The Impact of Taiwan High Speed Rail on Housing Price: Evidence from Taoyuan City and Yunlin County, Taiwan

賴昱瑋[1]

2020.06

Abstract

The development of high-speed rail had strongly improved the mobility and efficiency of Taiwan's intercity transportation. Nowadays, the pros and cons of the Taiwan High-Speed Rail (THSR) regained the public concern due to its extension plan. The research focused on the comparison of the housing price of Taoyuan and Yunlin and tried to find out how the level of the effect due to THSR. By using the housing price data from "Registering the Actual Selling Price of Real Estate System" and the hedonic price model, the estimation was made by the property, location, and neighborhood attributes. The results of using the log-linear function and box-cox transformation were also compared. The results suggested that high-speed rail did not imply a positive nor negative effect on the region.

Keywords: High-speed Rail, Accessibility, Hedonic Price

[1] 國立臺灣大學國際企業學系四年級賴昱瑋 B05704007

Abstract

1. Introduction

The operation of Taiwan High-Speed Rail (THSR) started in 2007 improved the mobility and efficiency of Taiwan's west coast intercity transportation. The travel time between Taipei and Kaohsiung was reduced from 3 hours to 90 minutes. According to the Ministry of Communications Railway Bureau, the plan of THSR was designed to "improve the quality of transportation services, promote economic growth and regional balanced development, and also take environmental maintenance and energy saving needs into account." (https://www.rb.gov.tw/) In 2020, the issue of "promote economic growth and regional balanced development" regained the attention due to the discussion about the THSR extension to Yilan and Pingtung.

Taiwan High-Speed Rail started its operation with 8 stations in the early stage, while after 9 years, Miaoli, Changhua and Yunlin stations joined the operation in 2015. After that, not only the three main metropolitan areas Taipei, Taichung, and Kaohsiung but also every county of the west coast was connected by HSR. The travel time of intercity transportation could be reduced by almost 50%. While comparing the high-speed rail of Taiwan to other countries, most of the THSR stations are far from the original railway system stations (TRA). Due to the historical development of the township, the original TRA (Taiwan Railways Administration, the origin mass transportation system) stations were also the CBD of each county. That is, most of the THSR stations were located in the suburbs. Compare with other countries, taking Japanese Shinkansen as an example, most of the Shinkansen stations were constructed with the local JR stations which were close to the traditional urban areas.

Only Taipei and Banqiao THSR stations were located in the CBD, while it would take much time from other CBDs to THSR stations. The table showed the distance between the CBDs and the THSR stations, the travel time both by public transportation and by car, and also the transportations options. As it showed, the average distance was 10.45 km. The average travel time to THSR stations from CBD is 21.33 minutes by car and 28 minutes by public transportation. It consumed a relatively much time for commuting between CBDs and THSR stations since we could travel over 150 km from Taipei to Taichung by spending 40 minutes.

Table 1: Access ways to THSR stations

Station Name	City	Distance to CBD (km)	Travel Time by Public Transportation (min)	Travel Time by Car (min)	Transportation
Taipei	Taipei City	-	-	-	TRA, MRT
Banqiao	New Taipei City	-	-	-	TRA, MRT
Taoyuan	Taoyuan City	10.3	-	20	Taoyuan MRT
Hsinchu	Hsinchu County	7.0	20	20	TRA (Liujia Station, Branch Line)
Miaoli	Miaoli County	4.0	5	10	TRA (Fengfu Station, Main Line)

Taichung	Taichung City	7.8	13	15	TRA (Xinwuri Station, Main Line)
Changhua	Changhua County	23.4	-	40	No
Yunlin	Yunlin County	13.0	65	25	No
Chiayi	Chiayi County	12.3	60	25	No
Tainan	Tainan City	11.0	23	20	TRA (Shalun Station, Branch Line)
Zuoying	Kaohsiung City	5.4	10	17	TRA (Xinzuoying Station, Main Line), Kaohsiung MRT
Average		10.45	28	21.33	

1.1 Regional Balanced Development? - About Population

As the plan of THSR from the Ministry of Communications Railway Bureau, the regional balanced development was one of the reasons that developed THSR. It might be somehow reasonable that some of the THSR stations were located in the suburbs. However, the population change after THSR established might not support this idea. Figure 1-A., 1-B., 1-C. showed the population change for several west coast counties. Figure 2 showed the change of the population for Taoyuan's and Yunlin's surrounding townships of the THSR station. The population data of all township was from Dept. of Household Registration, M.O.I. (https://www.ris.gov.tw/app/portal/346 , 內政部戶政司全球資訊網人口統計資料庫)

