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The nonlinear effect of convenience stores on residential property prices: A case study of Taipei, Taiwan

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ABSTRACT

This paper examines the nonlinear effect of convenience stores on residential property prices. In the light of Andrews's (1964) argument, this study seeks to advance Rosen's (1974) hedonic housing analysis by hypothesizing that residents' attitudes towards the accessibility of facilities (i.e. convenience stores), which is attributed to the compactness of supply of the services they are interested in accessing while on the move, may further have impact on local property prices.

The application of Koenker and Bassett's (1978) quantile regression on the property data of Taipei found that 'availability' of convenience store is positively related to low-quantile property prices, while 'density' demonstrates a nonlinear effect – positively related to low-quantile property prices but negatively related to high-quantile property prices. The residents in the neighbourhoods with lower-priced property may prefer accessibility to convenience stores where they can complete multiple tasks in one go, while those in the neighbourhoods with higher-priced property may be more mobile to access convenience stores in other suburbs en route from one place to another.

Introduction

> "An estimated 100 million Americans visit a convenience store on any given day; … Over 80 percent of all Americans, because of their busy schedules, prefer convenience stores to supermarkets"
>
> Altizio & York, 2007: 2

The convenience store, from the perspective of hedonic housing theory, would be simply treated as a local facility, the effect of which would be measured in terms of the shortest distance (from a property to its nearest store) in ordinary least squares regression. Its positive relationship with property is generally assumed since the convenience store, an American invention for the explosion in suburban living after World War II, generally serves as a substitute for shopping centres and supermarkets, such as 7–11/Circle K in United States, Mini-Mart/Couche-Tard in Canada, Carrefour City in France, Best-One/One Stop in United Kingdom, and many other brands across countries. The introduction of B-to-C (business to consumer) e-commerce service through in-store multimedia kiosks in Japan and other countries transformed conventional convenience stores (i.e. gas-station shops) to modern convenience stores that offer not only food/snacks/drinks but also daily services, including basic printing/faxing, purchase of tickets (e.g. trains/buses, concerts or sport events), payment of bills (e.g. parking, insurance, or utilities), delivery services (combined with online orders)[1] and many others.

The prosperity of convenience stores in Western and Asian countries leads to abundant academic research in several domains, including: (1) information economy: the e-commerce collaboration between convenience stores and online retailers is widely discussed (Aoyama, 2001; Hsu & Huang, 2006), (2) allocation theory: where a new convenience store would be optimally allocated is examined (Sakashita, 2000; Wood & Browne, 2007); (3) criminology: why convenience stores may fall for opportunistic bait for robbery in United States is analyzed (Amandus, Hunter, James, & Hendricks, 1995; Petrosino & Brensilber, 2003), (4) dietary behaviour: the association between unhealthy dietary behaviours and geographic proximity to convenience stores is examined (Murakami, Sasaki, Takahashi, & Uenishi, 2009; Skidmore et al.,

[1] The cooperation of convenience stores (providing the delivery service) with online shopping retailers (handling the ordering and payment processes) allows a consumer to purchase items online and choose the convenience store where he then picks up the items.

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Table 1
Convenience stores in United States, Japan and Taiwan.

Country	United States	Japan	Taiwan
Land size (km^2)	9,826,675	377,915	35,980
Population	313,847,465	127,368,088	23,110,923
Number of convenience stores (nationwide)	149,220	46,905	9831
Convenience store per 100 km^2	2	12	27

2010). Despite its importance to local neighbourhoods, the convenience store is rarely taken as a key determinant to property prices in housing studies.

Here, an attempt is made to examine the nonlinear effect of convenience stores on different scales of property prices in the case of Taipei Metropolis through the application of Koenker and Bassett's (1978) quantile regression. Moreover, in the light of Andrews's (1964) argument, the *density* of convenience stores is further examined to advance the hedonic analysis of location on property prices by taking account of the possibility that what may shape residents' attitudes towards the accessibility of facilities is not only how convenient it is for them to get to the nearest supply point for any individual service (which, as Andrews emphasized, is not necessarily best measures by its distance from where they live, given that they move around anyway as they go about their lives) but on the compactness of supply of the bundle of services they are interested in accessing.

At first sight (see Table 1), in 2012, the United States' leading record of 149,220 convenience stores along with Japan's 46,905 stores may make it seem parochial to focus on Taiwan's 9,831 stores locating across a relatively small land area (35,980 km^2). However, when it comes to geographic density, there are on average two convenience stores (per 100 km^2) in U.S., 12 in Japan but up to 27 in Taiwan – possibly the highest density across the globe. Taiwan's convenience stores in 2012 generate NTD$ 224.9 billion sales volume through 2.8 billion transactions from its widely-ranged services.

This paper is structured as follows. The theoretical framework is presented in the next section, followed by a section of data. The empirical model, hypotheses and the results of the nonlinear effect of convenience stores on property prices will be illustrated in the fourth section. The final section will conclude this paper.

