

LOW-INCOME CLASS'S RESIDENTIAL SEGREGATION AND URBAN REDEVELOPMENT PROJECT BETWEEN 2011 AND 2020 (1086)

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Abstract. This study aims to analyse the patterns of low-income residential segregation in South Korea from a macro and micro perspective and to determine the net effect of redevelopment policy implementation on low-income residential segregation. By manipulating the National Basic Livelihood Recipients as low-income people, we examine the residential segregation of low-income people measured by the dissimilarity index, isolation index, location quotient, and local Moran's I in seven metropolitan cities representing South Korea between 2011 and 2020. This study analyses the net effect of redevelopment on low-income residential segregation using the propensity score matching (PSM) method, estimating that redevelopment reduces low-income residential segregation by 0.0289. The findings show that low-income residents cluster in urban centres and become less concentrated as they move outwards, and PSM analysis shows that redevelopment mitigates low-income residential segregation. This article provides insight into the need to consult with those responsible for low-income housing policy to ensure redevelopment's positive impact on low-income residential segregation.

Keywords: low-income class, residential segregation, inequality.

1. Introduction

In most countries that have experienced an economic crisis, socioeconomic polarisation intensifies as the economy is revitalised to overcome the crisis (Piketty, 2014). In South Korea, in particular, the income distribution structure, which deteriorated sharply after the 1997 foreign exchange crisis, has become polarised, widening the gap between low-income and high-income earners (Park and Han, 2021). In recent years, regional polarisation has also intensified, with the combined earned income of the greater Seoul region, including Seoul, Gyeonggi, and Incheon, exceeding 60 percent of South Korea's total earned income (Koo, 2019).

People generally feel more secure around people who are similar to them, so even if there are no direct factors at play, people will spontaneously seek to form communities with like-minded people (Shalizi and Thomas, 2011). In a similar vein, a neighbourhood is not a single entity, but is spatially dependent on its geographically close neighbours,

meaning that neighbouring areas influence each other to have similar tendencies (Jun, 2020). In this context, the gap between low-income and non-low-income neighbourhoods appears to be difficult to close. However, we need to pay attention to the phenomenon of low-income residential segregation and devise ways to address it, as several urban studies have shown that the clustering of low-income people in certain neighbourhoods can lead to numerous socioeconomic pathologies (Brooks-Gunn, Duncan, Klebanov, and Sealand, 1993; Jargowsky, 1997; Massey and Eggers, 1990; Sampson, Raudenbush and Earls, 1997; Sampson, Morenoff, and Gannon-Rowley, 2002).

The spatial distribution of poverty plays an important role in understanding place-based structural inequalities, such as income and social class, as well as residential segregation (Lobao, Hooks and Tickamyer, 2008). Relationships at the micro-level of poverty are important, as people interact with their neighbours and act as a key factor in influencing each other's lives and futures (Sampson, 2008). The need for micro-level analysis of low-income residential segregation is highlighted by the view that the vicious cycle of poverty and increasing income inequality is an important cause of political polarisation that destabilises countries (Gu and Wang, 2022).

While the literature on residential segregation has primarily focused on residential segregation by race and ethnicity, there is growing academic interest in residential segregation by income and social class (Owens, 2018). Residential segregation is also a key driver of economic inequality, with government intervention in the housing market leading to extreme racial and economic segregation between neighbourhoods, as well as population-level inequalities along racial and class lines, including wealth inequality, life expectancy gaps, and differences in economic mobility, which persist across generations (Williams and Collins 2001; Oliver and Shapiro 2006; Sharkey and Elwert 2011; Chetty, Hendren, and Katz 2015). The answer to the question of how public policy can reduce spatial inequality is not straightforward, as research has shown that segregation patterns persist over time (Faber, 2021; Sampson, 2012). Therefore, this study analyses the patterns of low-income residential segregation in the rapidly changing socioeconomic structure of South Korea from a macro and micro perspective. It will also contribute to understanding the relationship between public policy and spatial inequality by identifying the net effect of redevelopment policy implementation on low-income residential segregation.

In the early 1960s, South Korea's steady economic growth, coupled with a thriving manufacturing industry, led to large-scale migration from rural to urban areas and a housing shortage in cities (Ha, 2010). In addition, consumer preferences for where to live shifted from single-family homes to apartments based on convenience, creating significant demand for apartments (Lee and Kim, 2020). To meet this demand, the redevelopment of existing low-rise neighbourhoods has involved many private

companies, resulting in profit-oriented housing developments and the loss of affordable housing (Seo, 2016). This has led to an influx of upper-middle and upper-income earners into working-class neighbourhoods, resulting in rents and house prices that low-income earners cannot afford, giving rise to the phenomenon of gentrification (Ha, 2007). The central government has begun to introduce new policies to address the problems arising from profit-driven redevelopment, such as gentrification, but more research is needed on the relationship between low-income residential segregation and redevelopment to see if they are effective.

This study aims to examine the impact of large-scale redevelopment on low-income residential segregation. The first part discusses the theoretical background on residential segregation of the poor and urban redevelopment. The second part describes the variables used and introduces the propensity score matching methodology to construct an index to measure residential segregation and the net effect of redevelopment. The third part will present the results on changes in low-income residential segregation and the impact of large-scale redevelopment on this. Finally, the results will be evaluated, and then a discussion of the implications that the results provide will follow.

2. Literature Review

2.1. Residential Segregation of the Poverty

The theory of residential segregation began to develop from the theory of racial segregation in the United States. The United States has been undergoing rapid industrialisation and urbanisation since the 19th century, creating a gap between those who have been able to adapt and those who have not. Black people, who were less able to accumulate capital than their white counterparts, were pushed into poorer housing conditions, and as poverty groups grew, slums were created. The emergence of slum-like concentrations of poverty and the different spatial patterns of residence between white and black people led scholars to study the phenomenon of residential segregation.

Some studies analysed the causes of residential segregation of the poor and immigrant populations using the Concentric Model (Burgess, 1924), while others analysed the residential segregation of specific ethnic groups in the wake of rapid immigration (Wirth, 1928). In sociology, there was a debate between two major perspectives on the causes of concentrated poverty in American cities, one theory combining deindustrialisation of central cities with class-based migration patterns among African Americans, and the other emphasising the importance of racial residential segregation (Wilson 1987, 1996: Massey and Denton, 1998a). Since then, research has focused less on residential segregation itself and more on the various urban problems that arise from this phenomenon, such as studies that suggest that the concentration of segregated low-

and high-income neighbourhoods can lead to social unrest, riots, increased crime, and distrust between segregated social groups (Reardon & Bischoff, 2011; Malmberg, Andersson and Östh, 2013; Musterd, 2016).

Against the background of these various studies, the causes of spatial segregation of the poor have been categorised into economic segregation, racial and ethnic segregation and segregation due to uneven development (Fong and Shibuya, 2000). Studies arguing that economic segregation is the cause of spatial segregation of the poor suggest that people move to specific neighbourhoods where there are available socioeconomic resources (Tiebout, 1956). It has therefore been suggested that the level of spatial segregation of the poor racial and ethnic groups simply reflects economic disparities within the group. In terms of racial and ethnic segregation as a cause, studies have shown that white low-income neighbourhoods are significantly isolated from white high-income neighbourhoods (Wang, 2018). It has been argued that the segregation of the poor due to uneven development is the most basic concept for understanding the differentiation of any urban space (Harvey, 1973; Hill 1977). Uneven development is an important cause of social stratification and group segregation, as newly redeveloped areas attract residents with socioeconomic resources, while old and neglected areas are left with only low-income people (Fong and Shibuya, 2000). Segregation also reflects socioeconomic status and patterns of social relations (Park et al., 1984; Massey, 1985; Musterd, 2017). Patterns of social relations are divided according to the perceived desirability of others, which results in minority groups being unable to neighbour with other groups, forcing them to live in poor physical and social environments and segregation (Alba and Logan 1991; Graif, 2017).

