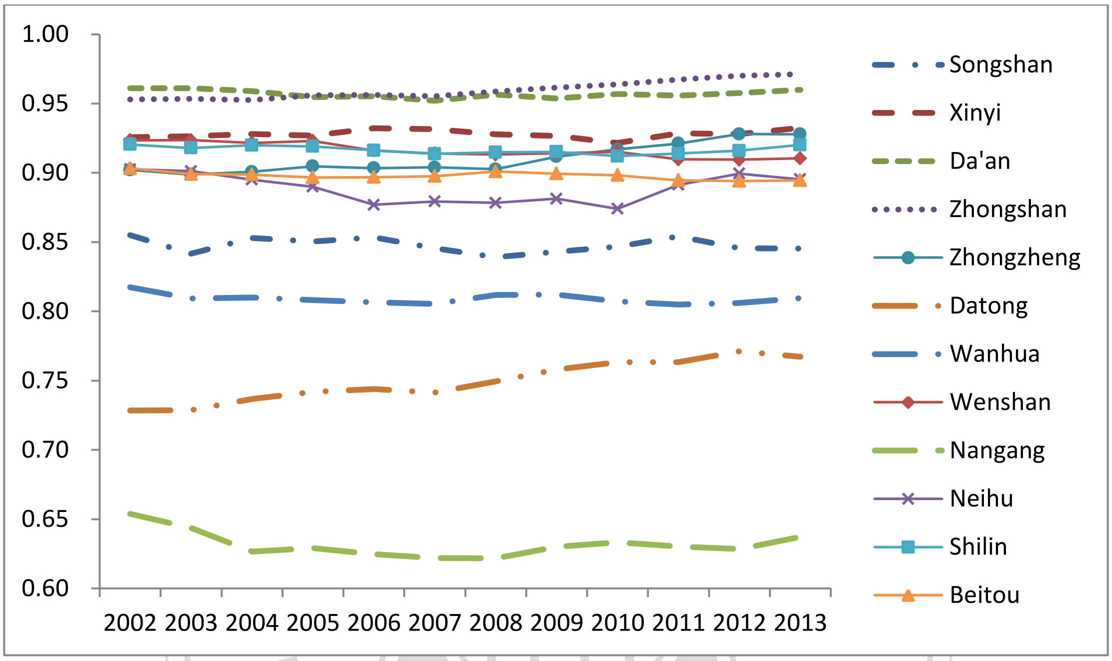
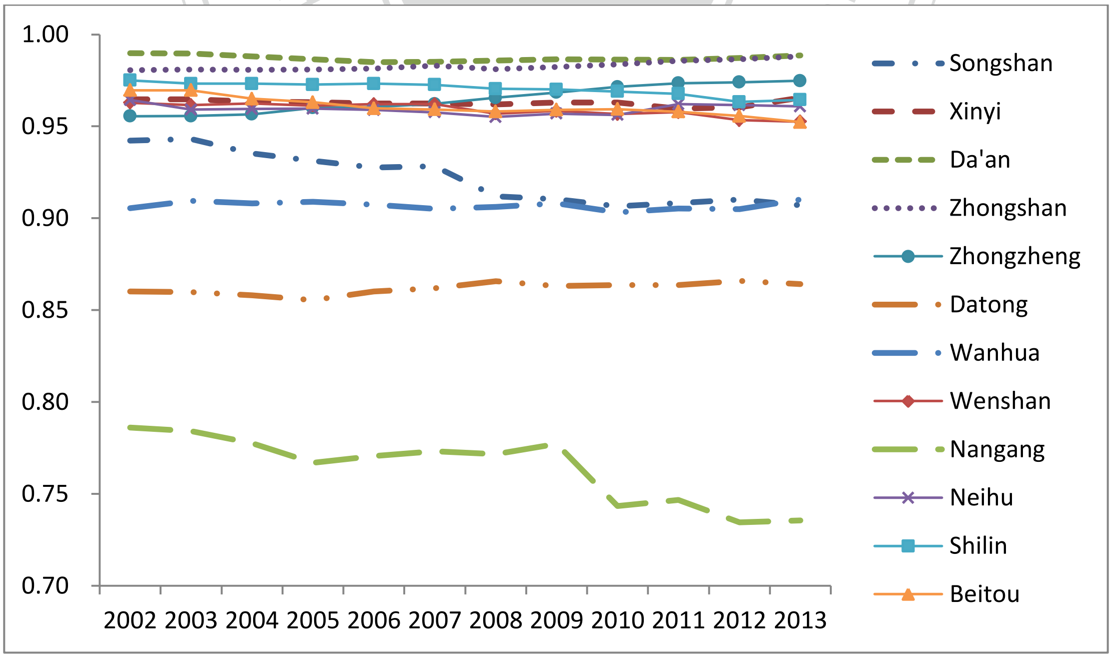