Theoretical framework

Rosen's (1974) hedonic model views a property as a bundle of valuable characteristics, and thus the implicit price of *a* characteristic can be derived from the market price of the property. These characteristics can be generally categorized into several types (c.f. Sirmans, Macpherson, & Zietz, 2005): (1) housing attributes: such as age of house, floor size, building materials, number of bathrooms/bedrooms, parking space and others (Clapp & Giaccotto, 1998; Forrest, 1991; Leishman, 2001); (2) environmental living quality: such as neighbourhood greenery (Luttik, 2000), noise (Theebe, 2004) or crime rate (Lynch & Rasmussen, 2001); and/or (3) local facilities, which can be generally classed into (a) amenities (which generate positive externalities): such as education institution (Black, 1999), parks (Li & Brown, 1980) or churches (Carroll, Clauretie, & Jensen, 1996), and (b) dis-amenities (which generate negative externalities): such as incinerators (Kiel & McClain, 1995), sewage treatment plants (Groothuis & Miller, 1994), cell phone towers (Bond & Xue, 2007), or landfills (Nelson, Genereux, & Genereux, 1992). It should be noted that, the convenience store, as one of the popular local facilities in our daily lives, is rarely discussed in literature.

In general, the empirical studies mentioned above mainly apply ordinary least square methods in analyzing the effects of these facilities on property prices (Sirmans et al., 2005). Moreover, the influence of each facility on property prices is determined by its spatial location, primarily measured in terms of the shortest straight-line distance (or trip duration) from a house to the nearest facility through GIS (geographic information system) technique. Therefore, in a conventional setting, convenience stores would be taken as a type of local facilities, the effect of which on property prices would be measured in terms of straight-line distance, and the application of ordinary least square regression would provide a single and marginal indicator of its location proximity to its potential consumers.

However, to take this approach seems to ignore the potentially significant arguments raised half a century ago by P.W.S. Andrews in his revival of Marshall's (1890) work. Andrews criticized Chamberlin's (1933) theory of location-oriented monopolistic profits. Andrews (1949, 1964) argued that location is not necessarily a differentiating factor since we consumers, who are mobile rather than paraplegic or confined to homes, "… tend to satisfy our continual needs for cigarettes [or other goods] from *any shop that we happen to pass*" (Andrews, 1951: 253–254; italics added). In other words, it would be futile for retailers to try to charge premium prices on the basis of their proximity to where consumers live, since consumers would shop elsewhere en route to workplaces or to any other locations "so long as these fit in with their way of life" (Earl & Wakeley, 2010: 173).

Given consumers' mobility and the dense supplies of convenience stores with multi-facet services, it is assumed in this study that the more convenience stores there are in neighbourhoods, the more likely consumers can get multiple tasks (e.g. buy magazines, buy train tickets, or pay phone bills) done in one trip when they happen to be 'passing' one en route between their homes and other places (e.g. railway stations, offices, or schools) without making a special journey for services. Having many convenience stores in neighbourhood does not only make it easier to do 'shopping on the run' on any journey but also increase the probability of a convenience store being close to where one lives. Hence, in this study, the effect of convenience stores on property prices will be measured in terms of the clustering of stores rather than the distance to the closest store from houses. That is, given a fixed boundary, the *availability* (i.e. whether a house has 'a' convenience store) and the *density* of convenience stores (i.e. whether a house has 'two or more') should have different effects on property prices.

Another step to reveal the effect of convenience stores is to recognize that their absence might make a suburb less attractive as a convenient place to live in but not everyone wants to live *really* close to such a store if in some respects it 'lowers the tone of the neighbourhood' via its impact on the streetscape, traffic noise or congestion as shoppers and delivery vehicles come and go. Whether we should view convenience stores as amenities or disamenities might thus depend on the type of suburbs in which they are located. Such nonlinear relationship tends to be overlooked in the widely-applied ordinary least square (OLS) regression, which indicates a *single* and *linear* estimate of regressor (i.e. house characteristics or facilities) on the *mean* value of the regressand (i.e. property prices). That is, the OLS setting may not be able to explain why residents in some counties with relatively lower property prices filed a petition of the installation of *a* convenience store for its convenient services[2] while residents in some counties with relatively higher property prices filed a

[2] Residents in several less-developed neighbourhoods felt ashamed of not having any convenience store – a basic 'necessity' in lives in their view (http://udn.com/NEWS/NATIONAL/NAT2/5959886.SHTML#IXZZ21W8k5MHa; accessed 15 August 2012).

lawsuit against the convenience store nearby due to its inconvenience (e.g. noise).[3]

Given these inconsistent preferences, Koenker and Bassett's (1978) quantile regression (QR), which estimates how changes in regressors affect the *distribution* (i.e. quantiles) of the regressand, is applied on the property data of Taipei Metropolis to unearth the nonlinear effect of convenience stores on quantiles of property prices (e.g. whether having a convenience store or not in neighbourhood may have different impacts on low-quantile and high-quantile property prices).

Data

In this study, 'Taipei' is the abbreviation of 'Taipei Metropolis' which covers Taipei City—the capital of Taiwan, and New Taipei City—the suburban area of Taipei City; a 'property' is loosely defined as a dwelling where a person or a household lives in. The properties in Taipei mostly are apartments or suites due to high population density (2,844 people per km^2 in 2012).

