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Impacts of Changes in Traffic Conditions on Preference for Public Apartments

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Abstract. The metro station can form a new commercial district. The residential development in the outskirts has a major impact on the value of real estate. However, the area near the metro station can be wrongfully affected due to the structure and function of the railway station, noise or congestion, etc. This study aims to analyze how changes in traffic conditions affect the apartments. The opening of the urban road is considered as traffic change. Regarding it, the price trend will be investigated. There is an assumption that preference will grow when opened. Daegu Subway Line 3 in Korea, which opened in 2015, is selected. It is the relatively recent case. Sales price of apartment houses included in the station area and apartment houses outside the station area is obtained, from which we calculate the rate of change. The difference between station area and non-station area was analyzed under two hypotheses whether it existed or not. The 2015 case and after-one-year case were compared. The subway station proved to raise housing price. T-test was utilized to confirm the reliability of the results. They were significant at the 95% confidence level of the two-sided test. Consequently, the station apparently tends to increase public housing price.

Keywords: Subway, selling price, public housing, preference, transportation

1. Introduction

Currently, the Korean government has plans to increase the supply of housing through urban regeneration. The supply rate is over 100%, and public housing accounts for 60% (Kang 2019). As the demand for it rises, the price also does. According to Korean Statistical Information Service (KOSIS), the trend of price rising continued from 2006 to 2011 and became more dramatic in 2021. The market principle of balancing supply and demand seems to be active (Jang 2009).

The factors that affect public housing price are categorized in many ways, which are location characteristics, complex characteristics, generation characteristics, and socio-economic characteristics (Choi 2017). It can also be determined as various residential factors such as the characteristics of each house, the characteristics of the complex, and the characteristics of the location. The desire, preference, and spending pattern of buyers are possible to impact the price. Especially, location conditions such as accessibility to nearby facilities, surrounding commercial districts and school districts, and natural environmental characteristics can determine the land price, which leads to price changing depending on regions. As buyers prefer better location, the apartment price tends to rise.

The traits of prices were examined by Choi Yoon-ah for new public apartments. Location factors such as neighboring roads or accessibility was thought to make the most distinct differences in prices (Choi 2007). In addition, the public transportation became better, the more likely consumers to choose (Sung 2012). Accordingly, it could be one of the meaningful conclusions.

Studying traffic change is limited to urban railroads. They are more expensive compared to buses but offers mass transportation. They are operated in large cities, which have some good effects. The railway can play a role as the axis of transportation. New commercial and residential area will be located. In doing so, decentralization of regional development and urban concentration can be achieved (Park 2011). Especially, the proximity of the station has impacts on residence. This tendency applies to selling new public apartments. Besides stations, social, economic, environmental and administrative factors are intertwined with land use and traffic conditions, which are obviously included in price factors. However, the most significant factor can be accessibility (Kim 2009).

Accessibility does not always provide good effects. Adjacent houses to stations are exposed to noise pollution or congestion. A previous study shows that in the case of being 200 meters close to station, price is possible to decline (Lee 2011). The purpose of this study is to figure out how building subways can affect housing price. We investigate correlations between changes in traffic environment and preference.

In this study, traffic change is assumed to be railway opening. Preference is represented as price. The data of Daegu Subway Line 3 is the most abundant, which is the reason for selecting.

This study is conducted as shown in Figure 1. Literature review of relevant topics, specifically the housing price of public apartments, was conducted. Moreover, targets for investigating are chosen by limiting station area. The prices and areas before and after station opening are collected. The rate of increase and decrease are obtained based on prices. Then, T-test is performed to improve the reliability of the obtained data. This study presents the correlations between traffic change and housing preference through T-test method.