Figure 15: Probabilities that non 7-11 CVS will enter the districts over time



In order to check whether the estimated probabilities fit the data, we ran a paired-t test. Table 5 shows that p-value equals 0.6212. Hence, we could not reject the hypothesis that the difference between two samples is zero. The estimated CCP are not significantly different from the data used in this study.

Table 5: Paired-t test

Ho: mean(diff) = 0	degrees of freedom = 287
Ha: mean(diff) != 0	Pr(|T| > |t|) = 0.6529

5.3 Related Literature

Some studies also examine the entry decisions of retail chains: Toivanen and Waterson (2005) and Yang (2012) on the UK fast food industry and Nishida (2008) on the convenience store industry in Okinawa, Japan. They all analyze the relationship between the profits and the outlet numbers (including own outlets and rival outlets). Our results are consistent with the conclusion that the numbers of outlets do affect retail chain companies' entry decisions.

However, the influences of the outlet numbers are monotonic in their papers. In our research, we adopt a quadratic form to measure the influence of the outlet numbers. The influences are positive when outlet numbers are small, but negative when the outlet numbers are large. The nonlinear profit functions in the outlet numbers allow us to measure the influences more precisely.

6. Conclusion

In this thesis, we investigated how the number of CVS outlets influences the entry decisions in Taipei, Taiwan. To this end, we constructed a dynamic discrete model and then estimated the entry decisions with the nested pseudo likelihood (NPL) method. In particular, we derived the CVS profit functions which enable us to estimate the probabilities that CVS companies will set up a new outlet in the market. When the number of outlets is small, the CVS profits rise as the outlet numbers increase because complement effects are larger than the substitution effects. In contrast, the CVS profits decrease when the number of outlets is large enough.

The number of outlets resulting in the maximum profits indicates that the markets are in an optimal situation for the CVS companies. If the outlet number is more than an optimal one, the markets are severely competitive. Our empirical results show that for a given number of own outlets, on average, the optimal number of rival outlets is five in a typical market. On the other hand, the optimal number of own outlets continually increases when the number of rival outlets is larger. In our empirical setting, the nonlinear profit functions allow us to measure the influences of outlet numbers more precisely.

In future work, much of the existing research on the influences of outlet numbers on the entry decisions may use models with two players. To improve our empirical results, models with more players in the markets are needed because the duopoly is merely a particular example of oligopoly markets. An extended model to deal with more than two companies would contribute to a better understanding of the imperfectly competitive CVS industry in Taipei City. In addition, an analysis of the whole CVS industry in Taiwan will be possible as well after more data are collected. In addition, more studies within a unified framework are needed to analyze entry and exit decisions. Although simultaneously considering entry and exit would make models much more complex, the unified framework would shed new light on the entry and exit dynamics of firms in the imperfectly competitive markets.

7. References

Aguirregabiria, V. (2009). *Estimation of Dynamic Discrete Games Using the Nested Pseudo Likelihood Algorithm: Code and Application.* Mimeo, University of Toronto.

Aguirregabiria, V. and Ho, C.-Y. (2010). *A dynamic game of airline network competition: Hub-and-spoke networks and entry deterrence.* International Journal of Industrial Organization, 28, 377-382.