The data employed in this analysis was obtained for academic use from a private bank,[4] which consisted of 17,809 properties in Taipei in 2009. The final sample size was 17,215 after the data cleaning process. This dataset consisted of the properties' geographic coordinates, prices and other details, some of which were chosen as regressors in empirical analyses based on the housing literature.

The descriptive statistics of these regressors are listed in Table 2. In 2009, the average property price per ping[5] in Taipei was 266,000 NTD; when it comes to 'housing attributes', on average, a typical house of this dataset was aged 18 (mean value = 17.7) with floor size of 36 pings (mean = 35.7) and was located at 6th floor (mean = 5.6) of the 10-level building (mean = 9.7). Moreover, only 10.6% of the sampled houses were located at first floor, and thus up to 62.8% of them had access to elevators. When 'geographic location' is considered, 40.1% of houses were located in Taipei City. When it comes to 'access to amenities', within a radius of 300 m, up to 57.8% of the houses had access to bank(s); about 50% had access to school(s), which is broadly defined in terms of any pre-university education institution (e.g. primary schools, junior/senior high schools); 13.2% and 12.7% of the houses had access to hospital(s) and MRT(s), respectively. On the other hand, within a radius of 300 m, 23.6% of the houses had access to 'disamenities' (including funeral parlour, cemetery, patrol station, electric tower that are listed in dataset); this variable is broadly defined since disamenities are relatively rare compared to amenities.

In regard to convenience stores, the initial continuous number of convenience stores within each house's 300-m radius (given in dataset) were re-coded into two dummy variables within a 100-m radius: 'availability of convenience store' (whether a house has one convenience store) and 'density of convenience stores' (whether a house has two or more convenience stores). Given this setting, 36.3% of the observed properties had one convenience store ('availability'), and 15.0% of them had two or more convenience stores ('density') within this boundary.

It should be noted that some may argue the consideration of quadratic term of 'convenience store' is a way to pin down the nonlinearity effect, buy this method may lead to the issue of over-fitting (Yang & Sue, 2011). Inspired by the work of Peng, Yang, and Yang (2009) which recoded the continuous distance of MRT into dummy variables to measure the nonlinear effect of MRT proximity on property prices, this study adopted the same method to estimate the different influence of 'availability' and 'density' of convenience stores, which represents how convenient for residents to do "shopping on the run" in their neighbourhoods.

The radius, within which the availability and density of convenience stores is measured, is reduced from 300 meters to 100 meters for two reasons:

(1) Revelation of convenience: the initial radius of 300 meters may blur the measurement of its convenience to daily lives due to high geographic density of convenience stores in Taiwan. According to the raw data, an observed property has seven convenience stores within a 300 meters radius (equivalent to 3.71-minute walking distance), but the number reduces to one within a 100 meters radius (equivalent to 1.23-min walking distance) (c.f. Levine & Norenzayan, 1999). Having seven stores within about 4-min walking distance is not as convenient as having one convenience store within about 1-min walking distance.
(2) Revelation of inconvenience: despite being close to a convenience store is an advantage, but being too close to it may be the opposite. It is known that the automatic sensor bell will make a pleasant 'ding-dong' sound (designed to notify the counter attendant) for every entry (and exit) to a convenience store. Given that on average two consumers per minute in convenience stores located in busy streets, this high frequency of bell sound (about 70–90 Decibels recorded at door) produced by a 24-h convenience store may be nothing if living far away from it (say, 300 m) but can become a nuisance if living right next to it (say, less than 100 m) especially during the night time. Potential crime – possible gathering of wandering teenagers or homeless – would be another type of 'inconvenience'.

Empirical analyses

Empirical model

Unlike ordinary least square regression providing a partial view of the relationship, quantile regression (QR), which minimizes a weighted sum of the absolute residuals, depicts the relationship between the regressand y and the regressors x_i at different points in the conditional quantile (or percentiles) distribution of y, denoted as $Q_q(y \mid x)$. This method has been widely applied in many topics; see Yu, Lu, and Stander (2003) for detailed review.

Quantile regression, initially proposed by Koenker and Bassett (1978) and discussed in further works (Koenker, 2005; Koenker & Hallock, 2001), has several advantages (Cameron & Trivedi, 2010): (1) compared to OLS regression, it is more robust to outliers; (2) it is able to analyze the impact of regressors on both the location and scale parameters of the model; and (3) as a semiparametric approach, it is not bounded to the assumption of parametric distribution of residuals.

The quantile regression model is presented as follows (Fitzenberger, Koenker, & Machado, 2002):

$$y_i = x_i'\beta_\theta + \varepsilon_{\theta i}, \quad Quant_\theta(\varepsilon_{\theta i}|x_i) = 0, \quad i = 1, 2, \ldots, n \tag{1}$$

where

y: regressand

[3] A famous lawsuit was fired by a resident in 2012 against the noise caused by the nearby convenience store, which got fine of NTD 300,000 (i.e. about US$10,000) (http://www.tvbs.com.tw/news/news_list.asp?no=nunumt19872012081009312 3&&dd=2013/2/10%20%A4U%A4%C8%2001:09:19).