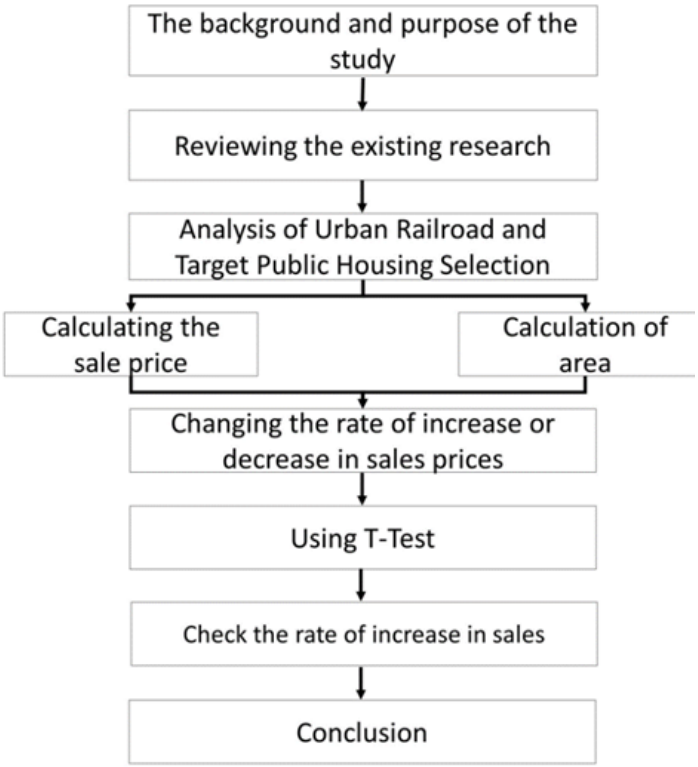

Fig. 1: Regional Apartment Sales Price Index (Korea Real Estate Agency, Real Estate Statistics Viewer).=

2. Literature Study

2.1. Station area

The meaning of station area can vary depending on study purpose or legal regulation. First, in terms of accessibility, there exists the maximum distance where pedestrians can access (Ahn 2021). Secondly, it refers to the population using railroad stations and the nature of use, which affect the railway area. Third, the area can be developed as the center, leading to ground and underground development. Fourth, land and house prices are affected by establishment of station which is among spatial characteristics such as land use, floor area ratio, and building-to-land ratio. Fifth, it is

the spatial scope of services in the public domain, market domain, and environmental city domain. It is formed around stations (Choi, 2005). The concept of station area is legally defined which is the most common. Figure 2 shows the range of the station area presented by Busan Metropolitan City, Korea. The train site is 200 meters, the direct station area is 500 meters, and the indirect station area is 1500 meters. (Lew Seung-hwan 2011) suggested that 100 to 500 meters are near area. 500 to 800 meters are named the influence area, 800 to 1000 meters are called the station influence area. The direct area means within a 5-minute walk within 500 meters, close to station. The indirect means a 10-15 minute walk within 1,000 meters excluding the direct station. The classification is diverse, and they have their own significance each. Based on previous studies, station area refers to a pedestrian zone that can be accessed by pedestrians centered on the station.

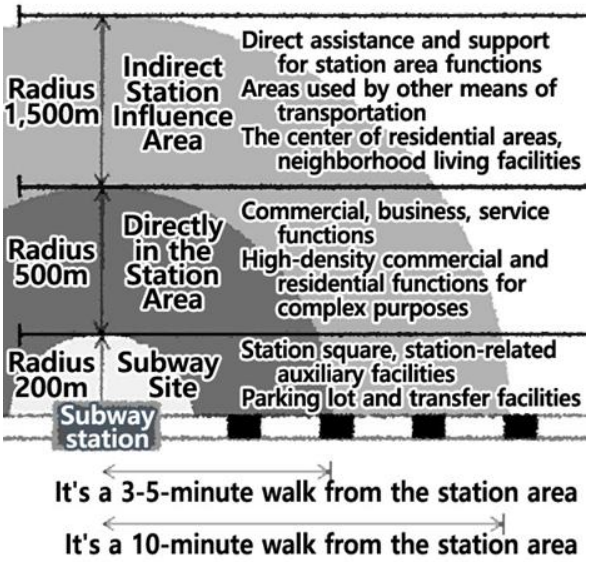

Fig. 2: A study on the station area (Busan Metropolitan City Hall, 2021)

