主　論　文　の　要　約

論文題目　Difference-in-differences Analysis on Railway Investment-induced Effects on Residential Distribution Changes
(鉄道公共交通の整備による居住地分布の変化に関する差分の差分分析)

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論　文　内　容　の　要　約

With the rapid development of automobile industry, traffic congestion has become a serious problem in some big cities. Railway investment program owns the merits of public transportation, and brings potential benefits to the economic development of regions nearby railway stations. Hence, transit-oriented development, a type of urban development, becomes a popular mode in recent years, especially in developing country.

Apart from the friendly to environment, the main essential reasons for policymakers to support urban railway systems is that they hope the railway investment can promote the economic development of nearby regions. To achieve it, urban planners, railway companies, and other partners prefer to design commercial facilities (e.g. department, shopping mall, etc.) around some important railway stations. As a result, the neighborhoods near such railway stations serve transportation accessibility and urbanized lifestyles for citizens. By extension, the residential distribution will be influenced, and the changes of proportion for different household types in community will form a new urban structure. Therefore, this dissertation aims to investigate and compare the different

railway investments induced residential distribution changes of different households in Nagoya city, by difference-in-differences (DID) estimators.

Firstly, Chapter 1 introduces research background, and explains the main problems solved in this dissertation. The main objectives of this study are: 1） observe the effects of railway investment on residential distribution changes of many different households; 2) Conduct a sensitivity analysis of standard DID model to find the best study scales for different household types; 3) Implement spatial DID model to investigate possible local spillover treatment effects induced by railway investment; 4) Proposed heterogeneous DID model to account for the heterogeneity in treatment group.

Based on the above key questions, Chapter 2 presents a general literature review of previous studies involving TOD mode, railway investment-induced effects on residential distribution, and DID model. Some previous studies observed that the neighborhoods along railway line can be an ideal community due to convenient transportation accessibility and commercial service; but some studies also stated that railway investments do not always have positive impacts, because of noise, congestion, pollution, and other living environment problems. Residential distribution is also influenced by housing attributes and land use properties, among other characteristics. Therefore, residential distribution trends may vary in different areas. However, few researchers compare the differences among impacts of railway investment in different areas of one city on residential distribution. Besides, DID model is a popular tool to assess the effects of interventions, such as infrastructure or economic policy, on certain relevant outcome variables in economic researches. However, present DID estimator can’t observe the heterogeneity among treatment group.

Chapter 3 describes some basic information about studied three railway lines (Meijo line, Aonami line, Sakura-dori line) in Nagoya city railway network. Meanwhile, the analysis unit and descriptions of variables are interpreted in this chapter. To better understand the estimation results in following chapters, a basic idea of the socioeconomic development in Nagoya city is presented here

too.

In Chapter 4, firstly, the assumptions in the standard DID model are presented. Then, the standard DID estimator was implemented to conduct sensitivity analysis for three lines. In standard DID model setup, since railway station has limited influence radius on neighborhoods, the neighborhoods within this influence radius to a railway station are classified into treatment group, and the other neighborhoods in study area are in the control group. After reviewing previous studies, this dissertation found that there is no clear guidance about how to define the influence radius of railway stations. In order to explore the household sensitivity to the influence radius, this dissertation first conducted a sensitivity analysis, and found the best study scales for each households along three lines. In general, the influence radii of Aonami stations are smaller than Meijo line and Aonami line. The possible reason may be related to the different service quality of these three lines. These three lines have similar travel cost and travel time, but Aonami line has longer headway, especially in peak hours. As the only Aonami line in that area, before the construction of Aonami line, road traffic modes had undertaken the main transportation tasks and induced serious traffic jams in there. So that it is reasonable the residents from these households have lower tolerance for longer distance to railway stations. In another words, once the distance to a Aonami station is a little longer, residents may choose other alternative road traffic modes. Besides, the influence radius of railway stations on older households is smaller than other household types.

Meanwhile, as the baseline model, based on the estimation results of standard DID estimators with best study scale, this dissertation can only found some significant average treatment effects in the neighborhoods within one kilometer to Meijo station: 1) These neighborhoods are significantly attractive to the households with higher income; 2) the proportion of middle-income households in these neighborhoods experienced a significant increase. Although the proportion of old-single households for Aonami line, and couple-with-children households proportion and old-couple

households proportion for Sakura-dori line showed the trend of increase, they are not statistically significant.