Aguirregabiria, V. and Mira, P. (2007). *Sequential estimation of dynamic discrete games.* Econometrica 75, 1-53.

Bajari, P., L. Benkard and J. Levin (2007). *Estimating dynamic models of imperfect competition.* Econometrica 75, 1331-1370.

Beresteanu, A., and P. B. Ellickson (2006). *The Dynamics of Retail Oligopoly.* Mimeo, Duke University.

Chen, Y.-C. (2013, July 31). *7-11 knocks down McDonald's even though it has no kitchens.* WEALTH MAGZINE, Taiwan. Retrieved from https://www.wealth.com.tw/

Data.Taipei (2010). *The Map of Village Border in Taipei City. The landmark data in Taipei City.* Retrieved from http://www.taipei.gov.tw/

Department of Budget, Accounting and Statistics, Taipei City Government (2002-2013). *Report on the Family Income and Expenditure Survey in Taipei.* Retrieved from http://www.dbas.taipei.gov.tw/

Department of Civil Affairs, Taipei City Government (2002-2013). Retrieved from http://www.ca.taipei.gov.tw/

Jhang, J.-L. (2013 March 4). *Convenience stores industry is China is endangered, nearly hundred stores are shut down in Shanghai.* Apple Daily, Taiwan. Retrieved from http://www.appledaily.com.tw/

Jung, C.-T., Sun, C.-H. and Lee, W.-K. (2005). *Spatial Data Mining on Census Data—A Case Study for Location Analysis of Convenience Stores in Taipei City.* Journal of Taiwan Geographic Information Science (2), 45-56.

Li, Y.-Z. (1991). *An analysis of location decisions of convenience store chains.* M.A.

thesis, National Cheng Kung University, Tainan, Taiwan.

Lin, J.-J. (2014, February 28). *Soft serve on fire, the stock values of FamilyMart supasses that of 7-11*. Commercial Times, Taiwan. Retrieved from http://ctee.com.tw/

Luo, L.-R. (2002). *The Evaluation Model of Convenience Chain Store''s Site Selection ∶ A Fuzzy AHP Approach.* M.A. thesis, National Cheng Kung University, Chiayi, Taiwan.

Mazzeo, M. (2002). *Product Choice and Oligopoly Market Structure*. RAND Journal of Economics, 33.

Ministry of Finance (1987-2013). Operation Registration Database. Retrieved from http://www.etax.nat.gov.tw/

Netz, J., and B. Taylor (2002). *Maximum or Minimum Differentiation? Location Patterns or Retail Outlets.* Review of Economics and Statistics, 84, 162–175.

Nishida, Mitsukuni (2012). *Estimating a Model of Strategic Network Choice: The Convenience-Store Industry in Okinawa.* NET Institute Working Paper 8 (27).

Smith, H.W. (2004). *Supermarket Choice and Supermarket Competition in Market Equilibrium.* Review of Economic Studies, vol. 71, 235-263.

Thomadsen, R. (2007). Product Positioning and Competition: The Role of Location in the Fast Food Industry. Marketing Science, vol. 26, iss. 6, 792–804.

Toivanen, O., and M. Waterson (2005). *Market Structure and Entry: Where's the Beef?.* RAND Journal of Economics, 36(3), 680-699.

Wang, S.-H., Lin, I-C., Chen, C.-Y., Chen, D.-R., Chan, T.-C. and Chen, W. J. (2013). *Availability of convenience stores and adolescent alcohol use in Taiwan: a multi-level analysis of national surveys.* Addiction, vol. 108, iss. 12, 2081-2088.

Yang, Nathan (2012). *Burger King and McDonald's: Where's the Spillover?.* International Journal of the Economics of Business, vol. 19, iss. 2.