2.2. Previous research

(Choi 2017) analyzed the priorities of housing price range through Fuzzy-ANP analysis. Factors affecting prices were established as 4 high-level categories and 15 low-level evaluation indicators. The correlation among indicators were brainstormed by experts and a questionnaire was prepared. Based on the survey results, weights were obtained. The weight was prioritized in the order of location characteristics, complex characteristics, socioeconomic characteristics, and generation characteristics. Location characteristics account for more than half, which seems to be very dominant. Location factors were the most significant. Other details such as transportation convenience, nearby commercial districts, convenience facilities, etc. proved to have some effects.

Table 1. Factors that form apartment prices (Hyunggeun Choi, 2017)

Sortation	Weight	Priority
Location characteristics	0.49	1
Zone characteristics	0.24	2
Generation characteristics	0.07	4
Socioeconomic characteristics	0.21	3

(Chung 2008) compared apartment price and residential service demand and usage with HPI. Systemic preference was presented using AHP. Based on it, price factors were suggested. (Hwang 2021) attempted to investigate how urban renewal affected prices using the hedonic price model. The project was divided by five stages. At all key stages, prices were confirmed to be rising.

(Gayer and Viscusi 2002) analyzed the way the amount of articles about Superfunds for Hazardous Waste Sites in newspapers affected prices by utilizing the iterative trading model. The study confirmed that article's amount could have some positive impacts on prices.

(Lee 2016) conducted how corelated part location and housing price were, targeting for Busan Metropolitan City, Korea, founded on relevant data. The apartment house was selected by the network analysis of the Geographic Information System (GIS) program. The data was extracted from the Ministry of Land, Infrastructure and Transport. It concluded that parks were possible to have some negative impacts on prices when centered in the city. Table 2 shows the previous studies related to the analysis of factors affecting prices.

Table 2: Analysis of factors affecting the sale price of apartment houses previous study

Author(year)	Research Content
Chung Jae Young (2008)	Analysis of factors affecting public housing prices by using previ ous approach with AHP, which features preference
Hwang Dong Heon (2021)	Analysis of the way city renewal can affect prices by using the he donic price model.
Gayer & Viscusi (2002)	Analysis of the way the articles' amount can affect prices through the iterative trading model.
Lee Go Eun (2016)	Analysis of the way park location can affect prices.

(Ma Chang Wook 2020) performed the study by dividing it into a treatment group and a control group. The treatment group has apartments within 500 meters from the station. The control group includes those within 500 to 1000 meters from the station.

Opening new railroads can lead to establishing new station area, which cause people to change their life styles. Naturally, it can pull the prices of the public houses.

(Lee Cheol Woo 2011) analyzed the cases in Daegu Metropolitan City, Korea as of April 2011. Based on the hedonic pricing technique, it was confirmed that subway area had some positive effects on prices. The more distant houses were from the station, the less expensive they were. Obviously, accessibility seemed to play a key role in raising prices.

(Kim Jae Won 2009) selected 156 apartment complexes that was sold near Daegu subway station, which were built from 2000 to 2006. Whether prices were affected by the shortest walking distance was examined. It proved that station affected prices by utilizing the hedonic price model for apartments within three kilometers. In addition, it showed that there was significance in the variables of flat size, year of sale, floor area ratio, highest floor, and distance to the city center.

(Kang Su Jin 2016) conducted an empirical analysis in a comprehensive way for 14 subway lines in Seoul to identify correlation between prices and stations. It was performed founded on the Box Cox method, which was an unconstrained function model of the hedonic price model.

(Lee Yong Hee 2018) focused on analyzing how the light rail affected the local real estate market. Official prices and various factors that were confirmed from previous studies were used. Multicollinearity was analyzed after verifying the correlation between variables. It was through regression analysis that showed that the average rate of price and household rising affected the land price. Within a radius of 500 meters to 1 kilometer, the ratio of floor area and the rate of houses increasing seemed to have some significant effects. Table 3 shows such precedent studies related to urban railroads.