Specifically, the standard DID model assumes that there are no social interaction or interference among neighborhoods. When this assumption can't be satisfied in reality, the estimation results will be inconsistent and biased. To solve this problem, firstly, Chapter 5 conducts Moran's I statistics for all models in different periods to investigate the existence of spatial autocorrelation in panel data. And the test results underscored the necessity to incorporate the standard DID model with local spatial interaction component. Therefore, the spatial DID model was implemented in Chapter 5 to investigate possible local spillover effects. Different from the estimation results of standard DID model, more new significant findings are observed by spatial DID estimator: 1) The investments of Meijo and Aonami line have similar trend of total average treatment effect for household income and household with different household income levels. However, only the neighborhoods near Meijo line show significant attraction to higher-income households. The convenient commercial and good living environment along Meijo make sense; 2) Although the proportion of high-income households in the neighborhoods nearby Sakura-dori stations experienced an increase with the opening of Sakura-dori line, the average household income didn't increase. This reveals the areas along Sakura-dori line has a certain potential for development; 3) For proportion of couple-with-children households, they experienced a significant spillover treatment effects due to the investment of Meijo line and Sakura-dori line. Compared to Aonami line, the high density of universities, convenient commercial service and good living environment in that areas may be valued by them; 4) The proportion of old-couple households in the neighborhoods along stations increased significantly, due to construction of Sakura-dori line; 5) The proportion of old-single households experienced a significant increase in the neighborhoods within 500 meters to railway stations following the opening of Aonami line. This may be related to the cheaper land price along Aonami line.

No matter in standard DID model or spatial DID model, all the treated neighborhoods in treatment group are assumed to be influenced by railway investment identically. That is there is only one treatment group in data. In fact, railway lines are always long and covers several administrative districts with different levels of development. Due to the differences caused by different land uses and living environments, the heterogeneity may exist in the treatment group. Hence, a heterogeneous DID estimator was proposed in Chapter 6. The treatment groups along Meijo line and Aonami line are divided into northern and southern region. Via the estimation results of heterogenous DID model, some interesting findings, which can't be observed in the standard DID and spatial DID models, are investigated in heterogeneous DID model, especially for the Aonami line. The new finding are: 1) In general, the neighborhoods near northern stations are attractive to higher-income households; 2) The southern neighborhoods near Aonami line are appealing to low-income and old-single households. These differences may be caused by the uneven development between northern and southern region, and the cheaper land price along Aonami line. On the other hand, considering the safety problem, the frequent earthquake also makes most residents prefer the northern neighborhoods than the southern neighborhoods along Aonami line, which are close to the shoreline. Specifically, incorporating local spatial autocorrelation component and random effects to heterogeneous DID model proved the flexibility of this model.

Lastly, the Chapter 7 summarizes the above conclusions. And the limitations of this study, and talk about some future research topics are discussed too: 1) Due to the easy data availability, DID estimator are used more often than residential location choice model to account for the causal effects. However, the DID estimator relies on census data as aggregation level to quantify the impacts of railway investments. The residential location choice model can be implemented based on the discrete choice framework, which can show the differences between individuals; 2) The effectiveness of causal effects in DID estimator are based on some strong assumptions. The SUTVA assumption is

released in the spatial DID model, and the heterogeneity in treatment group were investigated in the heterogenous DID model. However, the parallel assumption and common shock assumption still remain. The time paths in parallel test are unconditional, and the differences between two groups can be adjusted by applying exogeneous variables into regression. However, such strong assumptions are not easy to follow in reality; 3) Besides, in DID setup, the “treatment effect” is the average causal effect of a binary variable on an outcome variable by assuming the treatment is binary. The proposed new DID estimator only accounts for the heterogeneity in the treatment group, and doesn’t account for the heterogeneity of distance to a railway station. In reality, the attraction of neighborhoods along railway station may also varies among the distance to railway station. For instance, the high-income households may prefer the neighborhoods which are not so close to railway stations but still can be reached easily by walk or bicycle. If the treatment is assumed not to be binary, then the heterogeneous spatial DID estimator can be extend to the account for this heterogeneity in future work; 4) In addition, a simple DID estimator assumes that control variables are completely exogenous, disregarding the "endogeneity" and "autocorrelation" problems. While these possible problems are not discussed in this study, some econometrics have proposed approaches to address them; 5) The property values, like housing price, land price, are the common variables in some previous studies. But no such variables are utilized as outcome variables in this study, due to the limited data availability. In fact, the residential land price in years can be searched in the Land General Information System from MLIT Japan, but only a limited number of neighborhoods had price information. However, except the residential land price, researchers can aggregate the street price data as land price data for each neighborhoods. In the future research, such data can be utilized to reflect the railway investment-induced effects on land price more directly; 6) Generally, there are two main spatial autocorrelation components, spatial-lag autocorrelation and spatial-error autocorrelation. Since the spatial spillover effect can be reflected by the spatial-lag model, this study

focused on the spatial-lag component other than spatial-error term. Actually, the spatial-error component can be incorporated to the spatial DID model too. In the future work, it can be into counted, if this study extends to grasp all the spatial autocorrelations in panel data.

To conclude, this dissertation investigates how railway investments, in different land-use areas, affect the residential distribution changes of different household types in Nagoya City, Japan. Since planners and politicians expect urban railway systems to have premium effects on real estate and economic development, this dissertation's findings can provide strong implications for policymakers, city planners, and scholars.