2.2. Urban Redevelopment and Changes in Residential Segregation

One of the dilemmas associated with urban redevelopment and social equity is that building something new through redevelopment often imposes some form of social cost by replacing something old (Thomas and Hwang, 2003). Housing policies such as redevelopment play a central role in creating urban inequalities (Desmond 2012, 2016). In the United States, residents of neighbourhoods targeted for urban renewal were predominantly black and low-income (Fullilove, 2001), and the public housing that was subsequently built for them was also highly segregated by race and class (Rothstein, 2017).

Other disciplines, such as history and sociology, have also discussed the processes by which housing segregation occurs, such as redlining and exclusive zoning (Massey and Denton, 1998b; Rothstein, 2017). The negative impacts of redevelopment processes contribute to neighbourhood segregation, the concentration of undesirable land uses, and negatively impact the potential for wealth accumulation for low-income people

(Whittemore, 2017), further limiting their housing options (Swope and Hernández, 2019). As South Korea aims for rapid modernisation and economic growth, it has implemented redevelopment projects to stimulate growth. Economic growth and housing policies have had important consequences for economic performance, socio-political stability, and the formation of social welfare structures (Ronald and Kyung, 2013). Urban planning in South Korea has been dominated by the state, which has not distributed urban resources equitably in this process. Property owners in redevelopment areas acted as agents of the state and pushed through redevelopment plans at the will of the state (Lee, 2017). As a result of these redevelopments, low-income groups were forced to relocate to make way for higher-income groups, and the wealth that should have been distributed was concentrated in a few areas. Decisions related to the allocation of public resources become highly contested when redevelopment involves existing low-income housing (Thomas and Hwang, 2003), with groups in favour of redevelopment prioritising the accumulation of wealth from redevelopment over the improvement of living conditions for low-income groups, leading to further sociospatial polarisation (Ha, 2015).

3. Scope and Methodology of the Study

3.1. Scope and Variables

Redevelopment is a policy that changes the living environment and urban aesthetics by building new areas in existing deteriorated areas, and is mainly implemented in large cities that have become deteriorated due to a large number of people living there for a long time. Therefore, the spatial scope of the analysis was set to seven metropolitan cities representing South Korea and their autonomous regions. In South Korea, the sub-administrative divisions of a city are *gu*, *gun*, and *dong*. *Dongs* come together to become *gus* or *guns*, and *gus* and *guns* come together to become cities. In this study, *dongs* are denoted by neighbourhoods and *gus* by districts. Among the seven metropolitan cities, the area where more than 50% of the total population of South Korea lives is called the greater Seoul area, and Seoul and Incheon are included in this study. The spatial scope of this study includes a total of 74 *gus*, but 71 *gus* were excluded due to the lack of data in Ongjin-gun and Ganghwa-gun, Incheon, and Gangseo-gu, Busan.

The time span of this study is from 2011 to 2020, and the degree of residential segregation of low-income residents is measured by National Basic Livelihood Security recipients. The lack of micro-level income data in South Korea limits the ability to measure the spatial concentration of low-income households. The demographic data of the National Basic Livelihood Security recipients is not a direct measure of the poor below the poverty line and does not include the next lowest income group. However, it is the most realistic and appropriate variable for estimating the size of the low-income

group at this time, as it identifies those living below the subsistence level who require government protection.

The treatment variable in the propensity score matching analysis is redevelopment status. It is based on redevelopments of 500 units or more that occurred in 71 wards between 2011 and 2020, categorised by year of occupancy. The dependent variable is the low-income neighbourhood segregation index, which is the average of the values of the dissimilarity index, the isolation index, and the Location Quotient (LQ). The Propensity Score Matching (PSM) variables and control variables that affect the mean of the dependent variable, the low-income residential segregation index, are the number of rental apartment units, the number of general apartment units, the average sales price of an apartment, the average rental price of an apartment, and the area of green space per person in each year.

Unlike other policies, redevelopment is implemented in different areas each year rather than simultaneously in a given year. Therefore, unlike other studies, we introduce temporal scope into the spatial scope of the variables, i.e., Gangnam-gu, Seoul in 2011 and Gangnam-gu, Seoul in 2012 as one variable each. The final sample size for the analysis is 710.

Table 1. Variables and References

Variables	Source	Year
National Basic Security recipients	Statistics Korea	
Number of rental apartment for low-income units for sale	Korea Land & Housing Corporation, Metropolitan Corporations	
Number of general apartment units for sale	Korea Housing Association	2011-2020
Redevelopment or not (500+ units)	Korea Housing Association	
Average sale price of an apartment	Korea Real Estate Board	
Average apartment rental price	Korea Real Estate Board	
Green space area per person	Statistics Korea	

3.2. Research Methodology

3.2.1. Residential Segregation Index

There are two ways to measure residential segregation: a global segregation measure, which has one value for each city and allows for cross-city comparisons, and a local segregation measure, which allows for comparisons of residential segregation across neighbourhoods within a city. This study uses the index of dissimilarity and the index of isolation as global segregation measures, and the LQ and the local Moran's I (LISA) as local segregation measures to measure the segregation of low-income neighbourhoods.

Residential segregation has five spatial dimensions: evenness, exposure, concentration, clustering, and centralisation (Massey and Denton, 1988a), and the dissimilarity index was used as a measure of evenness, the isolation index as a measure of exposure, LQ as a measure of concentration, and LISA as a measure of clustering.

Duncan and Duncan's (1955) dissimilarity index, which measures how evenly a group of people is distributed across the entire analysis area, has been the most widely used index for the longest time, despite its limitations due to the aspatial nature of the checkerboard problem. No other metric measures equality more efficiently than the dissimilarity index (Wong, 2003). When two groups are completely segregated in terms of where they live, the value of the index is 1, which is the maximum value. The minimum value is 0, at which point the two groups are not separated at all, i.e., the higher the degree of residential segregation, the closer the value to 1.

$$\text{Equation 1. } D = \frac{1}{2} \sum_i \left| \frac{X_i}{X} - \frac{Y_i}{Y} \right|$$

(X_i : number of people on basic needs living in dong i , X : number of people on basic needs living in the gu to which dong i belongs, Y_i : number of people not on basic needs living in dong i , Y : number of people not on basic needs living in the gu to which dong i belongs)

The dimension of global exposure measures the likelihood of interaction between mainstream and minority groups (Massey and Denton, 1988b). Two indicators of exposure are the interaction index and the isolation index, whose values sum to one. The interaction index measures the extent to which people from minority groups are exposed to people from mainstream groups, while the isolation index measures the extent to which people from minority groups are exposed to each other. In this study, the isolation index is used to measure the degree of segregation in low-income neighbourhoods. The closer the value of the isolation index is to 1, the more segregated the neighbourhood.

