

# Exploring the Spatial Impact of MRT Gentrification by Different Processes: Taipei City MRT Station as an Example

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## 1 ABSTRACT

In recent years, the TOD model of urban development driven by public transportation systems has emphasized public transportation to achieve the concept of green transportation and sustainable development. It has been proven in the literature that MRT stations can reduce air pollution and energy consumption, improve transportation efficiency, accessibility, and land value, etc. However, these changes have led to higher local affordability costs, attracting affordable communities and businesses to develop and replace existing households or small and medium-sized enterprises, resulting in academic discussions of MRT-induced gentrification. This study investigates the impact of MRT station gentrification and the surrounding space, and examines the spatial and temporal effects of MRT station gentrification in Taipei City from 2012 to 2019. The study uses the area around the MRT stations in Taipei City as the target population, and distinguishes the early, middle, and late gentrification patterns in Taipei City through the ratio of residential housing price increase, education level, and household income, and further examines the demographic structure of the significant area.

Keywords: transit-oriented development, neighbourhood, changes, gentrification, urban planning

## 2 INTRODUCTION

In the field of land research, the term "gentrification" was first introduced in 1964 by the British sociologist Ruth Glass, who observed that the middle class in London, England, had replaced the areas formerly inhabited by the working class and thus changed the characteristics of the area, resulting in the renovation and beautification of the buildings in the area, the revival of the formerly decaying areas, and the change of social characteristics due to the change of class structure. This phenomenon is called "gentrification". This phenomenon has a negative impact on the disadvantaged groups and is usually accompanied by the relocation of families to the suburbs, increased cost of living, and social conflicts, which has led to a lot of international studies and discussions on gentrification. New York (Freeman & Bracoin, 2004), Seoul (Ha, 2004), Istanbul (Ergun, 2004), Stockholm (Millard-Ball, 2004), Mexico (Jones & Varley, 1999), and several cities in South Africa (Visser, 2002). The study of gentrification has also extended to various gentrification research directions, including humanities, ecology and social culture, quality of public facilities, political and economic perspectives, and housing market. For example, Sims (2021) and Qian (2018) confirmed that urban renewal areas have changed the demographic characteristics, showing that more residents and businesses move out every 200 meters; Boterman (2020), Candipan (2020) and Pearman (2020) confirmed that school choice increases the percentage of gentrification. However, as urban transit systems improve, Bardaka (2018), Chava (2021), and Deka (2017) confirm that transit systems have led to socioeconomic changes around transit, such as higher household income, higher housing prices, and an increase in whiteness.

After World War II, many emerging cities began to develop their public transit systems to achieve transportation efficiency and sustainable urban development. In East Asia, mass transit systems were built in Beijing (1969), Pyongyang (1973), Seoul (1974), Hong Kong (1979), Singapore (1987), Shanghai (1993), Kuala Lumpur (1996), Taipei (1996), Guangzhou (1997), and Bangkok (2004), and their regional spatial impacts include LeRoy (1983) was the first to suggest the impact of transportation innovations on gentrification, showing that transportation innovations lead to changes in the location of households of different incomes. This is reflected in the fact that households will consider income, rent, and transportation costs as the main factors for their residential location. Based on the above theories, transportation-induced gentrification is beginning to be supported worldwide, such as Lin's 2002 study on the impact of Chicago's rapid transit on gentrification. In the past literature, the impact of gentrification on urban areas was mostly focused on urban regeneration, such as Kovács, Z. (2013), who studied urban regeneration in the inner city of Budapest, and Ha, S.K. (2004), who focused on the contribution of urban regeneration to the development

of residents and communities in Seoul. Therefore, this study uses the example of MRT stations in Taipei City, Taiwan, to investigate the relationship between MRT-induced gentrification.