[4] The identity of this bank was required by the bank administrative to be kept anonymous for data confidentiality.

[5] The unit measurement of land or floor size in Taiwan is 'ping'. 1 'ping' = 3.3058 m^2 = 35.5832 square feet.

Table 2
Descriptive statistics.

Variables	Description	Descriptive statistics	
Dependent variable		**Mean**	**Std. deviation**
Sale price	New Taiwanese Dollar ($NTD) per 'ping'[a]	266,000.0	158,989.7
Independent variables (continuous variables)			
Housing attributes		Mean	Std. deviation
Total levels of the building	The total levels of the building where the observed property is located	9.7	5.9
Located level of the house	The level at which the observed property is located	5.6	4.4
Floor area	The size of floor area (number of 'ping's[a])	35.7	15.2
Age of the house	Age of the property (in years)	17.7	11.6
Independent variables (dummy variables)		**Relative frequency**	
Housing attributes		No ($D = 0$)	Yes ($D = 1$)
Located at 1st floor	Yes = 1, if the observed property is located at 1st floor	89.4%	10.6%
Elevator	Yes = 1, if the building of the observed property has elevator(s)	37.2%	62.8%
Access to facilities		No ($D = 0$)	Yes ($D = 1$)
Bank	Yes = 1, if the observed property has access to bank(s) within a radius of 300 m	42.7%	57.3%
Hospital	Yes = 1, if the observed property has access to hospital(s) within a radius of 300 m	86.8%	13.2%
MRT (Mass Rapid Transit)	Yes = 1, if the observed property has access to MRT(s) within a radius of 300 m	87.3%	12.7%
School	Yes = 1, if the observed property has access to school(s) within a radius of 300 m	50.2%	49.8%
Disamenity	Yes = 1, if the observed property has access to any disamenity within a radius of 300 m	76.4%	23.6%
Geographic location		New Taipei City ($D = 0$)	Taipei City ($D = 1$)
Taipei metropolitan area	$D = 1$, if the observed property is located in Taipei City; $D = 0$, if located in New Taipei City	59.9%	40.1%
Convenience store		No ($D = 0$)	Yes ($D = 1$)
Availability of convenience store	Yes = 1, if the observed property has one convenience store within a radius of 100 m; otherwise = 0	63.7%	36.3%
Density of convenience store	Yes = 1, if the observed property has two or more convenience stores within a radius of 100 m; otherwise = 0	85.0%	15.0%

[a] Unit measurement of land size in Taiwan is 'ping'. 1 'ping' = 3.3058 m^2 = 35.5832 square feet.

x: regressor
θ: quantile, $0 < \theta < 1$
β_θ: regression coefficient of regressor x at θth quantile of regressand y
i: sample observation

Hence, the conditional quantile of y_i given x_i, denoted as Quant $(y_i|x_i)$. The standard errors of coefficients are estimated through the use of bootstrapping (Gould, 1992) for the advantage of being less sensitive to heteroscedasticity.

Variables and hypotheses

Koenker and Bassett's (1978) quantile regression is applied to pin down the nonlinear effect of convenience stores on quantiles of property prices. The regressand is 'property price'. Based on Rosen's (1974) hedonic model, the characteristics that compose a property's price are categorized into three types of regressors.

Housing characteristics

'Age of house', implying the depreciation of structure, is assumed to be negatively related to property prices (Sirmans, MacDonald, Macpherson, & Zietz, 2006; Tse & Love, 2000), while 'floor area' is assumed to be positively related to property prices for it being a broad index of other housing features such as more bathrooms/bedrooms/living rooms (Brunsdon, Fotheringham, & Charlton, 1999; Sirmans et al., 2005).

In a crowded city like Taipei, most properties are apartments or suites. Property tax imposed on each property in Taiwan is based on Real Estate Appraisal Committees' appraisal price, which is mainly determined by three criteria.[6] As one of the criteria, 'total levels of the building' (in which the property is located), the higher of which implies higher construction costs (i.e. stronger steel reinforcing bars and more facilities installed for public safety) and thus higher property taxes, is assumed to be positively associated with property prices (Chang, Yang, & Hung, 2008; Peng, Wu, & Wu, 2007). 'Floor level' (at which the property is located), the higher of which indicates access to better view, less noise and fresher air, is assumed to be positively related to property prices (Chau, Wong, & Yiu, 2004; Hui, Chau, Pun, & Law, 2007; Jim & Chen, 2009). If a house is 'located at 1st floor', which indicates its potential of commercial use (such as coffee shops, banks or other commercial structures),[7] the property price should benefit from this attribute. Since most properties in Taipei are located in buildings of stories, having access to 'elevator(s)' should add value to property prices (Boris, Yakov, & Larissa, 2005; Maddala, Toda, & Nozdrina, 1998); however, the

[6] According to Taipei City Revenue Service website (http://www.taipei.gov.tw/mp.asp?mp=103011), Real Estate Appraisal Committee appraises each property for taxation mainly based on three criteria: structure (i.e. made of concrete or others), purpose (i.e. residential, commercial or others), and total level of the building.