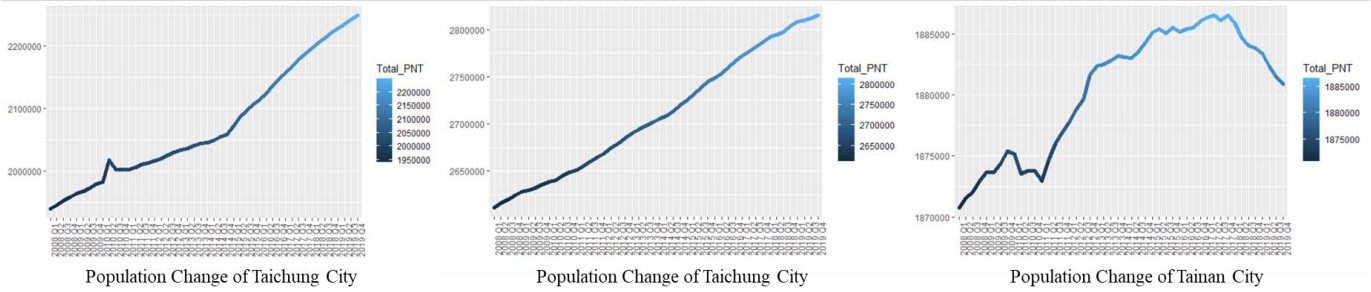

Fig. 1-A. Population Change of Three Municipality (直轄市) along the west coast

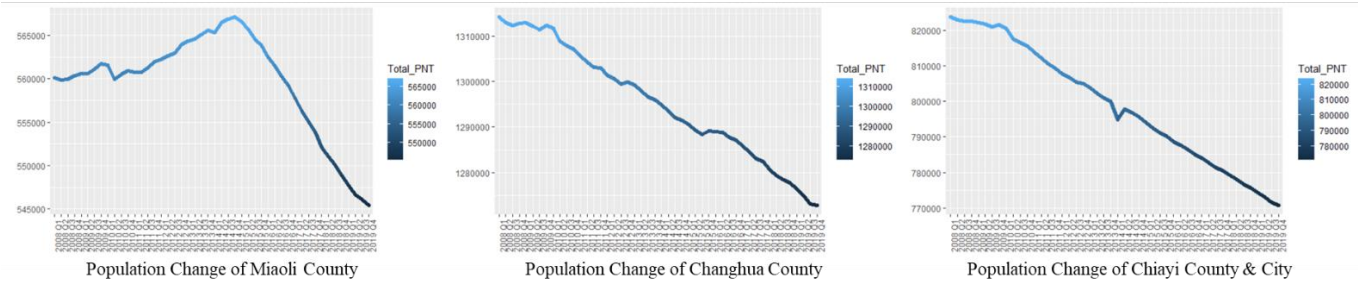

Fig. 1-B. Population Change of Three Normal Counties along the west coast

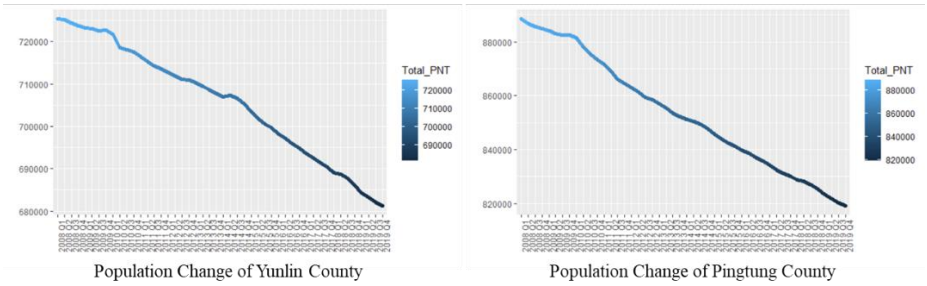

Fig. 1-C. Population Change of Yunlin County and Pingtung County

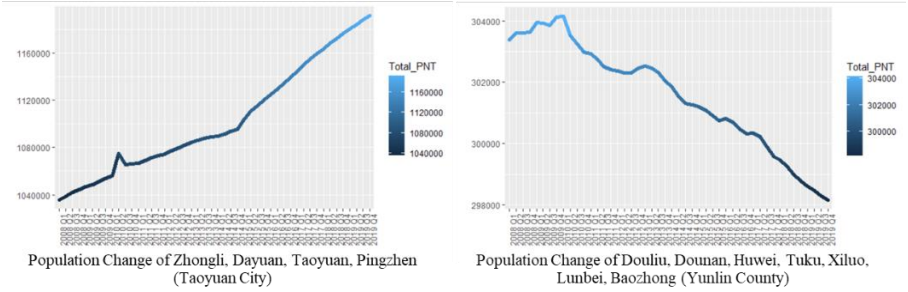

Fig. 2. Population Change of The Township Nearby THSR Station (Taoyuan and Yunlin)

As the figure showed, the population of each county of the west coast, except municipalities, decreased sharply. Although there were both THSR stations in Taoyuan and Yunlin, the population of the townships nearby went in quite different patterns. The argument of regional balanced development to the population seemed to be invalid with these patterns showed.

1.2 Regional Balanced Development? - About Housing Price

Focus on the housing price, Figure 3-A. showed the median unit price patten of the real estate market in Taoyuan, while Figure 3-B. showed the median unit price pattern of Yunlin.

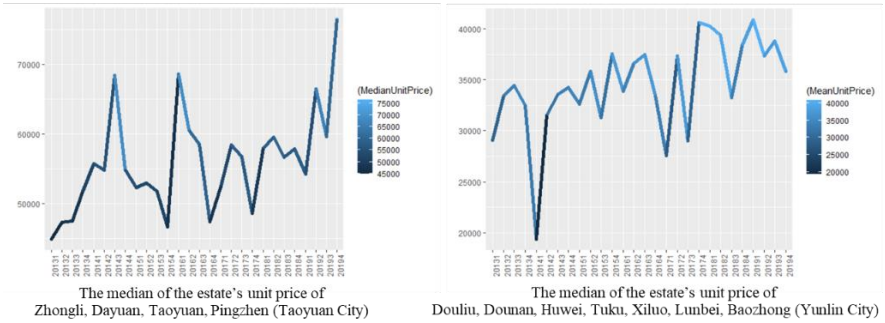

Fig. 3. The Change of Median Unit Price of Real Estate Market (Taoyuan and Yunlin)

The median unit price of Taoyuan in period 1 was about 1.6 times than the median unit price of Yunlin. In the

last period, Taoyuan's price was about 2.2 times the Yunlin's. The growth rate of the median unit price between 2013 Q1 and 2019 Q4, Taoyuan's was about 167% and Yunlin's was about 124%. Although there was some bumpy pattern of the median price, the median price of Taoyuan had greater growth than the median price of Yunlin between the 7 years. Further discussion of the housing price would be shown in the section of the regression model.

2. Literature Survey

The relationship between the transportation infrastructure developing and the local development has been concerned for a long time and no exception for the development of Taiwan High Speed Rail (THSR) in Taiwan. (林楨家, 馮正民 and 黃麟淇 "臺灣高速鐵路系統對地方發展之影響預測") In the studies about the former development in the American Midwest in the 19th century, Atack et al. suggested that the railway expansion in the "Transportation Revolution" significantly affect the urbanization in the American Midwest but less effect on the population density estimated by the differences-in-differences analysis.

Also, the disparities between regions due to the development of the transportation infrastructure are concerned. According to the simulation analysis of Shinkansen development in Kyushu, the regions with HSR stations have relatively higher growth for population, jobs, and economic scale, while there is a decline of the population for other regions. There come widened disparities (Hiramatsu).

When focusing on the interaction between transportation infrastructure development and residential property values, there are quite inconsistent results between the former studies. For example, Andersson et al. suggested that the accessibility to HSR in southern Taiwan only has a minor effect on housing prices. They attributed the unfeasibility for daily commuting between Tainan and other cities to the high ticket-price and entrenched residential location patterns. On the other hand, Chen and Haynes' study on the housing prices among 22 cities along with Beijing–Shanghai high speed rail (BJHSR) cited that the development of the BJHSR had a considerably positive regional impact on housing prices in medium and small cities but the minor impact in larger capital cities.

Furthermore, due to the externalities of the different infrastructures, there are also some studies suggesting that public transportation might have either a positive or negative direct impact on the house purchasing prices and rental prices. For example, commuting costs, accessibility to other location, retail activity, noises and the crime rate in the area could also affect the residential property values (Bowes and Ihlanfeldt; Efthymiou and Antoniou; Siripanich, Rashidi and Moylan) Efthymiou and Antoniou also suggested that these results by cases could not be directly transferred to other decision planning.

2.1 Model Building Method

- Hedonic pricing model

In order to deal with the heterogeneous between the real estates, the hedonic price should be considered (Andersson, Shyr and Fu) (Efthymiou and Antoniou) (Tsou et al.) (Chen and Haynes) (Siripanich, Rashidi and Moylan) Monteroc and Fernández-Avilés cited that there are two stages for the hedonic price method: first, estimate the implicit prices of the characteristics (marginal willingness to pay); secondly, estimates the demand function of the characteristic of interest. There are three typical function forms: log-linear, semi-logarithmic and linear Box-Cox function (Andersson, Shyr and Fu).

The way to achieve the hedonic pricing model was to deconstruct the real estate into several attributes, including some information about the house, the neighborhood, and the most important in the research, the transportation at the location. In this research, we would obtain the property attributes, location attributes, and neighborhood attributes. The reason we did so was because of the assumption that the buyers would be willing to pay some price due to these characteristics of the property.

- Box-Cox transformation

To improve hedonic pricing estimation Andersson et al. cited that when the theory with no specific form, data-specific transformations of functions (such as Box-Cox) can be a substitution. Besides, the error structure often violates the assumption of OLS in hedonic pricing analysis. Box-Cox transformation is essential to achieve a rigorous result (Chen and Haynes) and the standard form:

$$y_i^{\lambda_0} = \beta_0 + \sum_{j=1}^{k} \beta_j x_{ij}^{\lambda_j} + \varepsilon_i$$

The result of the residuals ε_i will more closely follow a normal distribution (Chen and Haynes).

2.2 Former Cases Studies

Efthymiou and Antoniou's study in Athens, Greece use the OLS and the special models to estimate the effect between transportation infrastructure and policies between house prices and rents. They included the residential property data (price and 15 characteristics), spatial data (including types and characteristics of infrastructures and environment). Comparing the models, all types of special models could deal with the autocorrelation. The results showed that there were also externalities on house prices and rents such as more expensive to a metro station and lower prices around the airport. The prices were also negatively affected by the distance from CBD and the distance from the coastline, but a positive effect on logarithmic distance from archaeological sites.

In Chen and Haynes' study, they use robust ordinary-least square regression, a Box-Cox transformation technique, and a spatial econometric model to estimate 22 counties' housing values. They divided the counties into two groups

to control heterogeneous patterns (economic condition and residential characteristics) and took the neighboring environment, the accessibility to HSR (time or distance) and housing characteristics as variables. The outcomes of Box-Cox transformation and the robust OLS are similar, while different from the special model. The spatial model is adequate since the lag parameters of the housing value and spatial weight variables are significant. The total positive effect is found in noncapital cities and the study cited that the property itself and its neighbors are similar.