$$\text{Equation 2. } {}_aP_a = \left(\frac{a_i}{A} \right) \left(\frac{a_i}{t_i} \right)$$

(a_i : number of people on basic needs living in dong i , A : number of people on basic needs living in the gu to which dong i belongs, t_i : total number of people living in the gu

to which i belongs)

As both a measure of regional equality and a measure of concentration, the LQ has been used in economic geography and regional economics as a measure of the degree of specialisation of a region (Burt and Barber, 1996). It is a measure of the relative importance of a group in a region to the same group in the rest of the country and is an index of the relative degree of specialisation of the group. If the value of the LQ is greater than 1, it means that the proportion of the study group in region i is greater than the proportion of the study group in all regions. This means that the study population is concentrated in that region. Conversely, a value less than 1 indicates that the population is scarce in the region.

$$\text{Equation 3. } LQ_i = \left(\frac{a_i}{t_i} \right) \left(\frac{T}{A} \right)$$

(a_i : number of people on basic needs living in gu i , A : number of people on basic needs living in the city to which gu i belongs, t_i : total number of people living in gu i , T : total number of people living in the city to which gu i belongs)

Unlike the LQ, which treats individual neighbourhoods independently, LISA is a measure of local spatial autocorrelation and considers each neighbourhood in relation to its neighbours (Anselin, 1995). The value of LISA is interpreted as a positive spatial dependence if the proportion of a particular class is relatively high in the area and the proportion of a particular class in the neighbouring area is also high, forming a cluster. On the other hand, if the proportion of a particular class is relatively low in both the area and the neighbouring area, it is interpreted as a negative spatial dependence, and in this study, the particular class is the National Basic Livelihood Recipient.

There are four patterns of spatial association that emerge from LISA. Areas with high index values are called hot spots in the HH (high-high) pattern and are clusters with positive spatial dependence as described earlier. If regions with low index values are adjacent to each other, they are called cold spots in the LL (low-low) pattern and have a negative spatial dependence. A region with a high-low pattern has a high index value in contrast to the low LISA index of its neighbours, and a low-high pattern is a cluster where the region has a low index value and its neighbours have a high index value.

$$\text{Equation 4. } I_i = \frac{Z_i}{m_2} \sum_j W_{ij} Z_j, m_2 = \frac{\sum Z_i^2}{N}$$

(Z_i : deviation between the value of the variable and the mean value, W_{ij} : spatially weighted matrix, N : sum of observations)

3.2.2. Propensity Score Matching (PSM)

PSM is a statistical method that approximates random selection in a pure experiment by

pairing individuals with similar attributes of a common variable represented by a covariate (Rosenbaum and Rubin, 1983). Propensity scores are balancing scores that summarise covariates and have the advantage of reducing the matching dimensions to a single dimension compared to direct matching of covariates. In observational studies, most studies comparing two or more variables are based on non-random sampling, which has the disadvantage of not being able to control selection bias. Therefore, this study uses PSM, one of the quasi-experimental research methods to control selection bias, to test the effectiveness of redevelopment policies. The propensity score is defined as the conditional probability of being assigned to a given treatment given a vector of covariates. In the equation below, $e(x_i)$ is the propensity score, x_i represents the covariate vector, and $D_i=1$ is the treatment group and $D_i=0$ is the control group.

$$\text{Equation 5. } e(x_i) = Pr(D_i = 1|X_i)$$

There are several ways to match the treatment and control cases: 1:1 matching with Nearest Neighbour Matching, 1:N matching, Caliper matching, and Radius matching. Nearest neighbour matching is the method of matching all subjects in the treatment and control groups in the order of the smallest estimated difference in propensity scores. The intuitive way to minimise confounding is to match each participant in the treatment group individually with a participant in the control group, so we used 1:1 nearest neighbour matching in this study (Sainani, 2012). Probit model was used to estimate the propensity score, and the variables used for PSM are as shown in Table 2.

Category	Variables	Definition
Dependent variable	Low-income residential segregation index	Average of dissimilarity index, isolation index, and LQ values
Independent variable	Large-scale redevelopment or not	Redeveloped areas with 500+ units (1), other (0)
Control variables (PSM variables)	Number of rental apartment for low-income units for sale	Number of units for rental apartment for low-income
	Number of general apartment units for sale	Number of units for general apartment
	Average sale price of an apartment	Average monthly apartment sale price

Average apartment rental price	Average monthly apartment rental price
Green space area per person	

Table 2. Structure of PSM variables

4. Analysis Results

4.1. Change in the Residential Segregation Index for the seven Metropolitan Cities

First, this study measures the degree of residential segregation for low-income residents in South Korea using a constant index based on evenness, which is the most central and important dimension of the five dimensions of residential segregation. Table 3 shows the values of the dissimilarity index by city. The top 10 gus with high index values are shown in red as the upper class, and the bottom 10 gus with low index values are shown in blue as the lower class in Table 3. According to the analysis, Seoul Gangnam-gu, followed by Seoul Gangseo-gu, Incheon Yeonsu-gu and Seoul Seocho-gu, showed severe segregation of low-income residents, and more than half of the top groups belonged to the Seoul city. When comparing the values of the index in 2011 and 2020, the values decreased overall. The lowest values were found in Busan Jung-gu, followed by Daegu Nam-gu, Seoul Geumcheon-gu, and Seoul Seodaemun-gu. When examining the changes in ranking within the upper and lower groups, it was found that the changes in ranking were relatively severe among the lower group gus. In addition, the emergence of new gus in the lower group over time was higher than in the upper group.

Table 3. Dissimilarity Index of Low-Income Residential Segregation by City

City	Gu/Gun	Year		City	Gu/Gun	Year	
		2011	2020			2011	2020
Seoul	Jongno	0.23026	0.31955	Busan	Yeongdo	0.26324	0.22162
	Jung	0.18022	0.15027		Dong	0.10078	0.14384
	Yongsan	0.31317	0.32799		Seo	0.18762	0.20480
	Seongdong	0.12118	0.14888		Jung	0.04966	0.05804
Daejeon	Gwangjin	0.18569	0.21003	Daedeok	Yuseong	0.36179	0.25563
	Dongdaemun	0.14264	0.13354		Seo	0.29970	0.21750
	Jungnang	0.17678	0.12259		Jung	0.33052	0.29497
	Seongbuk	0.11568	0.16593		Jung	0.26615	0.24626