8. Appendix

Proof of Proposition 1

The market demand Q_t can be expressed as a function of market size S_t and net market demand $D(P_t)$, which depends only on prices:

$$Q_t = S_t(a - bP_t) = S_t D(P_t) = q_{it} + q_{jt}, \qquad \text{A.1}$$

q_{it} and q_{jt} are quantities sold by firm i and j, respectively, which can be expressed as multiples of market size as well: $q_{it} = S_t d_{it}$, $q_{jt} = S_t d_{jt}$,

where d_{it} is the net quantity produced by firm i.

Profit π_{it} is equal to the total revenue $P_t \times q_{it}$ minus the total cost $MC_{it} \times q_{it}$. By using the substituting method, π_{it} can be written as S_t multiplying the expression consisting of d_{it}, d_{jt} and MC_{it}:

$$\pi_{it} = (P_t - MC_{it})q_{it} = (P_t - MC_{it})S_t d_{it} = S_t(D^{-1}(d_{it} + d_{jt}), -MC_{it})d_{it} \qquad \text{A.2}$$

It is known that $MC_{it} = MC(X_{it} + Y_{it})$, so the first order condition of (A.2) implies that the net quantity d_{it} is a function of $X_{it} + Y_{it}$ and $X_{jt} + Y_{jt}$, i.e. $d_{it} = d_{it}(X_{it} + Y_{it}, X_{jt} + Y_{jt})$. As a result, the variable profit can be expressed by the product of market size and a function of $X_{it} + Y_{it}$ and $X_{jt} + Y_{jt}$:

$$\pi_{it} = S_t V(X_{it} + Y_{it}, X_{jt} + Y_{jt}) \qquad \text{A.3}$$

We can let $V(X_{it} + Y_{it}, X_{jt} + Y_{jt})$ be in a quadratic form from (A.2). Furthermore, the net profit function of firm i is $\Pi_{it} = \pi_{it} - Y_{it}\varepsilon_{it}$. As a result, the net profit function is specified as:

$$\begin{aligned}\Pi_{it} = {} & S_t\{ \theta_{0i}1\{X_{it}+Y_{it} > 0\} + \theta_{1i}(X_{it}+Y_{it}) + \theta_{2i}(X_{jt}+Y_{jt}) + \theta_{3i}(X_{it}+Y_{it})^2 \\ & + \theta_{4i}(X_{jt}+Y_{jt})^2 + \theta_{5i}(X_{it}+Y_{it})(X_{jt}+Y_{jt}) \} - Y_{it}\varepsilon_{it},\end{aligned} \qquad \text{A.4}$$

where $1\{.\}$ is an indicator function.

Finally, factoring out the right hand side yields:

$$\begin{aligned}\Pi_{it} = {} & \theta_{0i}S_t 1\{X_{it}+Y_{it} > 0\} + \theta_{1i}S_t(X_{it}+Y_{it}) + \theta_{2i}S_t(X_{jt}+Y_{jt}) + \theta_{3i}S_t(X_{it}+Y_{it})^2 \\ & + \theta_{4i}S_t(X_{jt}+Y_{jt})^2 + \theta_{5i}S_t(X_{it}+Y_{it})(X_{jt}+Y_{jt}) - Y_{it}\varepsilon_{it}\end{aligned} \qquad \text{A.5}$$

(A.5) is exactly the same as Eq. (6) in Section 4.

Proof of Proposition 2

The function of CCP considering the future profits is:

$$P_i(\mathbf{X}_t) \;=\; F([\tilde{\mathbf{z}}^{\mathbf{P}}_{it}(1) - \tilde{\mathbf{z}}^{\mathbf{P}}_{it}(0)]\,\boldsymbol{\theta}_i - [\tilde{e}^{\mathbf{P}}_{it}(1) - \tilde{e}^{\mathbf{P}}_{it}(0)]), \qquad \text{A.6}$$

where $\tilde{\mathbf{z}}^{\mathbf{P}}_{it}(Y_{it})$ is the sum of expected $\mathbf{z}^{\mathbf{P}}_{it}(Y_{it})$ in each period discounted by the discount factor β:

$$\tilde{\mathbf{z}}^{\mathbf{P}}_{it}(Y_{it}) \equiv \mathbf{z}^{\mathbf{P}}_{it}(Y_{it}) + E\left(\sum_{s=1}^{\infty} \beta^s \mathbf{z}^{\mathbf{P}}_{it+s}(Y_{it+s}) \mid \mathbf{X}_t, Y_{it} \right) \qquad \text{A.7}$$