According to the literature, Jyothi Chava & John L. Renne (2021) studied the negative impact of the construction of new light rail stations on black and low-income households, and the data showed that the proportion of blacks in the nearby census tracts decreased due to the entry of the new light rail, and the corresponding proportion of whites increased significantly. Lin (2002) uses LeRoy's (1983) model to analyze changes in land values over a three-year period, confirming evidence of increased land values due to the presence of MRT stations; Zheng & Kahn (2013) argue that investors who advance the construction of a new light rail station in an area that has not yet been served by the MRT will be able to afford it. Brown (1993) argues that accessibility is considered to be one of the main factors in determining the location of businesses. With the increase of MRT operating years, the impact of MRT-induced commercial gentrification tends to expand, and the impact of MRT-induced commercial gentrification varies with the change of land use in the stations. Therefore, this study focuses on the spatial effects around the MRT stations in terms of housing value and population characteristics changes.

In the above literature, the research results support the argument of transportation-induced gentrification, however, it is clear from the literature that the changes of transportation-induced gentrification change over time, and the scope of impact also varies with the distance and land use of the stations. (2010) compared the gentrification index of 12 transit stations using census data from 1990 to 2000; Feinstein & Allen (2008) studied data from 1970 to 2000 and compared the gentrification change index of Boston transit census tracts and other census tracts; Brown (2016) compared the gentrification index of the Orange Line in Los Angeles to the gentrification index of 10 TODs opened before 2012. Brown (2016) compared the change in demographic indicators within 2 and 5 village of the stations, using 10 stations opened by 2012 as targets. Therefore, to support the spatial impact of MRT-induced gentrification, this study collected data from 2012 to 2019, and divided Taipei City MRT stations into three zones according to different operating periods to compare the demographic changes of stations at different distances.

The purpose of the study is:

- (1) Development Stage of Taipei City MRT Gentrification
- (2) Spatial Influence of MRT Gentrification in Taipei City
- (3) Spatial and Temporal Influences of MRT Gentrification in Taipei City

### 3 RESEARCH FRAMEWORK

#### 3.1 Classification principles of gentrification stage

When the development potential of an area is underestimated, i.e., the socio-economic indicators need to be lower than the regional average, and investors or high-income residents realize the development potential of the area, the phenomenon of gentrification occurs. With the increase of the upper class population, the vulnerable population cannot afford the higher housing market, resulting in the displacement of the vulnerable population from their homes or to the less accessible suburban areas. Therefore, the definition of gentrification stages should be classified according to "vulnerable population", "demographic change" and "real estate value", and the data should be compared with the city average and classified into different gentrification stages according to real estate prices and demographic conditions.

##### (1) Gentrification-prone stage

I. The area contains a high vulnerable population, i.e., the population with low education and household income; the area does not have a population replacement phenomenon, i.e., the demographic change with low increase in education and household income; the area has a low real estate price and is near a high value, i.e., the real estate price is low to medium and is near a high housing price area.

##### (2) Early gentrification

I. The area contains a high vulnerable population, i.e., a population with low education and low household income; the area does not experience population replacement, i.e., demographic changes with low increases in education and household income; the area's real estate prices show II. accelerated appreciation, i.e., real estate prices increase at a high rate but remain at a low to medium rate.

The area begins to attract the middle-class population, i.e., the population with high education and income starts to increase, but still contains a highly vulnerable population; the area also begins to experience population replacement, i.e., demographic changes in education and household income with medium to high rates of increase; the area's real estate prices show I. low values and are close to high values, i.e., the area's real estate prices are still medium to low and are surrounded by areas with high housing prices.

### (3) Mid-term gentrification stage

I. The area begins to attract the middle class population, i.e., the population with high education and income starts to increase, but still contains a high vulnerable population; the area begins to experience population replacement, i.e., the demographic change of education and household income population with medium to high increase; the real estate price of the area shows II. accelerated appreciation, i.e., the real estate price increases at a high value but the real estate price remains at a medium to low value.

### (4) In the late stage of gentrification

I. The area already contains more middle class population, i.e., the area contains high education and income population and no longer has high vulnerable population; the area has experienced population replacement, i.e., the rate of increase of education and household income population is medium-high; the area's real estate price shows III. continuous appreciation, i.e., the rate of increase of real estate price is high and the real estate price is still high.

II. Due to the limitation of the study period, the earliest data is obtained in 2012, so the early and late II areas of the study already contain more middle class population, i.e., they contain high education and income population and no longer have high vulnerable population; the real estate prices of the areas show IV. both high values, i.e., the real estate prices of both the early and late areas of the study are high.