Siripanich et al. used the smart card data to examines the relationship between residential property values and accessibility in Brisbane also by comparing OLS, spatial lagged model, spatial error model, and geographically weighted regression. The models took the property value from the transaction records as a dependent variable considering the housing characteristics, the accessibility indicators including trips time, characteristics of the trip (number and the ratio to or depart CBD, and job accessibility indicator) and economic indicators. They also concluded that the spatial model was better than the OLS model because of considering heterogeneity and spatial dependence.

2.3 THSR and Its Impact

Lin et al. ("臺灣高速鐵路系統對地方發展之影響預測 Forecasting the Impact of Taiwan High Speed Rail System on Local Development") implied that whether the high-speed rail would deepen the disparity of the region development after the operation of THSR was a key issue. They cited Vickerman's (1997) study that the high-speed rail development resulted in the deeper disparity between urban and rural areas due to the high-speed rails' characteristics – less stations set up and most in the urban area. The simulation results they found in Taichung living sphere suggested that THSR only gave the population and economic activities effect on the township in its service area. They also address a special condition about THSR that its stations were mostly set up in the suburbs, while other countries were mostly in urban area. The town development and connected transportation would be important.

Tsou et al. investigated the impact of THSR on residential values in THSR service townships by analysis the land price indexes with the special model. They suggested that there was impact on the price index of the nearby township during the different periods for the development and operation of THSR. The model investigated in three groups of characteristics: THSR indicators, economic indicators, and the environment indicators. They concluded the areas with three groups: (1) town planning before THSR development (2) town planning after THSR development and carried out (including Taoyuan, Hsinchu, Tainan) (3) town planning after THSR development, but not carried out. Townships in group 1 THSR had no impact on the housing price, while townships in group (2) and (3) THSR had impact on residential values in respectively stages. There might be some inconsistency with the result carried out by Andersson et al. that suggested that there is at most a minor effect on house prices due to THSR accessibility in Tainan.

3. Data Descriptions and the Model

Table 2: Property Attributes

Variables Name	Discription	Unit	Expected Sign	Ref. Article
(TOWN)	Located town name	-		
(TOWN_ID)	Located town ID	-		
(COUNTY)	Located county name	-		
(COUNTY_ID)	Located county ID	-		
TotalPrice	Total price of the property	NTD		(Andersson, Shyr and Fu)
ZoneType	Dummy Variable of the located zone type: · AgriculturalDistrict (reference group) if all other variables below = 0: located in agricultural district · BusinessDistrict if = 1: located in business district · IndustrialDistrict if = 1: located in industrial district ResidentialDistrict if = 1: located in residential district · Others if = 1: located in other district	-	BusinessDistrict: + IndustrialDistrict: ? ResidentialDistrict: + Others: ?	
TransactionType	Dummy Variable of the property's transaction type: · Building (reference group): the transaction only included building · Building_Land if =1: The transaction included land and building	-	Building_Land +	
(TransYear)	The year of the transaction made.	-	+	
(TransQtr)	The quarter of the transaction made.	-	?	
Time	Combined TransYear and TransQtr as the time fixed effect	-	+	
Age	The age of the property since it built.	Year	-	
BuildingType	Dummy Variables of the type of the building: · Apartment (reference group): the property was an apartment (under 10 stories without elevator) · Building_over10 if =1: the transaction property was the building over 10 stories · Building_under10 if = 1: the transaction property was the building under 10 stories with elevator · CommercialBuilding if = 1: the transaction property was a commercial building · Farmhouse if = 1: the transaction property was a farmhouse (農舍) · SingleHouse if = 1: the transaction property was a single house (透天厝) · Store if = 1: the transaction property was a store · Suite if = 1: the transaction property was a suite · Others if =1: the property is other that not listed upon (eg. factories)	-	Building_over10 + Building_under10 + CommercialBuilding + Farmhouse ? SingleHouse + Store + Suite + Others ?	
TransArea	Total transaction building's area of the property.	m^2	+	
TransLot	Total transaction land's area of the property.	m^2	+	
Bedrooms	Quantity of the bedrooms	(count)	+	(Siripanich, Rashidi and Moylan)
Bathrooms	Quantity of the bathrooms	(count)	+	
Livingrooms	Quantity of the living rooms	(count)	+	
ParkIncluded	Dummy variable if = 1 : transaction included parking lot	-	+	
RelatedPartyTrans	Dummy variable if = 1: related party transaction	-	-	
(Coordinate)	The specific location of the property	-		

Table 3: Location Attributes

Variables Name	Discription	Unit	Expected Sign	Ref. Article
DistanceToCBD	The distance between the property and the CBD. (Calculated from	km	-	(Andersson, Shyr and Fu)

	"Coordinate")			
DistanceToHSR	The distance between the property and the THSR station. (Calculated from "Coordinate")	km	-	
DistanceToIC	The distance between the property and the nearest highway interchange. (Calculated from "Coordinate")	km	-	
TrainStationsNearby	Dummy Variable if = 1: there is at least one train station in 1 km (MRT and TRA were both included)	-	+	
BusStopNearby	Dummy if = 1: there is at least one bus stop in 100 (m).	-	+	(Chen and Haynes)

Table 4: Neighborhood Attributes

Variables Name	Discription	Unit	Expected Sign	Ref. Article
ParkNearby	Dummy Variable if = 1: there was park in the neighborhood	-	+	
HospitalNearby	Dummy Variable if = 1: there was hospital in the neighborhood	-	+	(Chen and Haynes)
SchoolNearby	Dummy Variable if = 1: there was school in the neighborhood	-	+	

The transaction information of the housing market was obtained from “Registering the Actual Selling Price of Real Estate System” from the Department of Land Administration, Ministry of the Interior of Taiwan central government. (內政部不動產交易實價查詢服務網) With this system, the information on a real estate transaction could be obtained more easily. The actual transaction information about the price, the condition, the historical record about the estate and neighborhood were unveiled. The information asymmetry could be reduced. By using the price of the system, the result might fit the actual world better. The origin dataset included all of the transaction information for 22 districts from August 2012 to December 2019. The property attributes such as transaction price, transaction time, location, and the properties' information were obtained or transformed from this dataset.

The variable “ZoneType” was referred to as the zone development regulations. In the actual condition of the development in Taiwan, it was hard to separate each zone clearly from different types of use. (Andersson, Shyr and Fu) However, in the comparison from urban and rural area, and the new developed area, the zone regulation should also be considered. The variable “Time” would be included as the time fixed effect, since the unit price of the pattern showed in the section 1, figure 3. The “TransYear” and “TransQtr” should be considered together. Although there seemed to be same way of pattern among the quarter, the effect of each year were different.

The location attributes and the neighborhood attributes were obtained by Taiwan-map (臺灣電子地圖服務網 http://www.map.com.tw/) and Google Map. Each actual coordinate was first obtained by the address provided in each transaction record. For the location attributes, the actual coordinates of each transportation infrastructure were also collected, and the actual distance between housing objects and the infrastructures was calculated by these coordinates. For the neighborhood attributes, after locating the housing objects on the Google Map, the attributes were recognized manually.