Similarly, $\tilde{e}^{\mathbf{P}}_{it}(Y_{it})$ is the sum of expected $e^{\mathbf{P}}_{it}(Y_{it})$ in each period discounted by the rate of time preference β:

$$\tilde{e}^{\mathbf{P}}_{it}(Y_{it}) \equiv E\left(\sum_{s=1}^{\infty} \beta^s \varepsilon_{it+s} Y_{it+s} \mid \mathbf{X}_t, Y_{it} \right) \qquad \text{A.8}$$

We assume that β is 0.975 in our model, which implies that the discount rate is about 2.56%. Next, $\tilde{\mathbf{z}}^{\mathbf{P}}_{it}(Y_{it})$ and $\tilde{e}^{\mathbf{P}}_{it}(Y_{it})$ can be written in the following ways:

$$\begin{aligned} \tilde{\mathbf{z}}^{\mathbf{P}}_{it}(Y_{it}) &\equiv \mathbf{z}^{\mathbf{P}}_{it}(Y_{it}) + \beta \sum_{\mathbf{X}_{t+1} \in \mathcal{X}} f_i^{\mathbf{P}}(\mathbf{X}_{t+1} \mid Y_{it}, \mathbf{X}_t) W^{\mathbf{P}}_{Zi}(\mathbf{X}_{t+1}) \\ \tilde{e}^{\mathbf{P}}_{it}(Y_{it}) &\equiv \beta \sum_{\mathbf{X}_{t+1} \in \mathcal{X}} f_i^{\mathbf{P}}(\mathbf{X}_{t+1} \mid Y_{it}, \mathbf{X}_t) W^{\mathbf{P}}_{ei}(\mathbf{X}_{t+1}), \end{aligned} \qquad \text{A.9}$$

where $W^{\mathbf{P}}_{Zi}(\mathbf{X}_t)$ and $W^{\mathbf{P}}_{ei}(\mathbf{X}_t)$ represent $E(\tilde{\mathbf{z}}^{\mathbf{P}}_{it}(Y_{it})|\mathbf{X}_t)$ and $E(\tilde{e}^{\mathbf{P}}_{it}(Y_{it})|\mathbf{X}_t)$, respectively, i.e. $W^{\mathbf{P}}_{Zi}(\mathbf{X}_t) \equiv (1 - P_i(\mathbf{X}_t))\tilde{\mathbf{z}}^{\mathbf{P}}_{it}(0) + P_i(\mathbf{X}_t)\tilde{\mathbf{z}}^{\mathbf{P}}_{it}(1)$, $W^{\mathbf{P}}_{ei}(\mathbf{X}_t) \equiv (1 - P_i(\mathbf{X}_t))\tilde{e}^{\mathbf{P}}_{it}(0) + P_i(\mathbf{X}_t)\tilde{e}^{\mathbf{P}}_{it}(1)$. Furthermore, $f_i^{\mathbf{P}}(\mathbf{X}_{t+1} \mid Y_{it}, \mathbf{X}_t)$ is the transition probability:

$$f_i^{\mathbf{P}}(\mathbf{X}_{t+1} \mid Y_{it}, \mathbf{X}_t) \equiv 1\{X_{it+1} = X_{it} + Y_{it}\} P_j(\mathbf{X}_t)^{1\{X_{jt+1} = X_{jt}+1\}} (1 - P_j(\mathbf{X}_t))^{1\{X_{jt+1} = X_j\}} \qquad \text{A.10}$$