	Gangbuk	0.20265	0.13066		Dong	0.27636	0.16487
	Dobong	0.22892	0.25726	Daegu	Dal-seong	0.17923	0.21331
	Nowon	0.32535	0.26870		Dalseo	0.41475	0.40093
	Eunpyeong	0.20425	0.12535		Suseong	0.29169	0.31424
	Seodaemun	0.10447	0.11887		Buk	0.23632	0.29185
	Mapo	0.17789	0.16223		Nam	0.05964	0.10294
	Yangcheon	0.26072	0.27647		Seo	0.12502	0.13662
	Gangseo	0.51923	0.35587		Dong	0.23596	0.21827
	Guro	0.25895	0.20036		Jung	0.10812	0.16205
	Geomcheon	0.07058	0.13542	Gwangju	Gwang-san	0.44755	0.21311
	Yeongdeungpo	0.26287	0.28664		Buk	0.35002	0.29145
	Dongjak	0.15169	0.14324		Nam	0.19432	0.20038
	Gwanak	0.17969	0.13223		Seo	0.31712	0.31226
	Seocho	0.38010	0.34526		Dong	0.13529	0.14563
	Gangnam	0.53844	0.45123	Incheon	Seo	0.24961	0.25424
	Songpa	0.35300	0.31596		Gyeong	0.19153	0.12627
	Gangdong	0.23609	0.25385		Bu-pyeong	0.23919	0.20547
Busan	Gijang	0.12647	0.11241		Nam-dong	0.22446	0.16065
	Sasang	0.34357	0.33331		Yeonsu	0.43928	0.49956
	Suyeong	0.11256	0.12247		Michuhol	0.14477	0.16230
	Yeonje	0.20647	0.18930		Dong	0.17219	0.22339
	Geumjeong	0.22337	0.25369		Jung	0.27316	0.28477
	Saha	0.32430	0.22978	Ulsan	Ulju	0.24283	0.18762
	Haeundae	0.38796	0.38523		Buk	0.13767	0.11006
	Buk	0.37477	0.36277		Dong	0.34843	0.28255
	Nam	0.17515	0.21294		Jung	0.11428	0.16297
	Dongnae	0.17646	0.15886		Nam	0.30123	0.30118
	Busanjin	0.12247	0.13586				

* : upper group (10 gus with large index values), : lower group (10 gus with smaller index values)

The measure of low-income residential segregation using the isolation index is shown in Table 4. In both 2011 and 2020, Busan Sasang-gu had the highest isolation index among the 71 gu, followed by Busan Yeongdo-gu, Daegu Dalseo-gu, and Busan Buk-gu. Conversely, the least segregated gu, Ulsan Buk-gu, had the lowest isolation index in both years, as did Busan Sasang-gu in the previous top group. Busan accounted for half of the upper half of the isolation index, while the lower half of the index was dominated by the greater Seoul area, which accounted for nine out of 10 gus in 2011.

Table 4. Isolation Index of Low-Income Residential Segregation by City

City	Gu/Gun	Year		City	Gu/Gun	Year		
		2011	2020			2011	2020	
Seoul	Jongno	0.01879	0.04642	Busan	Yeongdo	0.08969	0.14184	
	Jung	0.03228	0.04433		Dong	0.08671	0.10788	
	Yongsan	0.03400	0.06050		Seo	0.07232	0.10460	
	Seongdong	0.02099	0.03715		Jung	0.05069	0.08643	
	Gwangjin	0.01582	0.04027		Daejeon	Daedeok	0.07187	0.07483
	Dongdaemun	0.02680	0.04647			Yuseong	0.02673	0.02795
	Junngang	0.02845	0.06577		Seo	0.05240	0.05946	
	Seongbuk	0.02076	0.04228		Jung	0.04777	0.07046	
	Gangbuk	0.04330	0.07310		Dong	0.08474	0.09339	
	Dobong	0.01656	0.05724		Daegu	Dal-seong	0.04584	0.04743
	Nowon	0.05843	0.07846			Dalseo	0.09556	0.10931
	Eunpyeong	0.03201	0.05096			Suseong	0.07346	0.08679
	Seodaemun	0.01873	0.03343			Buk	0.06283	0.06854
	Mapo	0.02007	0.03088			Nam	0.05355	0.09838
	Yangcheon	0.01968	0.04983			Seo	0.04759	0.08859
	Gangseo	0.09522	0.09712		Dong	0.06205	0.06952	
Guro	0.01919	0.03310	Jung	0.05594	0.06418			
Geomcheon	0.02998	0.05015	Gwangju	Gwang-san	0.07954	0.06564		
Yeongdeung-po	0.02659	0.03612		Buk	0.08944	0.10733		
Dongjak	0.01621	0.03400		Nam	0.05215	0.07091		
Gwanak	0.02173	0.04427		Seo	0.05911	0.08053		
Seocho	0.01565	0.02818		Dong	0.06177	0.06930		
Gangnam	0.08171	0.08227		Incheon	Seo	0.02057	0.04793	

	Songpa	0.01657	0.03842		Gye-yang	0.01715	0.05310
	Gangdong	0.01765	0.04028		Bu- pyeong	0.03609	0.06715
Busan	Gijang	0.04015	0.05871		Nam- dong	0.03758	0.06352
	Sasang	0.12597	0.17106		Yeonsu	0.05419	0.05717
	Suyeong	0.03224	0.02954		Michuhol	0.02519	0.06172
	Yeonje	0.04139	0.05876		Dong	0.04077	0.07182
	Geumjeong	0.04436	0.07299		Jung	0.04362	0.05327
	Saha	0.06484	0.08035	Ulsan	Ulju	0.01929	0.02911
	Haeundae	0.06745	0.09218		Buk	0.01189	0.02140
	Buk	0.09471	0.11772		Dong	0.02399	0.04615
	Nam	0.02961	0.04963		Jung	0.02296	0.04116
	Dongnae	0.02733	0.04273		Nam	0.02064	0.04154
Busanjin	0.03901	0.06047					

* : upper group (10 gus with large index values), : lower group (10 gus with smaller index values)

The measurement of low-income residential segregation through LQ is shown in Table 5. The LQ values of the upper groups are all greater than 1, so it can be seen that low-income people are concentrated in those areas. Busan Dong-gu is located at the top of the upper group, followed by Busan Yeongdo-gu and Daegu Nam-gu, where the concentration of low-income people is also severe. On the other hand, all the cities and gus in the lower group have LQ values lower than 1, indicating a low concentration of low-income residents. Seoul's Seocho-gu has the lowest degree of segregation, followed by Daejeon's Yuseong-gu and Busan's Gangseo-gu. Interestingly, both the upper and lower groups are dominated by gus in Seoul and Busan. We can see that Seoul and Busan are more segregated than other metropolitan cities.

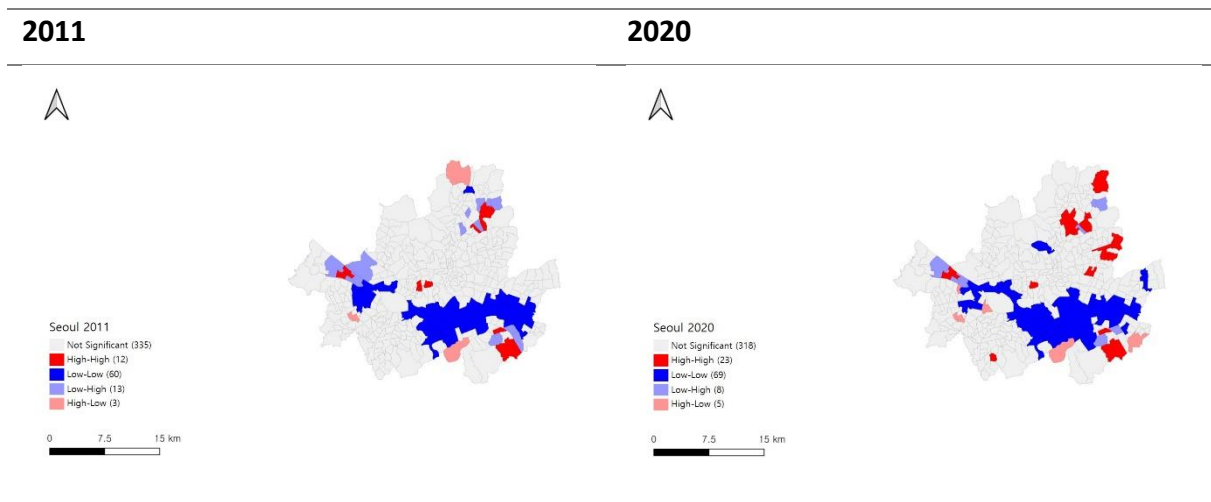
Table 5. LQ of Low-Income Residential Segregation by City