Table 3. Previous studies analyzing price-pulling factors

Author (year)	Research Content
Ma Chang Wook (2020)	Difference-in-Difference Analysis was used to determine the effect of the new station area on prices of nearby apartments.
Lee Cheol Woo (2011)	Applied the hedonic price model to examine house prices in Daegu; It analyzed how the physical feature of apartments such as distance from station affected prices.
Kim Jae Won (2009)	Used the same tool for examining Daegu apartments, which were divided by a total, routes, autonomous districts, and stations; although the price became set reflecting the effect of the station area, there was no effect of the subway station area on the sale price.
Kang Su Jin (2016)	An empirical study to figure out how historic subway lines affect prices was performed through the use of the Box Cox method, which was a non-constrained hedonic price analysis model.

Lee Yong Hee (2018)	Focused on how correlated newly opened Ui station and house prices were; regression was constructed designating real prices and official prices dependent variables; 500 meters are the standard distance dividing station and non-station area; determining targets for analysis

3. Analysis Target Setting

3.1. Overall status of Daegu Urban railway in Korea

The survey data used was from June 2016. The actual transaction price disclosure system of the Ministry of Land, Infrastructure and Transport of Korea was used. The survey showed that Line 9 opened in 2009 and Ui-Sinseal Line opened in 2017 in Seoul. In Incheon, Line 2 opened in 2016. Line 3 in Deagu opened in 2015. The year 2006 is just three years away from the year when Line 9 opened (2009), which meant the small number of the samples. It is difficult to include it in investigation. Thus, data before 2009 should be excluded. Moreover, Ui-Sinseal Line and Line 2 in Incheon did not have the enough number of public apartments. The sample size was also not sufficient, which was excluded for the same reason. In consequence, Line 3 in Daegu became the target for research.

Line 3 in Daegu connected the Yongji area of Beommul-dong, Suseong-gu, Daegu Metropolitan City and Chilgok Kyungdae Hospital Station in Dongho-dong, Buk-gu, Daegu Metropolitan City. It is a city railway and operating system of public transit corporation. It is an over-seated monorail, whose interval is seven minutes during normal hours or five minutes during rush hours. It starts from 5:30 and runs around midnight. The actual distance from Chilgok Kyungdae Hospital Station to Beommulyongji Station is 23.95 kilometers. The project cost was 1,491.3 billion wons, and its construction had been ongoing from 2009 to 2015. The second plan of Line 3 is a plan to extend from Beommul-dong to Shinseo Innovation City. The distance is 13 kilometers, the project cost is 695.2 billion wons, and it is scheduled to be operating from 2019 to 2030.

As shown in Figure 3, the passenger number did not exceed 20 million. It increased dramatically since 2016 and exceeded 25 million in 2019. However, the aftermath of COVID-19 pandemic would be the main cause to decrease the number. If the pandemic was over, it could be crowded with passengers, and consequently building railroads could become more important.

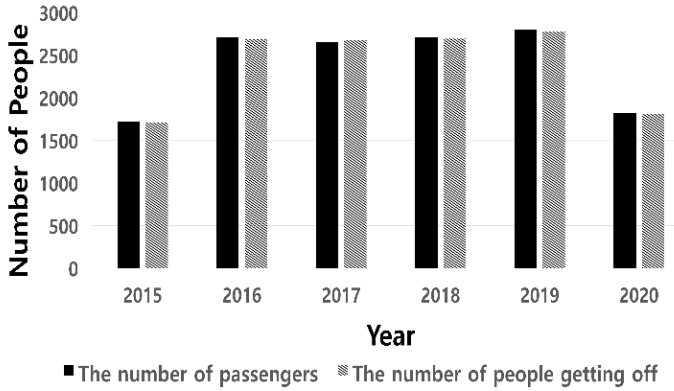

Fig. 3: Changes in the number of people getting on and off the Daegu Metro (Rail Statistics of the Ministry of Land, Infrastructure and Transport)

3.2. Determining station area

The method used in this study are as follows. Sectors of areas are divided in more details depending on traffic, natural conditions, and artificial barriers. It is the common method to separate when planning city development. It can be founded on accessibility, the type of use, and industry density.

