Identifying the Impacts of Union Stations on Housing Price in Kaohsiung City, Taiwan

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Abstract:

The aim of this study is to investigate the impacts of proximity to different mass rapid transit (MRT) stations on housing price in Kaohsiung City, Taiwan, in terms of the number of their transit lines. Kaohsiung is the only city in Taiwan where more than four different transit services were developed and built jointly in/around MRT stations as union stations, i.e. High-speed Rail (HSR), Light Rail Transit (LRT) and Commuter Rail Transit (CRT). Constructing such union stations is a way of implementing Transit-oriented Development (TOD) to synergize land use and transportation for promoting accessibility and sustainability in cities. This could lead to an increase in land value and housing price around the TOD project due to the increased proximity to the transit station. The uplift for housing price has been well studied by analyzing single stations or comparing stations across cities; however, little attention was paid to different types of transit union stations, where multiple transit rail lines converge. This study proposes that a union station project, in particular, could lead to a greater increase in the housing price due to its greater connectivity. This study hypothesized that if more types of transit lines are jointly constructed in a union station, it will bring about a larger effect on lifting housing price. The study collected housing transaction data from a real estate information system published by the Department of Land Administration, Taiwan, and built four regression models to test the hypotheses. The results show that union stations generally have larger impacts on lifting housing price, but rejected the hypothesis that three-modal union stations can exert a larger impact on housing price than two-modal union stations. The discussions and limitations are noted in the conclusion for further study.

Keywords: transit-oriented development; union station; housing price

Introduction

Transit-oriented Development (TOD) aims at synergizing land use and transportation to guide city development, by providing various benefits — reduced cost, time, congestion, clean air, walkable neighborhoods. The land around TOD projects thus could be valuable, uplifting neighboring housing price due to the increased proximity to transit stations.

The literature has cited accessibility provided by different types of transit stations as a factor positively influencing housing price significantly. The most common way of assessing how housing price is affected by the accessibility is to include the proximity factor in the analysis (Higgins and Kanaroglou, 2016, Duncan, 2011a). Some assessed the influence of single transit station, e.g. CRT station (Shi and Guo, 2009, Zhang *et al*., 2016), MRT station (Grass, 1992), LRT station (Hess and Almeida, 2007, Duncan, 2011b), and Bus Rapid Transit (BRT) station (Dubé *et al*., 2018).

The impacts of different transit services on land-value can be uneven (Cervero and Duncan, 2002), e.g. rail stations have a higher positive impact on the housing price compared to LRT and MRT stations (Debrezion *et al*., 2007). By comparing more than 130 analyses across 60 studies over 40 years, Higgins and Kanaroglou (2016) also found significant differences in changes to land value across transit modes, and concluded that MRT and CRT have larger impact on land value compared to LRT and BRT.

However, little attention was paid to different types of transit union stations in terms of what joint rail types are built in the stations. Although the uplift for housing price has been well studied by analyzing single stations and comparing these stations across cities. Station construction guided by TOD could take form in union stations, where different types of rail lines converge and share the facilities, in order to provide higher connectivity between among various rail line services, allowing the passengers conveniently transit.

This study proposed that union station projects, in particular, have a larger impact on the increase of housing price in the neighboring communities. That is, more types of transit services jointly constructed in a union station could bring about a larger effect on lifting housing price. Thus, it was hypothesized that union stations have a more powerful impact on housing price compared to single stations. Another hypothesis is that union stations constructed by three-modal union stations have more impacts on housing price than two-modal union stations. This study employed official housing transaction data and regression models to test the hypotheses.

This paper is structured as follows. First, the study area, data sources and methods used in this study are discussed. Second, research results are presented. Third, the results were discussed by comparing previous research, and suggestions are noted for further study in the conclusion.