When $W^{\mathbf{P}}_{Zi}(\mathbf{X}_t)$ and $W^{\mathbf{P}}_{ei}(\mathbf{X}_t)$ are written as matrices, the following equations hold:

$$\begin{aligned} \mathbf{W}^{\mathbf{P}}_{\mathbf{Z}i} &= (1 - \mathbf{P}_i) * \mathbf{Z}^{\mathbf{P}}_i(0) + \mathbf{P}_i * \mathbf{Z}^{\mathbf{P}}_i(1) + \beta \mathbf{F}^{\mathbf{P}}_{\mathbf{X}} \mathbf{W}^{\mathbf{P}}_{\mathbf{Z}i} \\ \mathbf{W}^{\mathbf{P}}_{ei} &= \boldsymbol{e}^{\mathbf{P}}_i + \beta \mathbf{F}^{\mathbf{P}}_{\mathbf{X}} \mathbf{W}^{\mathbf{P}}_{ei}, \end{aligned} \qquad \text{A.11}$$

where $\mathbf{W}^{\mathbf{P}}_{\mathbf{Z}i} \equiv \{W^{\mathbf{P}}_{Zi}(\mathbf{X}) : \mathbf{X} \in \mathcal{X}\}$, $\mathbf{W}^{\mathbf{P}}_{\boldsymbol{ei}} \equiv \{W^{\mathbf{P}}_{ei}(\mathbf{X}) : \mathbf{X} \in \mathcal{X}\}$. $\mathbf{Z}^{\mathbf{P}}_i(0)$ and $\mathbf{Z}^{\mathbf{P}}_i(1)$ are matrices containing $\mathbf{z}^{\mathbf{P}}_i(0)$ and $\mathbf{z}^{\mathbf{P}}_i(1)$ for the given state $\mathbf{X}_t$. " $*$ " represents element-by-element product. $\mathbf{F}_{\mathbf{X}}^{\mathbf{P}}$ is a transition matrix which transforms the s th element of $\mathbf{W}_{\mathbf{Z}i}^{\mathbf{P}}$ into the s' th element of expected value of $\mathbf{W}_{\mathbf{Z}i}^{\mathbf{P}}$, i.e.

$W_{Zi}^{\mathbf{P}}(\mathbf{X}_s) \rightarrow E[W_{Zi}^{\mathbf{P}}(\mathbf{X}_{s'})]$,

where $\mathbf{X}_{s'}$ is the set of all the possible next-period states of $\mathbf{X}_s$.

Accordingly, $W_{Zi}^{\mathbf{P}}(\mathbf{X}_t)$ and $W_{ei}^{\mathbf{P}}(\mathbf{X}_t)$ are calculated by the following equations:

$$\mathbf{W}_{\mathbf{Z}i}^{\mathbf{P}} = (\mathbf{I} - \beta \mathbf{F}_{\mathbf{X}}^{\mathbf{P}})^{-1}[(1-\mathbf{P}_i) * \mathbf{Z}_i^{\mathbf{P}}(0) + \mathbf{P}_i * \mathbf{Z}_i^{\mathbf{P}}(1)]$$
$$\mathbf{W}_{ei}^{\mathbf{P}} = (\mathbf{I} - \beta \mathbf{F}_{\mathbf{X}}^{\mathbf{P}})^{-1} \boldsymbol{e}_i^{\mathbf{P}}, \qquad \text{A.12}$$

where $\boldsymbol{e}_i^{\mathbf{P}} = \{\mathrm{E}(\varepsilon_{it} Y_{it} \mid \mathbf{X}_t, Y_{it} \text{ is optimal}) : \mathbf{X}_t \in \chi\}$ and $\mathbf{P}_i$ is a $|\chi| \times 1$ vector containing P_i. Because ε_{it} has a standard normal distribution as mentioned before, $\boldsymbol{e}_i^{\mathbf{P}}$ is specified as:

$$E(\varepsilon_{it} Y_{it} \mid \mathbf{X}_t, Y_{it} \text{ optimal}) = f(F^{-1}(P_i(\mathbf{X}_t))), \qquad \text{A.13}$$

where $f(.)$ and $F(.)$ are the PDF and the CDF of the standard normal distribution.