Table 5: Descriptive Statistics for Continuous Variables of Taoyuan

	TotalPrice	Age	TransArea	TransLot	Bedrooms	Livingrooms	Bathrooms	DistanceToCBD	DistanceToHSR	DistanceToIC

Min.	183378.00	(2.00)	5.36	0.00	0.00	0.00	0.00	0.40	0.60	0.268267
1st Qu.	4537500.00	1.00	103.31	17.62	2.00	2.00	1.00	3.97	7.55	1.8046
Median	7000000.00	8.00	146.82	24.43	3.00	2.00	2.00	8.54	9.71	2.781333
Mean	8598455.00	12.14	158.32	41.82	2.87	1.73	1.88	9.19	9.93	3.018215
3rd Qu.	10355000.00	21.00	191.35	41.43	4.00	2.00	2.00	13.35	11.96	3.711937
Max.	51680000.00	49.00	1117.80	604.00	11.00	4.00	6.00	27.38	23.87	13.83873
Variance	4.27E+13	1.55E+02	8.39E+03	3.06E+03	1.67E+00	4.75E-01	9.70E-01	3.47E+01	1.51E+01	3.84E+00

Table 6: Descriptive Statistics for Discrete Variables of Taoyuan

ZoneType										
AgriculturalDistrict		BusinessDistrict		IndustrialDistrict		Others		ResidentialDistrict		
4		63		16		113		476		
BuildingType										
Apartment		Building_over10		Building_under10		CommercialBuilding	Farmhouse	Others	SingleHouse	Store	Suite
54		334		97		5	3	8	128	12	31
ParkIncluded		**TrainStationsNearby**		**BusStopNearby**		**ParkNearby**		**HospitalNearby**		**SchoolNearby**	
No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
436	236	572	100	219	453	285	387	584	88	336	336

Table 7: Descriptive Statistics for Continuous Variables of Yunlin

	TotalPrice	**Age**	**TransArea**	**TransLot**	**Bedrooms**	**Livingrooms**	**Bathrooms**	**DistanceToCBD**	**DistanceToHSR**	**DistanceToIC**
Min.	250000	-2	6.85	0	0	0	0	0.134209	0.510976	0.519082
1st Qu.	3000000	1	124.4275	67.9625	3	1	2	2.215873	6.450029	3.172885
Median	5500000	10	176.785	101.71	4	2	3	8.826814	11.40708	4.156065
Mean	6115418	13.52395	178.4331	132.8073	3.747006	1.811377	2.974551	9.819913	10.62965	5.681624
3rd Qu.	7800000	23	208.72	126.705	5	2	4	12.86521	13.85849	5.421462
Max.	30000000	65	1448.17	3026	16	5	16	40.30287	31.33295	28.07665
Variance	1.840152e+13	1.952663e+02	9.866087e+03	7.149073e+04	2.477127e+00	6.330338e-01	2.375663e+00	7.248011e+01	3.249818e+01	2.422093e+01

Table 8: Descriptive Statistics for Discrete Variables of Yunlin

ZoneType										
AgriculturalDistrict		BusinessDistrict		IndustrialDistrict		Others		ResidentialDistrict		
5		40		21		231		371		
BuildingType										
Apartment		Building_over10		Building_under10		CommercialBuilding	Farmhouse	Others	SingleHouse	Store	Suite
17		28		72		4	7	10	501	12	17
ParkIncluded		**TrainStationsNearby**		**BusStopNearby**		**ParkNearby**		**HospitalNearby**		**SchoolNearby**	
No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
652	16	611	57	392	276	407	261	543	125	372	296

The descriptive statistics were shown above. The following models would be estimated for Taoyuan's and Yunlin's data separately. The first model was log-linear model with time fixed effect ("Time") and k variables:

$$\log(TotalPrice_i) = \beta_0 + \sum_{i=1}^{27} D_i(Time_i) + \sum_{j=1}^{k} \beta_i X_j + \varepsilon_i$$

The second model would be the model with simple box-cox transformation. The function form was showed in

section 2.1, and the dependent variable would be *TotalPrice*.

4. Results

The results of the estimation were summarized as the following table. Model 1 was the log-linear model for Taoyuan, and model 2 was the log-linear model for Yunlin. The model 3 and 4 were the Box-cox model for Taoyuan and Yunlin, respectively. (To know the detail of the model please refer to Appendix 1, 2, 3, 4)

Table 9: Results of Regression Models

Coefficients:	Model 1 (Log Taoyuan)		Model 2 (Log Yunlin)		Model 3 (Box-cox Taoyuan)		Model 4 (Box-cox Yunlin)	
(Intercept)	14.1516026	***	1.363e+01	***	93.388262	***	81.141008	***
factor(ZoneType)BusinessDistrict	0.2947463		7.009e-02		7.439830		4.199165	
factor(ZoneType)IndustrialDistrict	-0.1333308		4.490e-02		-7.173036		1.274345	
factor(ZoneType)Others	0.1209710		-2.705e-01		2.801016		-7.771892	
factor(ZoneType)ResidentialDistrict	0.1970978		9.088e-02		4.231862		3.518105	
TransactionTypeBuilding_Land	0.7905326	***	7.463e-01	***	26.823627	***	21.742592	***
factor(Time)2013_Q2	0.1017264		1.774e-01		3.154416		5.441297	
factor(Time)2013_Q3	0.1899934	*	2.178e-01	*	5.347250	.	7.592811	*
factor(Time)2013_Q4	0.0944242		1.050e-01		2.859917		3.436251	
factor(Time)2014_Q1	0.2470412	**	7.928e-02		7.285994	**	4.570138	
factor(Time)2014_Q2	0.1990585	*	1.815e-01	.	6.407657	*	7.019001	*
factor(Time)2014_Q3	0.0946189		2.978e-01	**	4.725891		9.508458	**
factor(Time)2014_Q4	0.2185788	*	1.439e-01		7.628017	**	4.622076	
factor(Time)2015_Q1	0.0708671		1.208e-01		2.169610		3.794655	
factor(Time)2015_Q2	0.3382387	***	3.745e-01	***	9.358138	***	11.990322	***
factor(Time)2015_Q3	0.2224903	*	3.917e-01	***	6.928869	*	12.813941	***
factor(Time)2015_Q4	0.2471625	**	3.683e-01	***	7.547066	*	11.281471	***
factor(Time)2016_Q1	0.2395810	*	2.816e-01	*	6.902419	*	9.026002	**
factor(Time)2016_Q2	0.2520728	**	5.070e-01	***	7.972567	**	15.559473	***
factor(Time)2016_Q3	0.3430473	***	3.466e-01	**	11.234140	***	12.114244	***
factor(Time)2016_Q4	0.3796947	***	3.553e-01	***	11.044849	***	10.712689	***
factor(Time)2017_Q1	0.2257053	*	3.302e-01	**	7.036274	*	10.549358	**
factor(Time)2017_Q2	0.4046049	***	3.529e-01	**	13.095139	***	11.072444	***
factor(Time)2017_Q3	0.3730408	***	3.367e-01	**	10.881919	***	10.386568	***
factor(Time)2017_Q4	0.3750561	***	4.866e-01	***	11.388259	***	15.159454	***
factor(Time)2018_Q1	0.3647787	***	3.544e-01	**	11.805655	***	11.654829	***
factor(Time)2018_Q2	0.2979159	***	3.522e-01	**	8.698229	**	10.977799	***
factor(Time)2018_Q3	0.2886591	**	4.735e-01	***	9.137561	**	14.829345	***
factor(Time)2018_Q4	0.3781570	***	4.223e-01	***	11.151998	***	14.154137	***
factor(Time)2019_Q1	0.3198563	***	5.669e-01	***	9.375698	**	18.368580	***
factor(Time)2019_Q2	0.4237780	***	4.082e-01	***	12.721613	***	13.109261	***
factor(Time)2019_Q3	0.3595200	***	4.753e-01	***	10.522461	***	15.059099	***
factor(Time)2019_Q4	0.4156697	***	5.811e-01	***	12.202115	***	17.886267	***
Age	-0.0318044	***	-4.521e-02	***	-1.002977	***	-1.315204	***
Age_sq	0.0004341	***	7.964e-04	***	0.014897	***	0.023101	***
BuildingTypeBuilding_over10	0.1028415	.	-6.487e-02		3.406926	.	-2.812417	
BuildingTypeBuilding_under10	0.1093353	.	7.777e-02		3.241758	.	0.820478	
BuildingTypeCommercialBuilding	0.0976198		3.437e-01		5.673169		5.038497	
BuildingTypeFarmhouse	0.6379761	*	3.697e-01		16.483009	*	13.764070	.