Data and methods

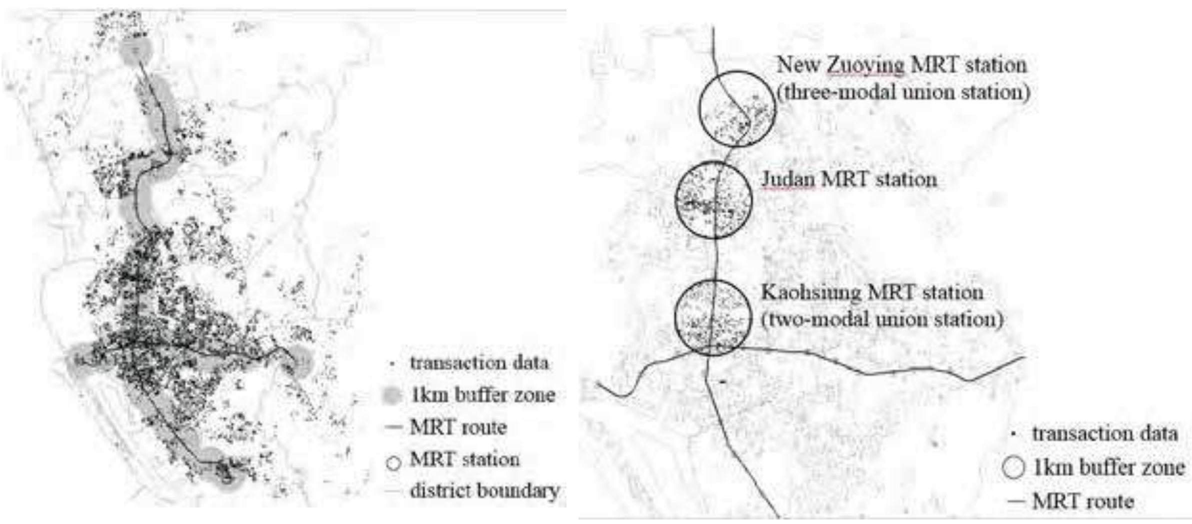
The empirical analysis in this study utilized multiple regression models to investigate the influence of proximity to stations on housing price. Prior to the model building, official housing transaction data in Kaohsiung were collected, and processed using ArcGIS. A model was then built for analyzing the transaction data within 1km to MRT stations in Kaohsiung, followed by three models being built for investigating the difference in influences of three types of stations, namely three-modal union station, two-modal union station and one-modal station.

Data collection and processing

Kaohsiung provides a particularly rich setting for studying how the housing price is impacted by different transit stations. It has four different modes of public transportation, i.e. MRT, LRT, HSR, and CRT, which is a trait other cities in Taiwan do not share.

The study employed housing transaction data for the empirical analyses, which consist of houses, apartments, and condominiums. The core data were drawn from the official website, a real estate information system published by the Department of Land Administration, Ministry of Interior, Taiwan, covering the information about real estate transactions from 2011 to 2015. In total, 174,913 housing transaction data were obtained, as shown in Figure 1(a).

According to the number of transit lines jointly built in an MRT station, this study specified three types of MRT stations as representatives, i.e. New Zuoying Station as a representative for three-modal union stations (MRT, HSR and CRT), Kaohsiung MRT Station for two-modal union stations (MRT and CRT) and Judan Station for one-modal stations (MRT only), as shown in Figure 1(b). The study used only those transaction data within 1km from the stations because people generally are willing to have a 10 minute walk to MRT station (Dwess, 1975; Anas and Duann, 1985), and particularly around 1km in Taiwan (Chen, 2016, Lin and Hwang, 2003, Tai *et al*., 2011).



(a) 1km buffer zones of all MRT stations (b) three representative stations

Figure 1 Transaction data in 1 km buffer zones of MRT stations in Kaohsiung

The data contain detailed records of transactions which include the transaction price, transaction site and transaction date, and various attributes, including property type, floor area, and floor level. This study used Geographic Information System (GIS) tools to extract the transactions within a 1km radius to the closest stations; 14,825 housing transactions were specified as those near the MRT stations out of 174,913 housing transactions. Among 14,825 transactions, 839 of them are within 1km proximity to New Zuoying Station, 1,231 to Kaohsiung Station, and 2,086 to Judan Station, as shown in Figure 1(b).

Table 1 presents the descriptive statistics of the data. Within 1km buffer zone of MRT stations in Kaohsiung City, the housing price is ranged from TWD 10,000 to 104,413,300, with an average price of TWD 7,859,500. The average floor area is 151 m^2. Around 18% of the housing sold are terraces, and about 37% of the housing sold are located in the commercial zone.