In this study, internet was used as the main source to divide the station area, as shown in Figure 4. The reasons 250 meters are set for station area is described. The general is 500 meters when identifying the station area. Regarding the direct area, it can be 250 meters. The 500-meters setting has many redundant cases so it was excluded. Therefore, the public apartments within 250 meters from station are randomly selected and utilized as subjects.

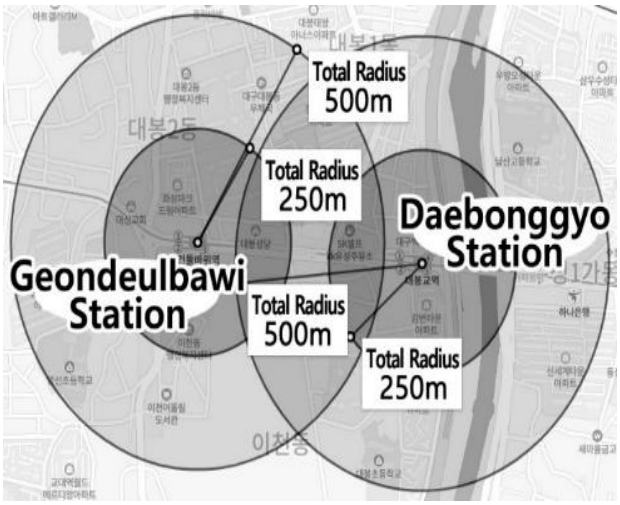

Fig. 4: Set the range of station area (Naver map)

3.3. Establishing the scope of analysis

Data related to apartment houses around Daegu Urban Railway Station are based on the internet or setting the spatial extent. A total of 13 stations where public apartments do not exist, such as Suseongmot Station, Children's Center Station, Myeongdeok Station, Namsan Station, and Seomun Market Station, are excluded among the 32 stations of Line 3. Only 29 stations will be covered. Some of the station area, which seems to not be affected, is considered within 250-station area group. The apartments that are not affected by Lines 1,2, and 3 are: Bonri-dong, Bon-dong, Wolseong 1-dong, and Bokhyeon 2-dong. Apartments which are not affected by city railroad are randomly picked. A total of 60 houses are selected for research scope.

The period of this study was from January 2011 to June 2021. The prices observed where transaction was active were selected for the past 11 years. Referring to the actual trade price disclosure system of the Ministry of Land, Infrastructure and Transport, over 500 trade prices during the period were selected and examined.

4. Analysis and evaluation of preference

In this study, 58 prices of public apartments from 2011 to 2021 were investigated. The private area is one, which was used when researching. However, it is impossible to apply consistently because it varies depending on cases. It should be converted into the price increase rate (or the price change rate).

To grasp increase rate, prices for 2014 and 2015 are surveyed from 2011 research. Converting selling prices into increase rates helps to check prices change.

Transaction prices in 2011 should be derived to calculate increase rate. As shown in equation (1), the average price generated in trading is obtained. The sum of the prices in 2011 can be divided by the sum of the cases. If the result is in decimal, rounding to the first point is required. This process applies to all investigation.

$$\text{Average price of transaction} = \frac{X_1+X_2+\cdots+X_n}{1+2+\cdots+N} \quad (1)$$

(X_n: Actual trading prices, N: the number of real trading cases)

As presented in Equation (2), actual trading prices from 2011 to 2021 are divided by the average selling prices mentioned. The obtained figures are arranged for 2014 and 2015 to be used further. Average prices are divided by the same values, which is derived as one. Based on increase rate as one, changes in prices can be found.

$$\text{Prices increase rate} = \frac{X_n}{Y_n} \quad (2)$$

(X_n: Prices of trading public apartments, Y_n: Average prices of public apartments in the initial year)

To examine how the opening of city railway can impact prices, only housing prices were compared except for other variables. Line 3 in Daegu played a key role when dividing station and non-station area. The opening year is 2015. The data before and after the standard year were compared.