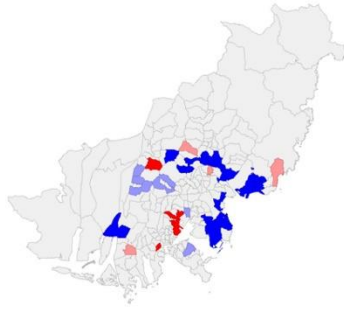
City	Gu/Gun	Year		City	Gu/Gun	Year	
		2011	2020			2011	2020
Seoul	Jongno	0.85480	0.75831	Busan	Yeongdo	1.46451	1.76436
	Jung	1.28868	1.00727		Dong	1.83397	1.69719
	Yongsan	0.87047	0.85721		Seo	1.52488	1.50058
	Seongdong	0.94077	0.83483		Jung	1.24235	1.45630

	Gwangjin	0.66048	0.85701	Daejeon	Daedeok	1.30974	1.23217
	Dongdaemun	1.17234	1.08812		Yuseong	0.43261	0.48658
	Jungnang	1.18044	1.59062		Seo	0.68723	0.79551
	Seongbuk	0.94878	0.89108		Jung	1.17679	1.20759
	Gangbuk	1.50585	1.64396		Dong	1.54617	1.49248
	Dobong	0.64587	1.08645	Daegu	Dal-seong	0.95661	0.74048
	Nowon	1.77799	1.50532		Dalseo	0.99786	0.96541
	Eunpyeong	1.21628	1.21289		Suseong	0.88015	0.82178
	Seodaemun	0.85995	0.81869		Buk	0.82641	0.73356
	Mapo	0.80417	0.67863		Nam	1.25802	1.69370
	Yangcheon	0.70273	0.90238		Seo	1.05961	1.50786
	Gangseo	1.54043	1.22121		Dong	1.03042	1.01375
	Guro	0.66775	0.71594		Jung	1.25948	1.04380
	Geomcheon	1.43720	1.19352	Gwangju	Gwang-san	0.75366	0.76193
	Yeongdeungpo	0.91127	0.66459		Buk	1.08787	1.15122
	Dongjak	0.70821	0.78240		Nam	1.04425	1.00745
	Gwanak	0.90977	1.03264		Seo	0.88758	0.95237
	Seocho	0.32705	0.40526		Dong	1.32050	1.07267
	Gangnam	0.78554	0.67594	Incheon	Seo	0.61536	0.73503
	Songpa	0.46204	0.60963		Gye-yang	0.57228	1.01120
	Gangdong	0.67978	0.80277		Bu-pyeong	1.09102	1.14578
Busan	Gijang	0.91109	0.94030		Nam-dong	1.03917	1.07526
	Sasang	1.11928	1.12271		Yeonsu	1.05767	0.52791
	Suyeong	0.73691	0.46656		Michuhol	0.88418	1.11621
	Yeonje	0.84721	0.82200		Dong	1.36461	1.16285
	Geumjeong	0.86835	0.92475		Jung	1.20151	0.74571
	Saha	1.04872	1.10094	Ulsan	Ulju	0.89966	0.82127
	Haeundae	0.80903	0.83883		Buk	0.68911	0.68763
	Buk	1.35187	1.22403		Dong	0.78237	1.13856
	Nam	0.63522	0.69771		Jung	1.39681	1.20923
	Dongnae	0.57451	0.69304		Nam	0.82856	0.98015
	Busanjin	0.89727	0.96526				

* : upper group (10 gus with large index values), : lower group (10 gus with smaller index values)

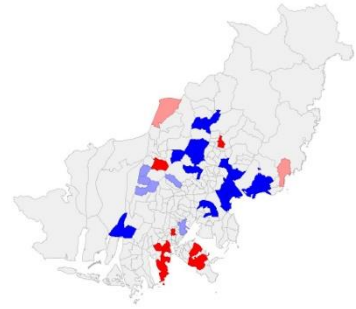
Figure 1 is a map of the LISA analysis of the proportion of the total number of residents in each ward who are recipients of the National Basic Livelihood by ward. In the case of Seoul, the number of wards in the LL, LH, and HL patterns has not changed significantly, but the number of how spot areas in the HH pattern has doubled. This means that the number of clusters with a high proportion of basic living recipients in both the neighbourhood and the surrounding areas has doubled, which means that low-income people are clustered together and residential segregation has intensified. In the case of Busan, the HH pattern increased by about two times, and the LL pattern increased slightly. In Daegu, the number of HH pattern areas tripled, and the HL pattern also increased, in contrast to the low proportion of basic living recipients in the surrounding neighbourhoods. Daejeon and Gwangju have also seen an increase in the number of HH-patterned neighbourhoods, leading to increased segregation of low-income residents, and Ulsan shows similar results over time. However, only Incheon shows a significant decrease in the number of HH pattern neighbourhoods in contrast to the other metropolitan cities, indicating that the segregation of low-income residents is easing.





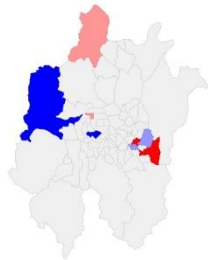
Busan 2011
Not Significant (162)
High-High (6)
Low-Low (23)
Low-High (7)
High-Low (4)

0 7.5 15 km



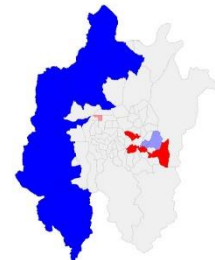
Busan 2020
Not Significant (156)
High-High (10)
Low-Low (29)
Low-High (5)
High-Low (2)

0 7.5 15 km



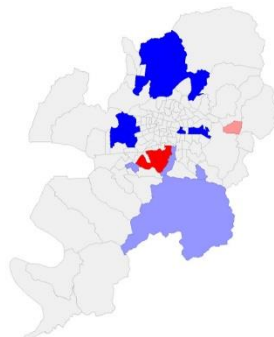
Daejeon 2011
Not Significant (68)
High-High (2)
Low-Low (4)
Low-High (2)
High-Low (2)

0 7.5 15 km



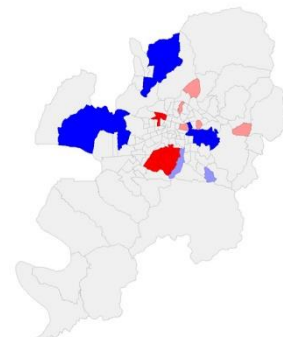
Daejeon 2020
Not Significant (60)
High-High (4)
Low-Low (11)
Low-High (2)
High-Low (1)

0 7.5 15 km



Daegu 2011
Not Significant (116)
High-High (4)
Low-Low (14)
Low-High (4)
High-Low (1)