## 3.2 Classification of MRT Stations

The Center for Transit Oriented Development (CfTOD) (2008) in the U.S. refers to the relationship between the value of transit facilities at different stages of operation. In the value curve of transportation, housing prices are affected by the announcement of transportation construction plans, the start of operation, and changes in residential investment and business patterns in the vicinity after the construction. Therefore, this study analyzed the socio-economic changes of Taipei City MRT stations according to their operating years, and classified them into three categories: early operating stations, mid-operating stations, and late operating stations, using five-year intervals. The early operating stations are Muzha Line, Danshui Line, Xindian Line, Zhonghe Line, Nangang Line, and Banqiao Line; the mid-operating stations are extended in nature (MRT lines); and the late operating stations are Wenhua Line and Xinyi Line.

## 3.3 Principles of selecting variables for the effect of MRT gentrification areas

This study focuses on the spatial effects of the gentrification of MRT. Referring to the review of literature on demographic changes and real estate price changes, the study should focus on demographic changes in addition to education level and household income variables, and should go deeper into the variables of the vulnerable population who are vulnerable to displacement, including the elderly population and youth groups, population density, low-income households, and migrating population. However, the affordability of housing in the area should also be included in the variables, including the rent-to-income ratio of housing prices. Therefore, in order to investigate the spatial effects of MRT gentrification, in addition to housing prices, the physical properties of housing should include age, building type (condominiums, luxury buildings, etc.), building size, and rent.

### (1) Rent

The rent gap theory was first proposed by Smith (1979), and many studies have further extended it, for example, Clark (1988) provided a basic explanation for gentrification from a Marxist perspective. The land rent gap is the difference between the level of potential land rent and the actual land rent capitalized under current land use. The theory states that investment in the real estate market will only take place when there is a sufficient rent gap. The rent gap increases rents and the supply of real estate, which in turn leads to migration between different classes. In Taiwan, ping is the commonly used unit of area (3.3m<sup>2</sup>). These two results are also used in previous gentrification studies, including Badcock (1989), Yung & King (1998), Feinstein & Allen (2011), Cavers & Patterson (2015), Kahn (2007), and Zheng & Kahn (2013).

## (2) Real estate prices

Su et al. (2021) explain the conceptual framework affecting real estate prices using the characteristic price model (Rose, 1974) and the TOD neighborhood structure. Real estate prices are affected by changes in the surrounding environment through factors such as (1) residential physical attributes, (2) accessibility attributes, and (3) environmental characteristics (Goodman, 1989; Williams, 1991), where residential physical attributes include building age, gross floor area, lot size, type of materials and finishes, neighborhood size, number of rooms, maintenance conditions, and structural condition (In addition, environmental characteristics include socioeconomic, external factors, local government (Chin&Chau, 2003), and public facilities (Roe et al., 2004). The value of the area varies greatly depending on the attributes. In addition, the impact of different stations in a region varies, with stations having little or no impact on housing prices in some areas, but a large impact in others (Wardrip, 2011).

## 4 RESEARCH METHODOLOGY

### (1) Land Suitability Analysis

Land Suitability Analysis refers to the process of analyzing the relationship between the current land use status and nature, the natural environment, and the human environment before the land use plan is prepared, in order to analyze the potential and limitations of the natural environment on various land uses. The purpose is to ensure that development is compatible with environmental conservation objectives and to effectively allocate resources in the most appropriate spatial manner. The analysis covers a wide range of aspects of the original suitability of the various lands and uses within the area, including existing and possible future use restrictions and potentials. Among the factors considered, emphasis is placed on the types and intensity of various land uses and other opportunities, i.e., the suitability and unsuitability of a particular use or type of use are considered in the analysis.