BuildingTypeOthers	-0.5514710	***	3.279e-01		-13.105307	**	14.291237	*
BuildingTypeSingleHouse	0.2643638	***	3.145e-01	**	7.077587	***	9.315339	**
BuildingTypeStore	0.7068388	***	7.049e-01	***	23.121529	***	22.371629	***
BuildingTypeSuite	-0.3955257	***	-5.055e-01	***	-8.363229	***	-13.245331	***
TransArea	0.0044410	***	2.422e-03	***	0.157857	***	0.074422	***
TransLot	0.0013948	***	3.014e-04	*	0.050625	***	0.007672	*
Bedrooms	0.0422446	*	5.729e-02	***	1.259050	*	1.475978	**
Livingrooms	-0.0171074		6.294e-02	**	-1.082714		1.754657	**
Bathrooms	0.0340347		4.367e-02	**	1.178727		1.586740	**
factor(ParkIncluded)1	-0.0800296	*	8.597e-02		-2.462403	*	3.099868	
DistanceToCBD	-0.0266874	***	-2.817e-02	***	-0.867856	***	-0.921723	***
DistanceToHSR	-0.0170842	***	-1.685e-03		-0.506516	***	-0.072220	
DistanceToIC	-0.0311401	***	2.625e-02	***	-0.944335	***	0.933991	***
factor(TrainStationsNearby)1	0.1113828	**	-7.181e-02		4.364530	***	-1.288739	
factor(BusStopNearby)1	0.0849671	**	-7.196e-02	*	2.009965	*	-1.880479	.
factor(ParkNearby)1	0.0307273		4.421e-02		1.370025		1.437233	
factor(HospitalNearby)1	0.0390454		4.823e-02		1.368981		1.813174	
factor(SchoolNearby)1	0.0151807		4.235e-02		0.465310		1.234156	
Lambda	-		-		0.2222222		0.2222222	
Adj. R-Square	0.8111		0.7657		-		-	
Log-likelihood	-138.99		-256.63		-2454.6		-2507.5	

The difference between log-linear model was small, and the coefficients which were significant were almost the same. Also, there were no large difference between the sign of the same place but different model. Each of the model could fit the data well, especially the models of Taoyuan. The pattern of the time effect on the housing price was also significant. The Adjusted R-square had value 0.8111 and 0.7657 to Taoyuan and Yunlin, which could fit the real estate price quite well. We could also draw the conclusion that the characteristics of real estate market were quite different between Taoyuan and Yunlin.

Referred to the Appendix 1 to 4, the signs of each variable of Taoyuan were almost same as the expectation, but there was much difference in Yunlin's. In the model of Taoyuan, only "Livingrooms" (the quantity of living rooms) (which was also insignificant) and "Age_sq" (Age square) had different sign as expect. "ZoneType" had no effect on each model. It showed that the government urban plan for land usage had no significant effect on the housing price, and referred to Andersson's conclusion that the mixed use of the houses was quite common (Andersson, Shyr and Fu). Neighborhood Attributes were all insignificant in the four model; that is, it was hard to distinguish the effect of public facilities on housing price.

As we can see, the variable of distance to THSR station (DistanceToHSR) was significant in both model of Taoyuan, but neither of it were significant of the model of Yunlin. Therefore, we could conclude that the accessibility to THSR station had significant effect on the housing price in Taoyuan, while no effect on the housing price in Yunlin. From other location attributes, we could find out that Yunlin had a special result of the variable "DistanceToIC" (the distance from the house location to the nearest highway interchange), the far from the IC, the housing price the higher. "DistanceToCBD" was significant in every

model, and we can conclude that the traditional life cycle of the cities still had huge impact on the housing price.

5. Conclusion

The result of the model suggested that the accessibility to THSR stations did not necessarily make an effect on the real estate value. Referred to the research of Tainan (Andersson, Shyr, and Fu), the result also showed that THSR had a minor effect on the housing price. It might due to the ticket price or the long-time developed life cycle. On the contrary, in Taoyuan, the THSR accessibility did affect the housing price. It might because of its special geographical characteristics, Taoyuan's population was still growing fast as figure 1 showed.

Also referred to Lin's et al. research in 2005 (林楨家, 馮正民 and 黃麟淇 "臺灣高速鐵路系統對地方發展之影響預測"), before the operation of THSR, they suggested that the specially developed region was on of the best way to balance regional development. Today the result of Taoyuan could be the evidence of that suggestion. Taoyuan THSR stations region was successfully developed, and this might be one of the reasons that the accessibility to THSR stations was important to some people in Taoyuan. Finally, the development of THSR did not imply the success of the promotion of economic growth and regional balanced development. It also needed to take effort on the whole regional plan.

References

Andersson, David Emanuel, Oliver F. Shyr, and Johnson Fu. "Does High-Speed Rail Accessibility Influence Residential Property Prices? Hedonic Estimates from Southern Taiwan." *Journal of Transport Geography* 18.1 (2010): 166-74. Print.

Atack, Jeremy, et al. "Did Railroads Induce or Follow Economic Growth?: Urbanization and Population Growth in the American Midwest, 1850–1860." *Social Science History* 34.2 (2010): 171-97. Print.

Bowes, David R., and Keith R. Ihlanfeldt. "Identifying the Impacts of Rail Transit Stations on Residential Property Values." *Journal of Urban Economics* 50.1 (2001): 1-25. Print.

Chen, Zhenhua, and Kingsley E. Haynes. "Impact of High Speed Rail on Housing Values: An Observation from the Beijing–Shanghai Line." *Journal of Transport Geography* 43 (2015): 91-100. Print.

Efthymiou, Dimitris, and Constantinos Antoniou. "How Do Transport Infrastructure and Policies Affect House Prices and Rents? Evidence from Athens." *Transportation Research Part A Policy and Practice* 52 (2013): 1-22. Print.

Hiramatsu, Tomoru. "Job and Population Location Choices and Economic Scale as Effects of High Speed Rail: Simulation Analysis of Shinkansen in Kyushu, Japan." *Research in Transportation Economics* 72 (2018): 15-26. Print.

Montero, José-María, and Gema Fernández-Avilés. "Hedonic Price Model." *Encyclopedia of Quality of Life and Well-Being Research*. Ed. Michalos, Alex C. Dordrecht: Springer Netherlands, 2014. 2834-37. Print.

Siripanich, Amairn, Taha Rashidi, and Emily Moylan. "Interaction of Public Transport Accessibility and Residential Property Values Using Smart Card Data." *Sustainability* 11 (2019): 2709. Print.

Tsou, Ko-Wan, et al. "應用空間特徵價格模型評估高速鐵路對土地價格影響之時空特性－以臺灣高鐵為例 Applying Spatial Hedonic Price Model to Explore the Effects of Taiwan High Speed Railway on Land Price." *Journal of Architecture and Planning* (2013): 47-66. Print.

林楨家, 馮正民, and 黃麟淇. "臺灣高速鐵路系統對地方發展之影響預測." *運輸計劃季刊* 34.3 (2005): 391-412. Print.

---. "臺灣高速鐵路系統對地方發展之影響預測 Forecasting the Impact of Taiwan High Speed Rail System on Local Development." *運輸計劃季刊* 34.3 (2005): 391-412. Print.