0 7.5 15 km



Daegu 2020
Not Significant (106)
High-High (12)
Low-Low (14)
Low-High (2)
High-Low (5)

0 7.5 15 km

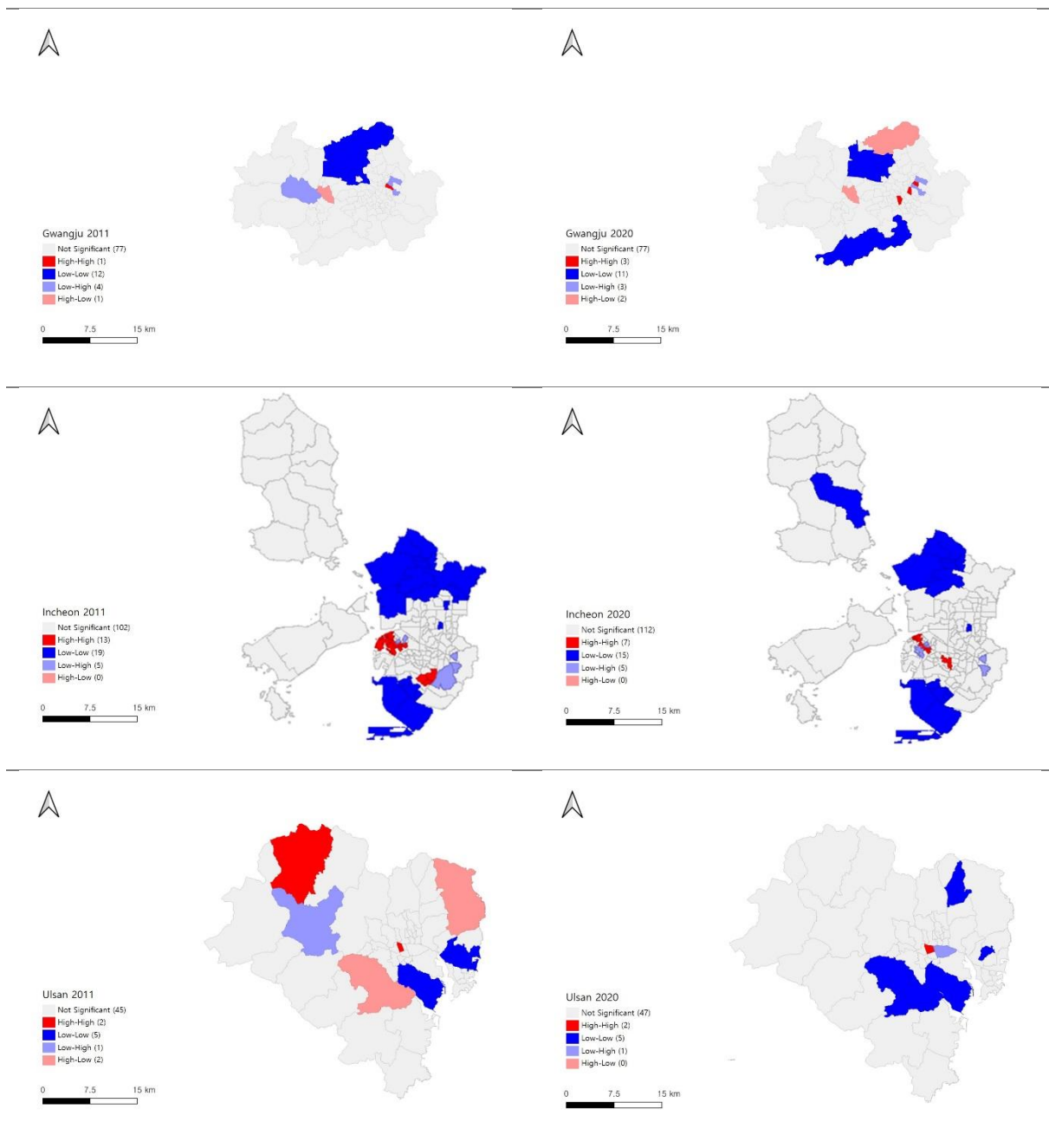


Figure 1. LISA analysis of seven large cities

4.2. Impact of Redevelopment Policies on Low-Income Residential Segregation

For PSM, treatment and control groups were determined by whether or not redevelopment was implemented. The treatment group is the group where redevelopment was implemented, and the basic statistics of the analysed data are shown in Table 6. Of the 710 gus, 181 gus are treatment groups and 529 gus are control groups. The mean of the residential segregation index is about 0.03 lower in the

treatment group than in the control group, and the mean of the number of rental and regular apartment units is lower in the control group. Average sales and rental prices are 1.5 times higher in the treatment group. However, the average green space per person in the treatment group is less than half of the average in the control group.

Table 6. Basic Statistics for Control and Treatment Groups

Variables	Control group			Treatment group		
	Observation	Mean	Std. Dev.	Observation	Mean	Std. Dev.
Average residential segregation index	529	0.434198	0.110682	181	0.403091	0.099859
Rental apartments	529	149.7278	404.9609	181	180.9613	533.4318
General apartment	529	376.1607	939.4394	181	408.2928	816.6966
Average selling price	529	309268.5	202479.5	181	458088.6	319928.9
Average rental price	529	2558.18	1218.815	181	3498.264	1662.985
Green space per person	529	190.5873	358.7899	181	88.34387	190.707

The average changes in the variables of the control and treatment groups before and after the ultra-proximity neighbourhood matching used in the study are presented in Table 7 as a result of the PSM before estimating the average treatment effect. The propensity score was estimated using the number of rental apartment units, number of general apartment units, average rental price, average sales price, and per person green space as covariates. The PSM resulted in improved homogeneity for all variables. Before matching, there was a statistically significant difference between the mean values of the treatment and control groups, but after matching, all variables were no longer significantly different. This suggests that the attributes of the two groups have become more similar.

Table 7. Changes in Homogeneity of Control and Treatment Groups

Variables	Un/	Mean	%	%	T-test	V(T)
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	Matched	Control group	Treatment group	bias	reduct lbiasl	t	p> t	/V(C)
Rental apartment	U	180.96	149.73	6.6		0.82	0.411	1.74*
	M	180.96	202.06	-4.5	32.4	-0.37	0.715	0.89
General apartment	U	408.29	376.16	3.7		0.41	0.682	0.76
	M	408.29	512.94	-11.9	-225.7	-0.98	0.328	0.48*
Average rental price	U	3498.3	2558.2	64.5		8.11	0.000	1.86*
	M	3498.3	3388.1	7.6	88.3	0.65	0.516	1.13
Average sales price	U	460000	310000	55.6		7.26	0.000	2.50*
	M	460000	410000	17.2	69.1	1.59	0.113	2.07*
Green per person	U	88.344	190.59	-35.6		-3.66	0.000	0.28*
	M	88.344	85.046	1.1	96.8	0.17	0.867	1.08*

To examine the effect of redevelopment on the segregation of low-income neighbourhoods, we estimated the average treatment effect (ATT) based on the matching results, and the results are shown in Table 8. The average treatment effect analysis shows an average difference of about 0.0289 between the treatment group with redevelopment and the control group without redevelopment. Therefore, assuming that all conditions are the same, redevelopment of an area without redevelopment reduces the degree of low-income residential segregation by 0.0289.