[7] The mix use of commercial and residential structures is one of the characteristics of Taiwan's property market.

Table 3
Empirical results.

Regressors	OLS regression			Qunatile regression							
				Q10		Q20		Q30		Q40	
	Coef.	*t*-Value	VIF	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value
Housing characteristics											
Age of the house	−2829.82	−27.31***	2.31	−2170.06	−17.93***	−2249.50	−27.25***	−2288.14	−21.08***	−2239.56	−23.19***
Floor area	1792.16	31.77***	1.19	223.64	4.18***	483.81	7.89***	681.26	8.24***	873.46	11.98***
Total levels of the building	3751.94	16.29***	3.00	1715.67	9.36***	2191.23	8.64***	2418.05	14.04***	2461.62	19.00***
Located level of the house	478.63	1.82**	2.19	507.28	2.56***	315.45	1.33	515.36	3.21***	969.90	5.22***
Located at 1st floor	95,406.74	34.28***	1.18	38,297.31	19.50***	46,060.24	22.63***	53,032.76	19.94***	61,195.90	28.26***
Elevator	4576.89	1.81**	2.40	−159.51	−0.09	−548.97	−0.32	−233.38	−0.11	2050.07	1.24
Taipei City	195,387.70	108.75***	1.25	118,781.50	69.21***	136,347.00	105.18***	149,138.60	73.15***	161,178.90	102.22***
Neighbourhood characteristics											
Bank	47,426.90	27.34***	1.18	35,242.35	28.36***	32,966.93	23.56***	29,581.08	31.70***	27,579.56	27.87***
Hospital	22,174.41	9.30***	1.05	4648.66	1.62*	11,702.84	4.67***	17,576.58	8.34***	21,391.06	11.11***
MRT	36,788.84	14.87***	1.09	19,987.43	7.89***	23,524.54	8.49***	27,483.54	11.70***	31,779.81	11.05***
School	6592.06	4.09***	1.04	1594.58	1.60	2059.26	2.21**	2803.72	2.91***	3151.77	3.54***
Disamenity	−14,001.84	−7.42***	1.09	−5750.11	−4.64***	−9121.17	−5.47***	−12,524.16	−7.79***	−16,200.90	−17.50***
Convenience stores											
Availability of convenience store	312.44	0.18	1.18	3113.92	1.97**	2787.82	1.80*	2762.19	2.12**	2295.91	1.71*
Density of convenience store	−3208.52	−1.34	1.16	4554.47	3.33***	1416.01	0.84	−1038.66	−0.71	−2877.89	−1.56
Constant	87,728.69	21.84		105,387.50	21.94	111,894.90	29.73	117,442.70	27.01	118,411.70	33.11
$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$											
R^2		0.58		0.27		0.31		0.34		0.37	

Regressors	Quantile regression									
	Q50		Q60		Q70		Q80		Q90	
	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value
Housing characteristics										
Age of the house	−2158.75	−21.10***	−2287.48	−20.97***	−2441.00	−19.12***	−2718.52	−17.94***	−3472.09	−18.62***
Floor area	1074.44	12.32***	1348.32	11.41***	1659.71	16.13***	1875.24	12.29***	1965.18	14.75***
Total levels of the building	2404.70	22.58***	2788.42	14.10***	2984.86	15.74***	3748.13	15.68***	4246.71	8.71***
Located level of the house	1278.02	7.79***	1130.67	4.18***	1267.14	5.56***	923.17	2.67***	1233.47	2.12**
Located at 1st floor	68,512.83	32.44***	72,956.41	21.40***	79,544.11	20.40***	91,412.08	21.67***	128,456.00	16.32***
Elevator	5729.59	2.77***	4527.90	1.96**	−905.76	−0.59	−7383.97	−2.66***	−21,610.95	−4.26***
Taipei City	170,331.80	108.94***	183,458.70	87.72***	202,602.70	108.24***	231,270.80	58.73***	281,474.70	54.57***
Neighbourhood characteristics										
Bank	27,654.03	20.97***	32,235.27	18.30***	34,776.23	18.19***	39,261.25	18.53***	44,782.71	17.54***
Hospital	24,521.30	10.29***	29,164.34	9.37***	29,562.75	10.08***	27,974.43	13.19***	22,997.13	8.22***
MRT	39,004.65	13.31***	45,294.74	20.80***	46,092.83	20.18***	47,800.52	14.02***	48,754.25	8.56***
School	2389.29	2.00**	4023.55	2.63***	3441.62	1.83*	2297.07	1.34	6828.18	3.15***
Disamenity	−15,947.83	−12.73***	−16,792.74	−11.28***	−16,274.05	−9.34***	−12,813.24	−5.90***	−11,679.62	−4.26***
Convenience stores										
Availability of convenience store	464.14	0.36	1194.58	0.72	−1247.99	−0.66	−1777.33	−0.78	−111.73	−0.04
Density of convenience store	−2382.02	−1.49	−5617.89	−3.29***	−10,998.65	−6.25***	−13,124.00	−5.70***	−14,647.15	−4.16***
Constant	118,170.40	31.60	119,719.10	21.83	129,178.60	21.15	143,624.50	20.13	176,989.80	20.62
$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$										
R^2	0.39		0.41		0.43		0.45		0.47	

association of this regressor with property prices may be blurred because the properties without elevators tend to be evaluated higher by appraisal for its potential of being demarcated under the recent urban renewal plan of Taipei Metropolis.