This study includes two assumptions such as follows. Hypothesis H0 states that the increase rate of station area is the same as non-station area. Hypothesis H1 states

that the increase rate of station area is distinctly different from non-station area. Both are under the independent factor, which is railway opening. The opening point is the significant factor when analyzing increase rate.

This study compared station area and non-station area for research.

The former is 152, and the latter is 208. The data in 2014 and 2015 are compared with each other. The increase rate in 2015 is subtracted by the rate in 2014 as shown in equation (3) below. The result is derived based on the calculations.

Increase rate $= S_n - W_n$ (3)

(S_n: Increase rate in 2015, W_n: Increase rate in 2014)

The difference is shown in Table 4, which is measured through the descriptive statistic method. The average of the first group (H0) was 0.4084 and the second one (H1) was 0.1223. Standard deviations of 0.25 and 0.21 were derived, respectively. Therefore, both contrast groups, which are station area and non-station area, appear to be statistically distinct.

Table 4: Descriptive statistics

Descriptive Statistics				
Group	Number	Mean	Std. Deviation	Std. Error Mean
H0	152	0.41	0.26	0.02
H1	280	0.12	0.21	0.01

To confirm the validity of prices and averages change, T-test is performed. Moreover, to complement skewed data, two-sided test (2-Tale) is implemented. The variance of both groups is not known. Two assumptions are established that variances can be the same or not the same.

The result in Table 5 shows that when the equal variance is assumed, the difference can be confirmed with a T value of 12.457 and a P value of 0.0. In addition, when equal variance is not assumed, the difference can be confirmed with a T value of 11.768 and a P value of 0.0. In both cases, meaningful results are achieved at the 95 % confidence level. Therefore, the null hypothesis in this test can be rejected. This concludes that station opening can have some positive effects on housing prices in accordance with preference.

Table 5: T-test results

	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	T	Df	Sig. (2-tailed)
Equal variances assumed	6.46	0.11	12.457	430	0.00
Equal variances not assumed			11.768	263.385	0.00

5. Conclusion

Changes in apartment prices can be caused by many factors such as location, complex, generation, and socio-economic characteristics, etc. In particular, traffic convenience seems to wield most powerful. In this study, the following results were found.

Changes in traffic environments represented as railway opening and the preference represented prices. Houses located in Line 3 in Daegu were divided as station and non-station area. The radius of 250 meters whose center is the station was marked as station area. The non-station area was selected excluding Lines 1, 2, and 3. The data of prices were derived from 2011 to 2021 set containing public houses, which were offered by the Ministry of Land, Infrastructure and Transport of Korea. The data actually utilized included standard year 2015. Materials before 1 and after 1 as of 2015 were compared. The private space is unified and applied by the region where transaction was most active.

In this study, there was an assumption that railway opening could increase house prices (preferences). To prove this, two assumptions H0 and H1 were established. The cases of both were 152 and 208 each. Moreover, to analyze different prices, the selling prices in 2014 and 2015 should be converted into increase rates.

After verifying, the mean of the same increase rate hypothesis was 0.41, and not the same with 0.12. The standard deviation of each other was 0.04. Therefore, it was seen that the station opening could influence the price-pulling positively.

T-test was performed to check whether both different groups showed significant distinction. The results were meaningful under both cases of equal-variance assumption and not-equal-variance, which was achieved at up to 95% of the two-sided test standard. Accordingly, the null hypothesis H0 was declined.

The purpose of the study was to prove that changes in traffic environment can impact price changes. It was largely focused on prices in station area being affected. The use of price models was limited to descriptive methods. When other multiple ones are applied, some difference can be observed. Traffic changes was confirmed to cause fluctuations in prices. Previous studies are mainly on subway stations but light mono railways were possible to have some effects. Consequently, traffic improvement is definitely a pull factor of public house prices. This factor should be taken into consideration when planning city development. This thesis may be able to be utilized as a basic measure for implementing projects such as building public apartments.

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