Appendix 1: Results of Model 1 (Log-Linear Model for Taoyuan)

Coefficients:	Estimate	Std. Error	t value	Pr(>|t|)		Expected Sign	As Expected
(Intercept)	14.1516026	0.3166616	44.690	< 2e-16	***	+	Yes
factor(ZoneType)BusinessDistrict	0.2947463	0.1831141	1.610	0.107991		+	Yes
factor(ZoneType)IndustrialDistrict	-0.1333308	0.1942284	-0.686	0.492679		-	Yes
factor(ZoneType)Others	0.1209710	0.1768352	0.684	0.494177		?	-
factor(ZoneType)ResidentialDistrict	0.1970978	0.1770288	1.113	0.265986		+	Yes
TransactionTypeBuilding_Land	0.7905326	0.2383105	3.317	0.000963	***	+	Yes
factor(Time)2013_Q2	0.1017264	0.0899229	1.131	0.258385		+	Yes
factor(Time)2013_Q3	0.1899934	0.0907355	2.094	0.036675	*	+	Yes
factor(Time)2013_Q4	0.0944242	0.0916776	1.030	0.303434		+	Yes
factor(Time)2014_Q1	0.2470412	0.0890623	2.774	0.005709	**	+	Yes
factor(Time)2014_Q2	0.1990585	0.0859765	2.315	0.020927	*	+	Yes
factor(Time)2014_Q3	0.0946189	0.1035793	0.913	0.361342		+	Yes
factor(Time)2014_Q4	0.2185788	0.0867255	2.520	0.011976	*	+	Yes
factor(Time)2015_Q1	0.0708671	0.0968210	0.732	0.464484		+	Yes
factor(Time)2015_Q2	0.3382387	0.0872783	3.875	0.000118	***	+	Yes
factor(Time)2015_Q3	0.2224903	0.0886418	2.510	0.012329	*	+	Yes
factor(Time)2015_Q4	0.2471625	0.0945670	2.614	0.009178	**	+	Yes
factor(Time)2016_Q1	0.2395810	0.0958365	2.500	0.012682	*	+	Yes
factor(Time)2016_Q2	0.2520728	0.0860653	2.929	0.003528	**	+	Yes
factor(Time)2016_Q3	0.3430473	0.0889366	3.857	0.000127	***	+	Yes
factor(Time)2016_Q4	0.3796947	0.1017064	3.733	0.000207	***	+	Yes
factor(Time)2017_Q1	0.2257053	0.0894142	2.524	0.011845	*	+	Yes
factor(Time)2017_Q2	0.4046049	0.0876494	4.616	4.76e-06	***	+	Yes
factor(Time)2017_Q3	0.3730408	0.0879107	4.243	2.54e-05	***	+	Yes
factor(Time)2017_Q4	0.3750561	0.1029831	3.642	0.000293	***	+	Yes
factor(Time)2018_Q1	0.3647787	0.0908450	4.015	6.67e-05	***	+	Yes
factor(Time)2018_Q2	0.2979159	0.0872533	3.414	0.000681	***	+	Yes
factor(Time)2018_Q3	0.2886591	0.0914062	3.158	0.001666	**	+	Yes
factor(Time)2018_Q4	0.3781570	0.0966978	3.911	0.000102	***	+	Yes
factor(Time)2019_Q1	0.3198563	0.0932880	3.429	0.000647	***	+	Yes
factor(Time)2019_Q2	0.4237780	0.0852126	4.973	8.56e-07	***	+	Yes
factor(Time)2019_Q3	0.3595200	0.0904265	3.976	7.85e-05	***	+	Yes
factor(Time)2019_Q4	0.4156697	0.1027350	4.046	5.87e-05	***	+	Yes
Age	-0.0318044	0.0038373	-8.288	7.23e-16	***	-	Yes
Age_sq	0.0004341	0.0001019	4.259	2.38e-05	***	-	No
BuildingTypeBuilding_over10	0.1028415	0.0605312	1.699	0.089828	.	+	Yes
BuildingTypeBuilding_under10	0.1093353	0.0605654	1.805	0.071526	.	+	Yes
BuildingTypeCommercialBuilding	0.0976198	0.1598835	0.611	0.541711		+	Yes
BuildingTypeFarmhouse	0.6379761	0.2548600	2.503	0.012564	*	?	-
BuildingTypeOthers	-0.5514710	0.1430633	-3.855	0.000128	***	?	-
BuildingTypeSingleHouse	0.2643638	0.0604680	4.372	1.45e-05	***	+	Yes
BuildingTypeStore	0.7068388	0.1129649	6.257	7.35e-10	***	+	Yes
BuildingTypeSuite	-0.3955257	0.0779400	-5.075	5.15e-07	***	-	Yes
TransArea	0.0044410	0.0002116	20.989	< 2e-16	***	+	Yes
TransLot	0.0013948	0.0004144	3.366	0.000811	***	+	Yes
Bedrooms	0.0422446	0.0200739	2.104	0.035744	*	+	Yes
Livingrooms	-0.0171074	0.0247306	-0.692	0.489355		+	No
Bathrooms	0.0340347	0.0233758	1.456	0.145909		+	Yes
factor(ParkIncluded)1	-0.0800296	0.0378403	-2.115	0.034838	*	+	No
DistanceToCBD	-0.0266874	0.0027596	-9.671	< 2e-16	***	-	Yes
DistanceToHSR	-0.0170842	0.0036909	-4.629	4.49e-06	***	-	Yes

Appendix 1(continued)

DistanceToIC	-0.0311401	0.0071693	-4.344	1.64e-05	***	-	Yes
factor(TrainStationsNearby)1	0.1113828	0.0381286	2.921	0.003614	**	+	Yes
factor(BusStopNearby)1	0.0849671	0.0302559	2.808	0.005139	**	+	Yes
factor(ParkNearby)1	0.0307273	0.0312483	0.983	0.325833		+	Yes
factor(HospitalNearby)1	0.0390454	0.0388668	1.005	0.315488		+	Yes
factor(SchoolNearby)1	0.0151807	0.0302752	0.501	0.616254		+	Yes

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3111 on 615 degrees of freedom
Multiple R-squared: 0.8269
Adjusted R-squared: 0.8111
F-statistic: 52.47 on 56 and 615 DF
p-value: < 2.2e-16

Appendix 2: Results of Model 2 (Log-Linear Model for Yunlin)