Table 8. The Effect of Redevelopment on the Low-Income Residential Segregation

Status	Treated	Controls	Difference	S.E.	T-stat
Unmatched	0.403090454	0.434197681	-0.031107227	0.00930296	-3.34
ATT	0.403090454	0.431952413	-0.028861958	0.013362742	-2.16
ATU	0.434197681	0.418813721	-0.01538396		
ATE			-0.018819901		

5. Discussion

South Korea has undergone significant urban restructuring over the past two decades. The early 2000s often saw large-scale demolition of low-rise residential neighbourhoods and redevelopment into high-rise apartments, which generated negative externalities such as the destruction of communities, displacement of existing residents, and loss of affordable housing (Weber et. al., 2006). Redevelopment initiated with the aim of improving low-income neighbourhoods has also had the effect of increasing the segregation of poor neighbourhoods by displacing the poor indigenous people who lived there (Tach and Emory, 2017). However, if the degree of low-income residential

segregation is measured by the change in the dissimilarity index value, the results of this study show that the overall dissimilarity index value decreased from 2011 to 2020, suggesting that residential segregation is reduced. These results are likely influenced by a new approach to housing redevelopment called the New Town Exit Strategy, which began in 2012. Instead of demolition and redevelopment, the New Town Exit Strategy pursues a programme of reconstruction and small-scale on-site demolition within older low-rise residential areas (Yang, 2020). This strategy makes it more difficult to refurbish existing neighbourhoods with high-density high-rise developments, resulting in a diversity of residential spaces in urban centres that had become homogenous. The result is that Seoul's boroughs have a significant number of low-income subgroups in the segregation index. Seoul and Busan have higher values than other metropolitan areas, which is consistent with previous research that high financial independence, high proportion of youth population, and high population density increase economic disparity (Park, 2019).

A PSM analysis of the net effect of redevelopment policies shows that neighbourhoods with redevelopment have a lower low-income residential segregation index than neighbourhoods without redevelopment. The conclusion that redevelopment reduces low-income residential segregation can be explained by the phenomenon of gentrification caused by redevelopment. Over the past 40 years, urban redevelopment in South Korea has aimed to maximise housing supply and improve the physical environment, and redevelopment programs have focused on maximising landlord profits rather than improving the residential welfare of low-income residents or revitalising communities. As a result, low-income residents are pushed out of their neighbourhoods and move to the periphery, where they are replaced by middle- and high-income residents (Ha, 2015). Therefore, residential segregation is explained by the dispersal of low-income natives who used to live together due to redevelopment.

The significance of this study is that it analyses the micro-level spatial structure of poverty, which is at the centre of structural inequality, and identifies the net effect of redevelopment projects on residential segregation. On the other hand, there are also limitations. First, although the PSM method was used to reduce selection bias, it is impossible to achieve complete randomisation in social science research. It is not possible to assume that the control group was matched equally and similarly on all other factors. Second, the manipulated variable for the low-income group, the National Basic Livelihood Recipients, does not accurately represent the low-income group as a whole. While it is clear that the group is similar in meaning to the low-income group, it does not include everyone below the absolute or relative poverty line. Finally, there are no clear conclusions to be drawn from the various measures of residential segregation. Continued efforts are needed to develop a single indicator that encompasses all five dimensions of residential segregation.

6. Conclusion

Development to address the housing shortage caused by rapid urbanisation has led to an increase in the value of real estate and other assets, and a rise in income inequality between those who have accumulated wealth and those who have not. Against this context, this study analyses changes in the residential segregation of low-income households in metropolitan areas where there have been many changes in residence. We analysed residential segregation from a macro perspective with the dissimilarity index and isolation index, and from a micro perspective with the LQ and LISA analysis. From a global perspective, the residential segregation of low-income residents has generally eased, and in terms of exposure, the segregation of low-income residents is highest in Busan and lowest in Seoul. Low-income residents clustered in urban centres and became less dense towards the outer periphery. PSM analyses controlling for apartment price and residential environment showed that redevelopment areas were less segregated than non-redevelopment areas, with implications for urban development policy.

As many high-income earners move to the outer periphery of the city to escape the complexity of urban life and enjoy a life similar to Howard's countryside, low-income residents are concentrated in the centre of the city. In addition, urban development is now slowing down, with many regulations in place to prevent sprawl and allow for meaningful redevelopment. Large cities have extended the timeframe for redevelopment consideration to 20-40 years. In this reality, research on urban renewal and low-income residential segregation can be an important reference for the formulation and implementation of urban planning and housing policies. It can be used in the formulation of low-income housing policies because it addresses changes in the residential segregation of the poor, which is not often addressed due to the lack of alternative indicators, and the conclusion that redevelopment has a positive impact on low-income residential segregation emphasises the need to consult with those responsible for low-income housing policies in the selection of future redevelopment areas for greater effectiveness.

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References

Alba, R. and Logan, J. (1991) Variations on two themes: Racial and ethnic patterns in the

- attainment of suburban residence. *Demography*, 28 (3), pp. 431-453.
- Anselin, L. (1995) Local indicators of spatial association - LISA. *Geographical Analysis*, 27 (2), pp. 93-115.
- Briggs, X. (ed.) (2005) *The geography of opportunity: Race and housing choice in metropolitan America*. Washington, D.C.: Brookings Institution Press.
- Brooks-Gunn, J., Duncan, G., Klebanov, P. and Sealand, N. (1993) Do neighborhoods influence child and adolescent development? *American Journal of Sociology*, 99 (2), pp. 353–395.
- Brown, L. and Chung, S. Y. (2006) Spatial segregation, segregation indices and the geographic perspective. *Population Space and Place*, 12 (2), pp. 125-143
- Burgess, E. (2008). *The growth of the city: An introduction to a research project*. In: et al. *Urban Ecology*. Boston: Springer.
- Burt, J., G. Barber, and D. Rigby (2009) *Elementary statistics for geographers, Third Edition*. New York: The Guilford Press.
- Charles, C. (2003) The dynamics of racial residential segregation. *Annual Review of Sociology*, 29 (1), pp. 167-207.
- Chung, S. and Brown, L. (2007) Racial/ethnic residential sorting in spatial context: testing the explanatory frameworks. *Urban Geography*, 28 (4), pp. 312-339
- Duncan, D. and Duncan, B. (1955) A methodological analysis of segregation indexes. *American Sociological Review*, 20 (2), pp. 210-217.
- Fong, E. and Shibuya, K. (2000) The spatial separation of the poor in Canadian cities. *Demography*, 37 (4), pp. 449-459.
- Graif, C., Lungeanu, A. and Yetter, A. (2017) Neighborhood isolation in Chicago: Violent crime effects on structural isolation and homophily in inter-neighborhood commuting networks. *Social Networks*, 51, pp. 40–59.
- Gu, Y. and Wang, Z. (2022) Income inequality and global political polarization: The economic origin of political polarization in the world. *Journal of Chinese Political Science*, 27 (6), pp. 375–398.
- Guo, S. and Fraser, M. (2015) *Propensity score analysis: Statistical methods and application, First Edition*. Los Angeles, London, New Delhi, Singapore, Washington D.C.: Sage Publications.
- Ha, S. (2007) Housing regeneration and building sustainable low-income communities in Korea. *Habitat International*, 31 (1), pp. 116–129.
- Ha, S. (2010) Housing crises and policy transformations in South Korea. *European Journal of Housing Policy*, 10 (3), pp. 255–272.
- Ha, S. (2015) *The endogenous dynamics of urban renewal and a gentrification process in Seoul*. In: Lees L, Shin HB and Lopez-Morales E (eds) *Global Gentrifications: Uneven Development and Displacement*. London: Policy Press, pp. 464–477.
- Harvey, D. (1973) *Social justice and the city*. Georgia: University of Georgia Press
- Hill, E. and Wolman, H. (1997) City-suburban income disparities and metropolitan area