Neighbourhood characteristics and convenience stores

The prices of properties located in 'Taipei City' (i.e. CBD— central business district — in Taipei Metropolis) are assumed to be higher than properties located in New Taipei City (i.e. suburbs) because the properties in CBD tend to be valued higher for convenient access to work and entertainment (Archer, Gatzlaff, & Ling, 1996; Paul & Forrest, 1996).

In regard to neighbourhood facilities, having accesses to amenities such as 'bank' (facilitating monetary transaction), 'hospital' (offering immediate medical service; Yang and Sue (2011)), 'MRT (Mass Rapid Transit)' (alleviating the hazard of travelling to work; Fan, Ong, and Koh (2006)), or 'school' (indicating convenient access to children's education; Black (1999)), are assumed to be positively related to property prices. Having access to 'disamenities' (e.g. electric towers, cemeteries and others) is hypothesized to be negatively related to property prices (Bond & Xue, 2007; Raymond & Love, 2000; Zabel & Guignet, 2012).

As an indicator of convenient access for "shopping on the run", 'availability' of convenience store is assumed to be positively related with lower-quantile property prices for offering convenient services in relatively deprived neighbourboods. 'Density' of convenience stores is assumed to be positively related with lower-quantile properties (for facilitating residents to run into the

service they need more easily), but negatively related with higher-quantile properties. This dense supply of convenience in neighbourhood is less likely to be appreciated by the residents in higher-priced neighbourhood since they tend to have more variety of transportation, which allow them to travel wider and likely run into stores in other suburbs; moreover, the high supply of convenience stores may become a nuisance to indulged neighbourhood where convenience is less likely to be a must.

Empirical results: OLS regression vs. quantile regression

For the purpose of comparison, the empirical results of ordinary least square (OLS) regression and quantile regression are presented in Table 3.

As demonstrated in Table 3, the OLS regression was statistically significant in accounting for 58% of the variation in 'property price' (p-value of F-test < 0.00). The VIF values of regressors indicated the lack of multicollinearity (VIF < 10). Most of the regressors were statistically significant in explaining the variation of property prices ($p < 0.05$) – except the regressors of 'convenience stores'.

As seen in Table 3, quantile regression was further applied with the same set of regressors (used in OLS regression) to examine the possible nonlinear effect of convenience stores on quantiles of property prices. In a setting from the 10th quantile to the 90th quantile, the set of "housing characteristics", including 'age of house', 'floor area', 'total levels of the building', 'floor level', 'located at 1st floor' and 'Taipei City,' along with the set of "neighbourhood characteristics", including 'bank', 'hospital', 'MRT' and 'disamenities', demonstrated their consistent significant influence ($p < 0.05$) across all the quantiles of property prices. The impacts of these regressors were as expected as discussed in the literature review.

It is worth-noting that the 'convenience store' regressors, which were insignificant in OLS model, revealed their nonlinear effects in quantile regression. 'Availability of convenience store' ($D = 1$, whether a house has one store within a 100-m radius) was positively related to the lower quantiles (Q10–Q40) of property prices ($p < 0.05$). It indicates that in the neighbourhood with relatively low property prices, the 'existence' of a convenience store may add value to local real estate market.

On the other hand, 'density of convenience stores' ($D = 1$, whether a house has two or more stores within a 100-m radius) demonstrates a nonlinear effect on property prices: it had significant positive relationship with the lowest quantile (Q10) of property price but negative relationship with the higher quantiles (Q60–Q90) of property prices ($p < 0.01$). It implies that the 'density' of convenience stores may offer more convenience to local residents in the neighbourhoods with lower-priced houses, but, on the hand, might reduce local living quality (i.e. 24-h noise or potential crime), which are more highly valued by the residents in the neighbourhoods with higher-priced houses. This nonlinear effect is further supported by the inter-quantile regression (10th quantile vs. 90th quantile), in which the coefficient of 'density' of convenience stores is significantly different between these two quantiles of property prices ($p < 0.01$). See Table 4.

Moreover, from Andrews's perspective, the residents living in the neighbourhoods with high-quantile property prices, who are likely to be richer, may be more mobile to access the services of convenience stores in other suburbs or to shop at supermarkets/other retailers at greater distance from their homes *whilst on the move*. That is, having convenience store(s) or not around the corner may matter less to richer residents since they tend to be more mobile given they may have a wider set of choices of transportation that facilitate their door-to-door travelling (c.f. Schafer & Victor, 2000).