Coefficients:	Estimate	Std. Error	t value	Pr(>|t|)		Expected Sign	As Expected
(Intercept)	1.363e+01	2.752e-01	49.517	< 2e-16	***	+	Yes
factor(ZoneType)BusinessDistrict	7.009e-02	1.905e-01	0.368	0.713044		+	Yes
factor(ZoneType)IndustrialDistrict	4.490e-02	1.993e-01	0.225	0.821796		-	No
factor(ZoneType)Others	-2.705e-01	1.802e-01	-1.501	0.133924		?	-
factor(ZoneType)ResidentialDistrict	9.088e-02	1.786e-01	0.509	0.611064		+	Yes
TransactionTypeBuilding_Land	7.463e-01	1.520e-01	4.908	1.18e-06	***	+	Yes
factor(Time)2013_Q2	1.774e-01	1.170e-01	1.517	0.129901		+	Yes
factor(Time)2013_Q3	2.178e-01	1.084e-01	2.009	0.044989	*	+	Yes
factor(Time)2013_Q4	1.050e-01	1.058e-01	0.992	0.321489		+	Yes
factor(Time)2014_Q1	7.928e-02	1.296e-01	0.612	0.540865		+	Yes
factor(Time)2014_Q2	1.815e-01	1.064e-01	1.706	0.088440	.	+	Yes
factor(Time)2014_Q3	2.978e-01	1.070e-01	2.784	0.005538	**	+	Yes
factor(Time)2014_Q4	1.439e-01	1.052e-01	1.368	0.171700		+	Yes
factor(Time)2015_Q1	1.208e-01	1.094e-01	1.104	0.269869		+	Yes
factor(Time)2015_Q2	3.745e-01	1.126e-01	3.326	0.000933	***	+	Yes
factor(Time)2015_Q3	3.917e-01	1.132e-01	3.462	0.000574	***	+	Yes
factor(Time)2015_Q4	3.683e-01	1.079e-01	3.413	0.000685	***	+	Yes
factor(Time)2016_Q1	2.816e-01	1.128e-01	2.497	0.012772	*	+	Yes
factor(Time)2016_Q2	5.070e-01	1.208e-01	4.195	3.13e-05	***	+	Yes
factor(Time)2016_Q3	3.466e-01	1.059e-01	3.272	0.001130	**	+	Yes
factor(Time)2016_Q4	3.553e-01	1.049e-01	3.387	0.000751	***	+	Yes
factor(Time)2017_Q1	3.302e-01	1.226e-01	2.694	0.007259	**	+	Yes
factor(Time)2017_Q2	3.529e-01	1.120e-01	3.152	0.001703	**	+	Yes
factor(Time)2017_Q3	3.367e-01	1.056e-01	3.189	0.001500	**	+	Yes
factor(Time)2017_Q4	4.866e-01	1.068e-01	4.557	6.26e-06	***	+	Yes
factor(Time)2018_Q1	3.544e-01	1.184e-01	2.994	0.002863	**	+	Yes
factor(Time)2018_Q2	3.522e-01	1.073e-01	3.283	0.001087	**	+	Yes
factor(Time)2018_Q3	4.735e-01	1.081e-01	4.380	1.39e-05	***	+	Yes
factor(Time)2018_Q4	4.223e-01	1.126e-01	3.750	0.000194	***	+	Yes
factor(Time)2019_Q1	5.669e-01	1.157e-01	4.901	1.23e-06	***	+	Yes
factor(Time)2019_Q2	4.082e-01	1.076e-01	3.795	0.000162	***	+	Yes
factor(Time)2019_Q3	4.753e-01	1.092e-01	4.354	1.57e-05	***	+	Yes
factor(Time)2019_Q4	5.811e-01	1.142e-01	5.090	4.77e-07	***	+	Yes
Age	-4.521e-02	3.457e-03	-13.077	< 2e-16	***	-	Yes
Age_sq	7.964e-04	8.991e-05	8.857	< 2e-16	***	-	No
BuildingTypeBuilding_over10	-6.487e-02	1.224e-01	-0.530	0.596239		+	No
BuildingTypeBuilding_under10	7.777e-02	1.057e-01	0.735	0.462361		+	Yes
BuildingTypeCommercialBuilding	3.437e-01	2.263e-01	1.519	0.129305		+	Yes
BuildingTypeFarmhouse	3.697e-01	2.772e-01	1.334	0.182798		?	-
BuildingTypeOthers	3.279e-01	2.079e-01	1.578	0.115174		?	-
BuildingTypeSingleHouse	3.145e-01	1.022e-01	3.078	0.002179	**	+	Yes
BuildingTypeStore	7.049e-01	1.494e-01	4.717	2.97e-06	***	+	Yes
BuildingTypeSuite	-5.055e-01	1.378e-01	-3.670	0.000264	***	-	Yes
TransArea	2.422e-03	2.477e-04	9.774	< 2e-16	***	+	Yes
TransLot	3.014e-04	1.203e-04	2.506	0.012470	*	+	Yes
Bedrooms	5.729e-02	1.543e-02	3.712	0.000225	***	+	Yes
Livingrooms	6.294e-02	2.180e-02	2.887	0.004029	**	+	Yes
Bathrooms	4.367e-02	1.677e-02	2.604	0.009431	**	+	Yes
factor(ParkIncluded)1	8.597e-02	1.045e-01	0.823	0.411066		+	Yes
DistanceToCBD	-2.817e-02	3.580e-03	-7.870	1.62e-14	***	-	Yes
DistanceToHSR	-1.685e-03	3.239e-03	-0.520	0.603150		-	Yes

Appendix 2(continued)

DistanceToIC	2.625e-02	6.508e-03	4.033	6.19e-05	***	-	No
factor(TrainStationsNearby)1	-7.181e-02	5.999e-02	-1.197	0.231820		+	No
factor(BusStopNearby)1	-7.196e-02	3.405e-02	-2.113	0.034967	*	+	No
factor(ParkNearby)1	4.421e-02	3.582e-02	1.234	0.217653		+	Yes
factor(HospitalNearby)1	4.823e-02	4.561e-02	1.057	0.290723		+	Yes
factor(SchoolNearby)1	4.235e-02	3.590e-02	1.180	0.238485		+	Yes

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3715 on 611 degrees of freedom
Multiple R-squared: 0.7657
Adjusted R-squared: 0.7442
F-statistic: 35.65 on 56 and 611 DF
p-value: < 2.2e-16

Appendix 3: Results of Model 3 (Box-Cox Model for Taoyuan)

Coefficients:	Estimate	Std. Error	t value	Pr(>|t|)		Expected Sign	As Expected
(Intercept)	93.388262	9.934258	9.401	< 2e-16	***	+	Yes
factor(ZoneType)BusinessDistrict	7.439830	5.744625	1.295	0.195774		+	Yes
factor(ZoneType)IndustrialDistrict	-7.173036	6.093301	-1.177	0.239571		-	Yes
factor(ZoneType)Others	2.801016	5.547647	0.505	0.613809		?	-
factor(ZoneType)ResidentialDistrict	4.231862	5.553718	0.762	0.446360		+	Yes
TransactionTypeBuilding_Land	26.823627	7.476239	3.588	0.000360	***	+	Yes
factor(Time)2013_Q2	3.154416	2.821046	1.118	0.263930		+	Yes
factor(Time)2013_Q3	5.347250	2.846539	1.879	0.060784	.	+	Yes
factor(Time)2013_Q4	2.859917	2.876095	0.994	0.320431		+	Yes
factor(Time)2014_Q1	7.285994	2.794048	2.608	0.009337	**	+	Yes
factor(Time)2014_Q2	6.407657	2.697240	2.376	0.017824	*	+	Yes
factor(Time)2014_Q3	4.725891	3.249474	1.454	0.146358		+	Yes
factor(Time)2014_Q4	7.628017	2.720737	2.804	0.005212	**	+	Yes
factor(Time)2015_Q1	2.169610	3.037454	0.714	0.475321		+	Yes
factor(Time)2015_Q2	9.358138	2.738082	3.418	0.000673	***	+	Yes
factor(Time)2015_Q3	6.928869	2.780857	2.492	0.012978	*	+	Yes
factor(Time)2015_Q4	7.547066	2.966742	2.544	0.011206	*	+	Yes
factor(Time)2016_Q1	6.902419	3.006568	2.296	0.022024	*	+	Yes
factor(Time)2016_Q2	7.972567	2.700026	2.953	0.003269	**	+	Yes
factor(Time)2016_Q3	11.234140	2.790106	4.026	6.37e-05	***	+	Yes
factor(Time)2016_Q4	11.044849	3.190717	3.462	0.000574	***	+	Yes
factor(Time)2017_Q1	7.036274	2.805089	2.508	0.012384	*	+	Yes
factor(Time)2017_Q2	13.095139	2.749724	4.762	2.39e-06	***	+	Yes
factor(Time)2017_Q3	10.881919	2.757921	3.946	8.87e-05	***	+	Yes
factor(Time)2017_Q4	11.388259	3.230769	3.525	0.000455	***	+	Yes
factor(Time)2018_Q1	11.805655	2.849974	4.142	3.92e-05	***	+	Yes
factor(Time)2018_Q2	8.698229	2.737295	3.178	0.001559	**	+	Yes
factor(Time)2018_Q3	9.137561	2.867582	3.187	0.001513	**	+	Yes
factor(Time)2018_Q4	11.151998	3.033587	3.676	0.000257	***	+	Yes
factor(Time)2019_Q1	9.375698	2.926615	3.204	0.001427	**	+	Yes
factor(Time)2019_Q2	12.721613	2.673277	4.759	2.43e-06	***	+	Yes
factor(Time)2019_Q3	10.522461	2.836845	3.709	0.000227	***	+	Yes
factor(Time)2019_Q4	12.202115	3.222985	3.786	0.000168	***	+	Yes
Age	-1.002977	0.120383	-8.332	5.21e-16	***	-	Yes
Age_sq	0.014897	0.003197	4.659	3.90e-06	***	-	No
BuildingTypeBuilding_over10	3.406926	1.898974	1.794	0.073290	.	+	No
BuildingTypeBuilding_under10	3.241758	1.900049	1.706	0.088486	.	+	Yes
BuildingTypeCommercialBuilding	5.673169	5.015839	1.131	0.258474		+	Yes
BuildingTypeFarmhouse	16.483009	7.995426	2.062	0.039670	*	?	-
BuildingTypeOthers	-13.105307	4.488159	-2.920	0.003629	**	?	-
BuildingTypeSingleHouse	7.077587	1.896992	3.731	0.000208	***	+	Yes
BuildingTypeStore	23.121529	3.543918	6.524	1.43e-10	***	+	Yes
BuildingTypeSuite	-8.363229	2.445122	-3.420	0.000667	***	-	Yes
TransArea	0.157857	0.006638	23.781	< 2e-16	***	+	Yes
TransLot	0.050625	0.013001	3.894	0.000109	***	+	Yes
Bedrooms	1.259050	0.629756	1.999	0.046019	*	+	Yes
Livingrooms	-1.082714	0.775844	-1.396	0.163360		+	No
Bathrooms	1.178727	0.733342	1.607	0.108494		+	Yes
factor(ParkIncluded)1	-2.462403	1.187121	-2.074	0.038470	*	+	No
DistanceToCBD	-0.867856	0.086575	-10.024	< 2e-16	***	-	Yes
DistanceToHSR	-0.506516	0.115789	-4.374	1.43e-05	***	-	Yes