### (2) The Analysis of Variance

One-way analysis of variance (ANOVA) is a statistical method used to determine the difference between the means of three or more groups when the analysis contains a single independent variable or factor and the objective is to check whether the variables or different degrees of factors have a measurable effect on the corresponding variables. ANOVA is a statistical method for detecting the null hypothesis ( $H_0$ ), which assumes that three or more parent means are equal, and the alternative hypothesis ( $H_a$ ), which assumes that at least one of the means is not equal.

$$H_0: \mu_1 = \mu_2 = \dots = \mu_K$$

$$H_a: \text{not all means are equal}$$

One-way analysis of variance (ANOVA) is used to compare the mean differences between multiple groups, in the method of comparing whether the means are the same. The total variance formula is as follows.

$$SST : SSB + SSW$$

$$TSS : \sum_i \sum_j (Y_{ij} - \bar{Y})^2$$

$$BSS : \sum_i n_i (\bar{Y}_i - \bar{Y}_{total})^2$$

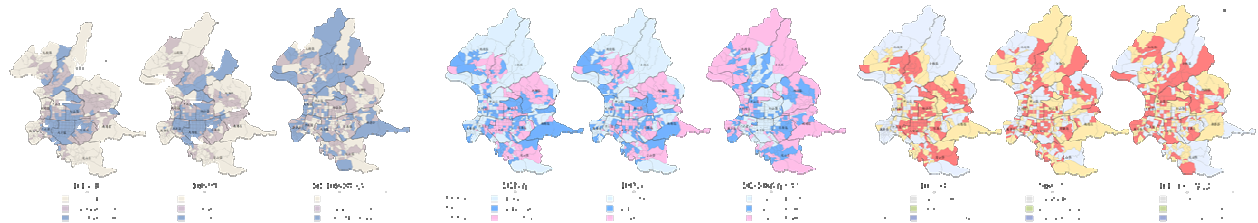
$$WSS : \sum_i \sum_j (Y_{ij} - \bar{Y}_i)^2$$

## 5 PRELIMINARY RESULTS

In measuring the gentrification stage variables, the housing price indicators were selected for analysis, and the housing price information in the real price register was used to select residential use as the data for analysis; the year of completion of the original column was replaced by the variable housing age as the data for analysis; the transactions of friends, relatives, employees, or other special relationships, and the transactions of rough housing that affect the housing price were removed from the real price register variables. Due to the classification principle of the gentrification stage, the real estate price data are divided into three categories of data: (1) the tertile of real estate price in 2012, (2) the tertile of real estate price change in 2019, and (3) the ratio of real estate price increase in 2012 to 2019. The data are presented in detail according to the type of data.

Among the variables measuring the gentrification stage, educational attainment indicators were selected for the analysis, and the number of people who graduated from tertiary institutions or above was screened out. Due to the classification principle of the gentrification stage, the educational attainment data are divided into the following three data categories: (1) tertile of educational attainment in 2012, (2) tertile of change in educational attainment in 2019, and (3) ratio of increase in educational attainment from 2012 to 2019. The data are presented in detail according to the type of data.

In measuring the gentrification stage, the median household income of each mile was used as the indicator of household income for analysis. Due to the classification principle of the gentrification stage, the household income data are divided into the following three data categories: (1) the tertile of household income in 2012, (2) the tertile of household income change in 2019, and (3) the ratio of household income increase from 2012 to 2019. The data are presented in detail according to the type of data.



### (1) Gentrification-prone stage

There are a total of 14 villages in the gentrification stage, and the neighborhoods are mainly located in the following administrative districts: Shihlin District contains 3 villages, Daan District contains 3 villages distributed in, Zhongzheng District contains 1 village, Wenshan District contains 1 village, Beitou District contains 1 village, Songshan District contains 3 villages, and Wanhua District contains 1 village.

### (2) Early gentrification

In the early gentrification stage I, there were 5 villages, and each neighborhood was mainly located in the following administrative districts: Hsinyi District contained 1 village, Chungcheng District contained 1 village, Wanhua District contained 1 village, Shilin District contained 1 village, and Beitou District contained 1 village.

During the Early Gentrification Stage II, there were a total of 83 village, which were mainly distributed in the following administrative districts: 2 village in Songshan District, 6 village in Xinyi District, 8 village in Zhongshan District, 1 league in Zhongzheng District, 9 village in Datong District, 11 village in Wanhua District, 10 village in Wenshan District, 5 village in Nangang District, 13 village in Neihu District, 5 village in Shilin District, and 13 village in Beitou District.