It should be noted that both 'availability' and 'density' of convenience stores had positive impact on the 10th quantile of property prices. Besides the possibility of the increased marginal value of convenience stores imposed by local residents, from Andrews's viewpoint, given other regressors constant, residents living in the neighbourhood with low-quantile property prices, may prefer the proximity to convenience stores where they can get a package of tasks (e.g. buy newspaper pay gas bills and others) done in one go.

Diagrams: 'availability' and 'density' of convenience stores

The coefficients and confidence intervals of regressors in OLS and QR (in Section 4.3) can be further demonstrated in the same diagram for comparison. In the case of 'availability of convenience store' (Fig. 1(a)), QR coefficients (grey solid nonlinear line) was higher than OLS coefficient (straight bold dash line) in lower-quantile property prices but lower in higher-quantile property prices, which implies that OLS regression may slightly underestimate the effect of 'availability of convenience store' in lower-quantile property prices (Q10–Q40) but overestimate its effect in high quantiles (Q60–Q90); nevertheless, the QR coefficients were still within the boundary of OLS confidence interval. In the case of 'density of convenience stores' (Fig. 1(b)), the QR coefficient was far above the OLS confidence intervals in lower quantiles but far below in higher quantiles, indicating the OLS coefficient may underestimate its effect on low-quantile property prices (Q10), but overestimate its effect on high-quantile property prices (Q60–Q90). These figures visualize that QR setting may unveil the nonlinear effect of convenience stores on property prices.

Conclusion: limitation and future application

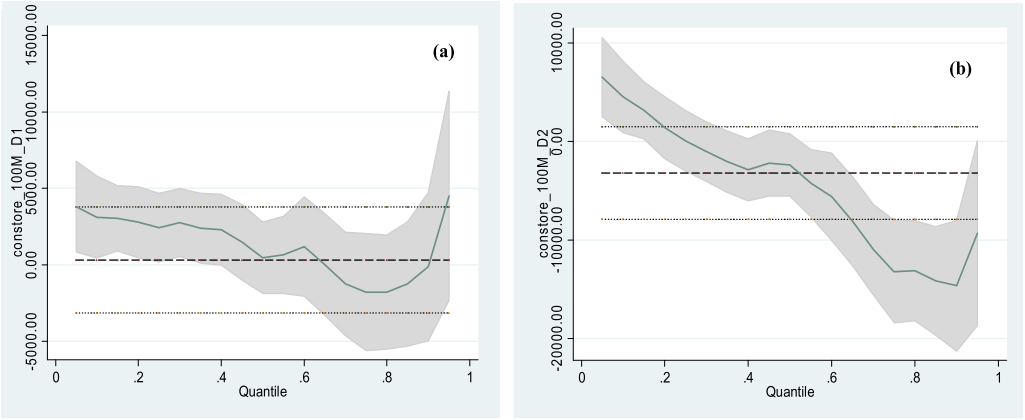
As one of the widely-spread facilities in neighbourhoods across nations, the convenience store is implicitly viewed as a type of facilities in the housing literature despite its close relationship with residents' lives and local business in several domains. Moreover, the service accessibility of a facility, which is usually measured in terms of shortest straight-line distance, may to some extent overlook individuals' mobility.

Therefore, in this study, in the light of Andrews's consideration of how people move around and access services en route from one place to another in the ordinary course of everyday life, the compactness of convenience stores in an area, which is regarded as

Table 4
Inter-quantile regression (10th quantile vs. 90th quantile).

Regressors	Coef.	t-Value
Housing characteristics		
Age of the house	−1302.02	−5.89***
Floor area	1741.54	9.27***
Total levels of the building	2531.04	5.39***
Located level of the house	726.21	1.70*
Located at 1st floor	90,158.67	15.66***
Elevator	−21,451.44	−4.03***
Taipei City	162,693.20	28.99***
Neighbourhood characteristics		
Bank	9540.36	3.43***
Hospital	18,348.47	6.52***
MRT	28,766.82	5.63***
School	5233.60	2.19**
Disamenity	−5929.51	−1.97**
Convenience stores		
Availability of convenience store	−3225.65	−1.53
Density of convenience store	−19,201.62	−3.86***
Constant	71,602.28	7.97

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.



Horizontal axis: quantiles of house price
Vertical axis: coefficient of 'availability of convenience store' (constore_100M_D1); coefficient of 'density of convenience store' (constore_100M_D2)
Straight dash lines: the bold one (**----**) and the other two lighter ones (------) represent the estimated single coefficient and the confidence interval of OLS regression, respectively
Nonlinear lines: the middle solid one and the other two shaded ones represent the estimated coefficients at quantiles of house prices and the confidence interval of quantile regression, correspondingly

Fig. 1. 'Availability' and 'density' of convenience stores in OLS and QR.

one of the characteristics of residential property under Rosen's (1974) hedonic theory, is empirically examined in quantile regression to reveal its nonlinear effect on property prices, given a dataset of 17,215 properties in Taipei Metropolis, Taiwan.