Appendix 3(continued)

DistanceToIC	-0.944335	0.224914	-4.199	3.08e-05	***	-	Yes
factor(TrainStationsNearby)1	4.364530	1.196163	3.649	0.000286	***	+	No
factor(BusStopNearby)1	2.009965	0.949183	2.118	0.034612	*	+	No
factor(ParkNearby)1	1.370025	0.980316	1.398	0.162757		+	Yes
factor(HospitalNearby)1	1.368981	1.219325	1.123	0.261987		+	Yes
factor(SchoolNearby)1	0.465310	0.949790	0.490	0.624373		+	Yes

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Lambda = 0.2222222

Likelihood ratio test
Log-Likelihood = -2454.6
Chi-sq = 1227
p-value < 2.2e-16 ***

Appendix 4: Results of Model 4 (Box-Cox Model for Yunlin)

Coefficients:	Estimate	Std. Error	t value	Pr(>|t|)		Expected Sign	As Expected
(Intercept)	81.141008	7.998227	10.145	< 2e-16	***	+	Yes
factor(ZoneType)BusinessDistrict	4.199165	5.537019	0.758	0.448516		+	Yes
factor(ZoneType)IndustrialDistrict	1.274345	5.791893	0.220	0.825927		-	No
factor(ZoneType)Others	-7.771892	5.238683	-1.484	0.138442		?	-
factor(ZoneType)ResidentialDistrict	3.518105	5.191345	0.678	0.498227		+	Yes
TransactionTypeBuilding_Land	21.742592	4.419200	4.920	1.11e-06	***	+	Yes
factor(Time)2013_Q2	5.441297	3.400404	1.600	0.110073		+	Yes
factor(Time)2013_Q3	7.592811	3.151072	2.410	0.016265	*	+	Yes
factor(Time)2013_Q4	3.436251	3.076007	1.117	0.264384		+	Yes
factor(Time)2014_Q1	4.570138	3.766285	1.213	0.225433		+	Yes
factor(Time)2014_Q2	7.019001	3.092182	2.270	0.023560	*	+	Yes
factor(Time)2014_Q3	9.508458	3.108967	3.058	0.002323	**	+	Yes
factor(Time)2014_Q4	4.622076	3.057630	1.512	0.131139		+	Yes
factor(Time)2015_Q1	3.794655	3.180560	1.193	0.233302		+	Yes
factor(Time)2015_Q2	11.990322	3.272624	3.664	0.000270	***	+	Yes
factor(Time)2015_Q3	12.813941	3.289151	3.896	0.000109	***	+	Yes
factor(Time)2015_Q4	11.281471	3.136426	3.597	0.000348	***	+	Yes
factor(Time)2016_Q1	9.026002	3.277930	2.754	0.006070	**	+	Yes
factor(Time)2016_Q2	15.559473	3.512248	4.430	1.12e-05	***	+	Yes
factor(Time)2016_Q3	12.114244	3.079087	3.934	9.30e-05	***	+	Yes
factor(Time)2016_Q4	10.712689	3.048456	3.514	0.000474	***	+	Yes
factor(Time)2017_Q1	10.549358	3.563358	2.961	0.003190	**	+	Yes
factor(Time)2017_Q2	11.072444	3.254212	3.402	0.000711	***	+	Yes
factor(Time)2017_Q3	10.386568	3.068262	3.385	0.000757	***	+	Yes
factor(Time)2017_Q4	15.159454	3.103416	4.885	1.32e-06	***	+	Yes
factor(Time)2018_Q1	11.654829	3.440621	3.387	0.000751	***	+	Yes
factor(Time)2018_Q2	10.977799	3.118233	3.521	0.000463	***	+	Yes
factor(Time)2018_Q3	14.829345	3.142100	4.720	2.93e-06	***	+	Yes
factor(Time)2018_Q4	14.154137	3.273057	4.324	1.79e-05	***	+	Yes
factor(Time)2019_Q1	18.368580	3.362187	5.463	6.81e-08	***	+	Yes
factor(Time)2019_Q2	13.109261	3.126685	4.193	3.16e-05	***	+	Yes
factor(Time)2019_Q3	15.059099	3.173208	4.746	2.59e-06	***	+	Yes
factor(Time)2019_Q4	17.886267	3.318066	5.391	1.00e-07	***	+	Yes
Age	-1.315204	0.100488	-13.088	< 2e-16	***	-	Yes
Age_sq	0.023101	0.002613	8.839	< 2e-16	***	-	No
BuildingTypeBuilding_over10	-2.812417	3.556642	-0.791	0.429396		+	No
BuildingTypeBuilding_under10	0.820478	3.073677	0.267	0.789608		+	Yes
BuildingTypeCommercialBuilding	5.038497	6.576726	0.766	0.443907		+	Yes
BuildingTypeFarmhouse	13.764070	8.056470	1.708	0.088061	.	?	-
BuildingTypeOthers	14.291237	6.041946	2.365	0.018325	*	?	-
BuildingTypeSingleHouse	9.315339	2.970384	3.136	0.001795	**	+	Yes
BuildingTypeStore	22.371629	4.343187	5.151	3.50e-07	***	+	Yes
BuildingTypeSuite	-13.245331	4.003949	-3.308	0.000995	***	-	Yes
TransArea	0.074422	0.007201	10.335	< 2e-16	***	+	Yes
TransLot	0.007672	0.003495	2.195	0.028539	*	+	Yes
Bedrooms	1.475978	0.448621	3.290	0.001059	**	+	Yes
Livingrooms	1.754657	0.633676	2.769	0.005793	**	+	Yes
Bathrooms	1.586740	0.487450	3.255	0.001196	**	+	Yes
factor(ParkIncluded)1	3.099868	3.037902	1.020	0.307944		+	Yes
DistanceToCBD	-0.921723	0.104047	-8.859	< 2e-16	***	-	Yes
DistanceToHSR	-0.072220	0.094140	-0.767	0.443288		-	Yes

Appendix 4(continued)

DistanceToIC	0.933991	0.189161	4.938	1.02e-06	***	-	No
factor(TrainStationsNearby)1	-1.288739	1.743776	-0.739	0.460160		+	No
factor(BusStopNearby)1	-1.880479	0.989684	-1.900	0.057893	.	+	No
factor(ParkNearby)1	1.437233	1.041227	1.380	0.167991		+	Yes
factor(HospitalNearby)1	1.813174	1.325712	1.368	0.171909		+	Yes
factor(SchoolNearby)1	1.234156	1.043322	1.183	0.237305		+	Yes

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Lambda = 0.2222222

Likelihood ratio test
Log-Likelihood = -2507.5
Chi-sq = 1005.4
p-value < 2.2e-16 ***