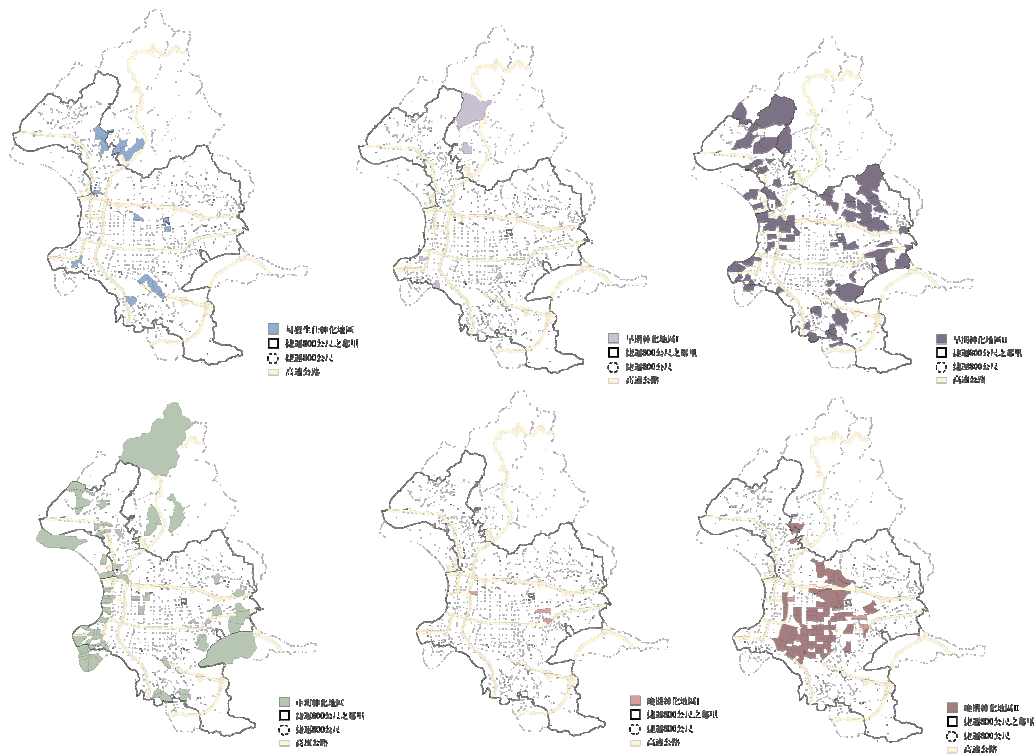
### (3) Mid-term gentrification stage

There are a total of 58 village in the mid-term gentrification stage, and the neighborhoods are mainly located in the following administrative districts: Xinyi District contains 2 village, Daan District contains 1 village, Zhongshan District contains 4 village, Zhongzheng District contains 2 village, Datong District contains 5 village, Wanhua District contains 18 village, Wenshan District contains 3 village, Nangang District contains 5 village, Neihu District contains 2 village, Shilin District contains 8 village, and Beitou District contains 8 village.

### (4) In the late stage of gentrification

In the Late Gentrification Stage I, there are 4 village, and each neighborhood is mainly located in the following administrative districts: Hsinyi District contains 2 village, Songshan District contains 1 village, Zhongshan District contains 1 league, and Hsinyi District contains 1 village.

In the Late Gentrification Stage II, there are 75 leagues, and the neighborhoods are mainly located in the following administrative districts: Hsinyi District contains 3 leagues, Songshan District contains 12 leagues, Xinyi District contains 1 league, Daan District contains 33 leagues, Zhongzheng District contains 9 leagues, Neihu District contains 1 league, and Shilin District contains 4 leagues.



## 6 CONCLUSION

In this study, we used "vulnerable population", "population change" and "real estate value" to classify the gentrification process in Taipei City, and compared the data with the city average. From the results of the gentrification process in Taipei City, the areas prone to gentrification are mainly in Shilin and Beitou, while the early and middle stages of gentrification are mainly in the outer administrative areas of Taipei City, and the late stages of gentrification are in the city center of Taipei City. By examining the results of the gentrification process, we can prioritize the policy to prevent the problem of dislocation brought by gentrification.

## 7 REFERENCES

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