Table 1 Descriptive statistics of housing transaction data

Vector	Variable		Code	Min.	Max.	Mean	Std.
Structural	Housing price	(TWD 1,000)	PRC	10.00	10441.33	785.95	1416.07
	Floor area	(m^2)	HSAR	5.91	4752.09	151.23	147.10
	Fourth floor	(1: yes)	STOR	0	1	0.08	0.28
	Building type (Terrace or not)	(1: yes)	TYPE	0	1	0.18	0.38
Neighborhood	Commercial zone	(1: yes)	COM	0	1	0.37	0.48
Proximity	Distance to station	(meter)	ST_DIS	21.98	999.19	559.34	232.89

Source: Ministry of Interior, Taiwan

The exchange rate is USD 1 to TWD 33

Due to the fluctuation of GDP, the data before 2015 were adjusted by the consumer price index (CPI) and GDP deflator, as listed in Table 2.

Table 2 GDP deflator in Taiwan (2015 as base year)

Year	2011	2012	2013	2014	2015
CPI	100	101.93	102.74	103.97	103.65
GDP deflator	1.036	1.016	1.008	0.996	1

Source: Directorate General of Budget, Accounting and Statistics, Taiwan

Model specification

Empirical studies mainly employ four model specifications for housing price estimation, namely linear, semi logarithmic, double logarithmic, and log-linear (Debrezion *et al*., 2007), which were all employed in this study. The basic linear regression model for estimating the housing price is given by Eq.1 below.

$$P_i=f(X_i,Y_i,Z_i) \tag{1}$$

The dependent variable P_i is the estimated price of housing i, X the vector of structural characteristics (e.g. floor area), Y the neighborhood characteristics, and Z the vector that measures proximity to the transit station. As shown in Table 1, the vector X includes housing price, floor area, floor level (fourth floor or not), and building type (terrace or not). The neighborhood vector attribute is property location (whether it is located in a commercial zone). The vector Z includes distance to the nearest station. Six variables were included to explain the housing price. Accordingly, the above model was refined as the following model given by Eq.2.

$$PRC_i=\beta_0+\beta_1(HSAR)_i+\beta_2(COM)_i+\beta_3(STOR)_i+\beta_4(TYPE)_i+\beta_5(ST\_DIS)_i \tag{2}$$

HSAR represents housing area; TYPE is whether the housing sold is located in a commercial zone; COM shows if the housing sold is a terrace. STOR means whether a transaction involves the fourth floor, as people tend not to buy a housing on the fourth floor, which shares a same pronunciation of death in Taiwanese (Lin *et al*., 2012). Since variables COM, STOR and TYPE are dummy variables, this study adjusted the double logarithmic model accordingly as follows.

$$\ln PRC = \beta_0 + \ln \beta_1 (HSAR) + \beta_2 (COM) + \beta_3 (STOR) + \beta_4 (TYPE) + \ln \beta_5 (ST_{DIS}) \quad (3)$$

Results

This section explains the result of each model. Prior to investigating influences of different union stations using three local models, a global model was built to fit the data within 1km buffer zones of all MRT stations in Kaohsiung.

The global models for all MRT stations in Kaohsiung

This study first confirmed that the correlations among variables are low enough to not cause the collinearity effect. Table 3 shows the highest correlation among the five variables is less than 0.3, suggesting all variables are not considered highly correlated.

Table 3 Result of the correlation analysis

	HSAR	COM	STOR	TYPE	ST_DIS
HSAR	1				
COM	.044	1			
STOR	-.050	-.030	1		
TYPE	.028	-.222	-.142	1	
ST_DIS	.003	-.243	.005	.090	1

The results of the four regression models are listed in Table 4. Each variable in the four models has a high explanatory power at the 99% confidence level, as shown in Table 4. This means all independent variables could help explain the housing price within the 1km buffer zone of all MRT stations in the study area. Among the four models, the double logarithmic model has the highest explanatory power with an R2 of 0.718, followed by the linear, log-linear, and semi logarithmic models.

Table 4 Effects of the independent variables on housing price in four regression models

	Linear		Double logarithmic		Log-linear		Semi logarithmic	
	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value
Const.	-139.285	*** .000	0.586	*** .000	5.663	*** .000	-3865.11	*** .000
HSAR	6.646	*** .000	1.234	*** .000	.004	*** .000	1159.237	*** .000
COM	88.636	*** .000	.190	*** .000	.084	*** .000	217.382	*** .000
STOR	-92.533	** .002	-.194	*** .000	-.283	*** .000	-111.472	** .002
TYPE	221.926	*** .000	.285	*** .000	.368	*** .000	227.307	*** .000
ST_DIS	-.258	*** .000	-.067	*** .000	-.001	*** .000	-167.543	*** .000
Adjusted R^2	0.493		0.718		0.388		0.270	

*p<0.05 **p<0.01 ***<0.001

The signs of coefficients for HSAR, COM and TYPE are all positive, showing that housing price tends to be higher due to greater floor area, neighboring commercial area and building type (terrace). The signs of STOR and ST_DIS are both negative, suggesting the presence of the fourth floor and a greater distance to station would lead to a lower housing price.