From Andrews's perspective, the more convenience stores there are, the higher the service accessibility for consumers' 'shopping on the way', and thus the higher the prices of residential houses. While OLS regression finds the insignificance of convenience stores, the application of quantile regression further reveals that the compactness of convenience stores has different effects on house prices: 'availability of convenience store' is positively related to low-scale property prices (due to service accessibility), while 'density of convenience stores' demonstrates a nonlinear relationship with property prices – positive relationship with low-scale property prices (due to higher service accessibility) along with negative relationship with high-scale property prices (due to residents' higher mobility to access farther services possibly along with higher concern of its nuisance such as noise).

Given these findings, some may question the possibility of endogeneity because of the use of cross-sectional secondary data. That is, the hypothesized direction between 'availability'/'density' of convenience stores and house prices could be the opposite (i.e. high house prices may, in return, pull more convenience stores to be located in this high-price neighbourhood). Granger Causality Test could justify the 'cause-effect' relationship between these variables, but this test requires time-series dataset, which is not applicable in cross-sectional data. Using instrumental variables (such as store size, number of employees, and other data related to each convenience store) would be another option to pin down the possibility of endogeneity, but it is very unlikely that any of these franchised convenience stores would like to release this confidential information due to the fear of being used for other purposes.[8]

Despite this concern, the descriptive data (Table 5 in Appendix) suggests that convenience stores may not cluster *only* in high-income districts. Take districts of Taipei City for example, the average house prices of Zhongshan District (NTD 578,000 per ping) and Datong District (NTD 577,000 per ping) were close, but the first has up to 197 convenience stores and the second has 74. Also, Beitou District has up to 108 convenience stores but its average house price (NTD 524,000 per ping) is lower than Datong District (NTD 577,000 per ping), which has 74 convenience stores. A simple correlation test between the number of convenience stores and house prices in districts demonstrated an insignificant result (p value of Pearson coefficient = 0.112).

Although this test may not be a solid evidence to imply the lack of endogeneity, it is suggested here that the researchers, who are interested in using cross-sectional housing data for other relevant topics, may need to consider the application of spatial regression, which takes into account the 'spatial-lagged' value of the dependent variable (i.e. house price in this case); refer to Ward and Gleditsch (2008) for further details. But the application of spatial regression requires a detailed set of longitudes and latitudes of house observations (i.e. houses) and facilities (i.e. convenience stores), which, unfortunately, is not available in the secondary dataset used in this study.

While recognizing this limitation, it should still be recognized that the empirical analyses of this study demonstrate some further applications for future micro-structural researches in housing market. From the perspective of *house prices*, an individual thinking of buying a house in high-priced neighbourhood may need to be cautious if a house has easy access to many convenience stores, because it may lower the tone of the neighbourhood and possibly the house prices, while buying a house in low-priced neighbourhood may suggest otherwise because of the needs for high proximity to the services of convenience stores.

On the other hand, from the perspective of *convenience stores*, these findings imply further that the successful operators of convenience stores need to get the location right so as to facilitate consumers' en-route shopping behaviours (cf. Kirby, 1986). Contradictory to the conventional logic that a new store should be open in affluent neighbourhoods (i.e. high-priced houses) for potential

[8] In fact, I contacted the top four brands of convenience stores in Taiwan (including 7–11, FamiMart, OK and Hi-Life) and asked for 'store size' of their franchised convenience stores, which I presumed is the least confidential information, but all of them turned me down for the issue of 'confidentiality'.

higher earning, this study suggests that allocating a new convenience store in lower-priced neighbourhoods may be a 'win-win' situation in the long run since its widely-ranged service is appreciated by local residents and its existence may have positive impact on local property prices. Moreover, from Andrews's viewpoint, competition arises from offering specialized products rather than cheaper prices. Thus, convenience stores, especially those located in low-income neighbourhood, can enforce its competitiveness by specializing in offering particular products/services that make the store itself different from others, which may further have positive impact on local house prices. For example, the highest geographically-located 7–11 store at Ali-Mountain (2170 m above sea level) in Taiwan is popular (and making money) for allowing local residents to pay bills through electronic service, and mountain hikers to have access to hot foods during their trip.

Besides the applications discussed above, this study is believed to offer further insights on urban planning (e.g. how to allocate a store in a 'not-too-close-and-not-too-far' place to nearby houses), and other socio-economic aspects especially to countries where convenience stores become an important facility in daily lives. Take the rapidly-ageing countries for example, such as Japan (or Taiwan), one issue may be worth in-depth analyses in the coming future: The trend of ageing population may shift residents' attitudes towards convenience stores because convenience stores in Japan start to tailor their goods and services given the needs of these 'active' and 'cash-rich' seniors, which may change the impact of convenience stores on local house prices in the future (c.f. Financial Times, 2012[9]).

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Appendix

Table 5
Number of convenience stores and average property prices in Taipei's districts.

District	Total number of convenience stores	Average property price (NTD per ping)
Shilin	133	412,000
Datong	74	577,000
Da'an	178	958,000
Zhongshan	197	578,000
Zhongzheng	127	728,000
Neihu	138	461,000
Wenshan	106	439,000
Beitou	108	524,000
Songshan	120	807,000
Xinyi	126	685,000
Nangang	61	445,000
Wanhua	82	372,000

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