- employment: Can tightening labor markets reduce the gaps? *Urban Affairs Review*, 32 (4), pp. 558–582.
- Jargowsky, P. (1996) Take the money and run: Economic segregation in U.S. metropolitan areas. *American Sociological Review*, 61 (6), pp.984-998.
- Jun, H. (2020) Spillover effects in neighborhood housing value change: A spatial analysis. *Housing Studies*, 37 (8), pp. 1–28.
- Koo, H. (2019) Rising inequality and shifting class boundaries in South Korea in the neo-liberal era. *Journal of Contemporary Asia*, 51 (1), pp. 1–19.
- Lee, J and Kim, G. (2020) A study on preference for shared housing as an alternative to college student housing welfare: Focusing on the Seoul metropolitan area. *Journal of Korea Real Estate Analysis Association*, 26 (3), pp. 81-97.
- Lee, S. (2017) Cities for profit: Profit-driven gentrification in Seoul, South Korea. *Urban Studies*, 55 (12), pp. 2603–2617.
- Lobao, L., Hooks, G. and Tickamyer, A. (2008) Poverty and inequality across space: Sociological reflections on the missing-middle subnational scale. *Cambridge Journal of Regions, Economy and Society*, 1 (1), pp. 89–113
- Malmberg, B., Andersson, E. and Östh, J. (2013) Segregation and urban unrest in Sweden. *Urban Geography*, 34 (7), pp. 1031–1046.
- Massey, D. (1985) Ethnic residential segregation: A theoretical synthesis and empirical review. *Sociology and Social Research*, 69, pp. 315-350.
- Massey, D. and Eggers, M. (1990) The ecology of inequality: Minorities and the concentration of poverty, 1970-1980. *American Journal of Sociology*, 95 (5), pp. 1153-1188.
- Massey, D. and Denton, N. (1988) The dimensions of residential segregation. *Social Forces*, 67 (2), pp. 281-315.
- Massey, D. and Denton, N. (1998) *American apartheid: Segregation and the making of the underclass*. Massachusetts: Harvard University Press.
- Musterd, S. (2016) Social and ethnic segregation in Europe: Levels, causes and effects. *Journal of Urban Affairs*, 27 (3), pp. 331–348.
- Musterd, S., Marcińczak, S., Van Ham, M. and Tammaru, T. (2017) Socioeconomic segregation in European capital cities. Increasing separation between poor and rich. *Urban Geography*, 38 (7), pp. 1062–1083.
- Owens, A. (2018) Income segregation between school districts and inequality in students' achievement. *Sociology of Education*, 91 (1), pp. 1-27.
- Park, C. and Han, G. (2021) The financialization of non-financial firms: The case of South Korea, 1997–2015. *Current Sociology*, 70 (7), pp. 1085–1105.
- Park, R., Burgess, E. and McKenzie, R. (1984) *The city*. Chicago: University of Chicago Press.
- Park, Y. (2019) Determinants of economic segregation and spatial distribution of poverty. *Journal of Distribution Science*, 17 (3), pp. 21-30.
- Piketty, T. (2014) *Capital in the twenty-first century*. Massachusetts: Harvard University

Press.

- Ploegmakers, H. and Beckers, P. (2014) Evaluating urban regeneration: An assessment of the effectiveness of physical regeneration initiatives on run-down industrial sites in the Netherlands. *Urban Studies*, 52 (12), pp. 2151–2169.
- Reardon, S. and Bischoff, K. (2011) Income inequality and income segregation. *American Journal of Sociology*, 116 (4), pp. 1092–1153.
- Ronald, R. and Kyung, S. (2013) Housing system transformations in Japan and South Korea: Divergent responses to neo-liberal forces. *Journal of Contemporary Asia*, 43 (3), pp. 452–474.
- Rosenbaum, P. and Rubin, D. (1983) The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70 (1), pp. 41–55.
- Sager, L. (2011) Residential segregation and socioeconomic neighbourhood sorting: Evidence at the micro-neighbourhood level for migrant groups in Germany. *Urban Studies*, 49 (12), pp. 2617–2632.
- Sainani, K. (2012) Propensity scores: Uses and limitations. *Physical Medicine and Rehabilitation*, 4 (9), pp. 693–697.
- Sampson, R. (2008) Moving to inequality: Neighborhood effects and experiments meet social structure. *American Journal of Sociology*, 114 (11), pp. 189–231.
- Sampson, R. and Wilson, W. (1995) *Toward a theory of race, crime, and urban inequality*. In J. Hagan and R. D. Peterson (eds.), *Crime and inequality*, pp. 37–54. California: Stanford University Press.
- Sampson, R., Raudenbush, S. and Earls, F. (1997) Neighborhoods and violent crime: A multilevel study of collective efficacy. *Science*, 277 (5328), pp. 918–924.
- Sampson, Robert, J., Jeffrey, D., Morenoff and Gannon-Rowley, T. (2002) Assessing ‘neighborhood effects’: Social processes and new directions in research. *Annual Review of Sociology*, 14 (28), pp. 443–478.
- Seo, J. (2016) Housing policy and urban sustainable development: Evaluating the process of high-rise apartment development in Korea. *Urban Policy and Research*, 34 (4), pp. 330–342.
- Shalizi, C. and Thomas, A. (2011) Homophily and contagion are generically confounded in observational social network studies. *Social Methods Res*, 40 (2), pp. 211–239.
- Talò, C., Mannarini, T. and Rochira, A. (2013) Sense of community and community participation: A meta-analytic review. *Social Indicators Research*, 117 (1), pp. 1–28.
- Thomas, J. and Hwang, H. (2003) Social equity in redevelopment and housing. *Journal of Planning Education and Research*, 23 (1), pp. 8–23.
- Tiebout, C (1956) A pure theory of local expenditures. *Journal of Political Economy*, 64 (5), pp. 416–424.
- Weber, R., Doussard, M., Bhatta, S. and McGrath, D. (2006) Tearing the city down: Understanding demolition activity in gentrifying neighborhoods. *Journal of Urban Affairs*, 28 (1), pp. 19–41.

- White, M. J. (1983) The measurement of spatial segregation. *American Journal of Sociology*, 88 (5), pp. 1008-1018.
- Wilson, (1987) *The truly disadvantaged: The inner-city, the underclass, and public policy*. Chicago: University of Chicago Press.
- Wirth, L. (1928) *The ghetto*. Chicago: University of Chicago Press.
- Wong, D. (2003) Implementing spatial segregation measures in GIS. *Computers, Environment and Urban Systems*, 27 (1), pp. 53-70.
- Yang, H. (2020) Spatio-temporal changes of housing features in response to urban renewal initiatives: The case of Seoul. *Sustainability*, 12 (19), pp. 7918.