In the linear model, it suggests when an increase of 100m in distance to station, a drop in housing price of TWD 258,000 could be expected. In the double logarithmic model, when the distance increase by 0.1%, the housing price would drop by 0.07% at 95% confidence level.

The local models for New Zuoying, Kaohsiung, and Judan MRT stations

To test the hypothesis proposed in this study, three representative stations were chosen for their different mode types in the union station. The New Zuoying Station has three railways, i.e. HSR, CRT, and MRT; the Kaohsiung Station has two railways, i.e. commuter rail and MRT; the Judan Station has only MRT. Since the double logarithmic model has a higher explanatory power among global models. It is used to test the hypotheses. The results are shown in Table 5.

Table 5 Results of the local model

	New Zuoying		Kaohsiung		Judan	
	coefficient	p-value	coefficient	p-value	coefficient	p-value
Const.	1.267	*** .000	1.387	*** .000	.631	*** .000
HSAR	1.181	*** .000	1.229	*** .000	1.255	*** .000
COM	.120	*** .000	.077	*** .000	.112	*** .000
STOR	-.029	.440	-.145	* .010	-.112	*** .000
TYPE	.466	*** .000	.545	*** .000	.178	*** .000
ST_DIS	-.123	*** .004	-.182	*** .000	-.045	** .004
Adjusted R^2	0.770		0.798		0.757	

*p<0.05 **p<0.01 ***<0.001

It was initially hypothesized that more modals in a union station would have a greater influence on housing price and thus have a larger elasticity. Thus, three null hypotheses are proposed, i.e. $\beta^{ZUO}_{ST\_DIS} = \beta^{JU}_{ST\_DIS}$, $\beta^{KAO}_{ST\_DIS} = \beta^{JU}_{ST\_DIS}$ and $\beta^{ZUO}_{ST\_DIS} = \beta^{KAO}_{ST\_DIS}$.

The first two hypotheses are rejected as the F-values are 160.3 and 130.58, compared to the critical value of 3.12 (df=5, ∞). Hence the reduction in the elasticity is therefore significant at the 95% level, indicating that the union stations generally have larger impacts on housing price than single-modal stations. However, comparing the coefficients of ST_DIS in the New Zuoying model, and Kaohsiung model shows that the influence of Kaohsiung MRT Station as a two-modal station is larger than that of New Zuoying MRT station.

Conclusions

The impact of transit station proximity on housing price has received wide attention in the transport and land economic literature. Several studies investigated the impact by analyzing a certain mode of transit station or comparing different modes of a transit station. This study further introduced a new factor, the number of transit mode in station, to explore the difference in the impacts on housing price. This study confirmed that union transit stations have larger impacts on housing price as the elasticity of proximity with respect to housing price is greater. However, the results show that the impact of three-modal stations is not greater than that of two-modal stations.

The Kaohsiung MRT station is built before the New Zuoying Station and its influence on the housing market might inherently be larger. The study found that the housing price fluctuation is significantly higher between 2010 and 2015, compared to Wu (2010) that employed data from 1997 to 1999 and suggested an increase of TWD 38,000 when a drop of 100m in proximity to the MRT station. This indicates that further study should take temporal factor into account.

Moreover, a bus transit hub is located near the Kaohsiung MRT station, which is considered in the study as it is not physically constructed in the station. Nevertheless, further study could attempt to include other transit services near the union stations.

On the other hand, HSR in the New Zuoying station provides regional transit instead of intra-city transit service, which possibly reduce the impact on local housing price. Further study could expand the research scope to include different cities that also have HSR to confirm that inter-city transit rail has less impact on the local housing market. Different combinations of modes in union stations could also be explored, e.g. MRT station combined with LRT, or that with HSR, for a deeper understanding of their influences on housing price.

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