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# Spatio-Temporal Changes of Housing Features in Response to Urban Renewal Initiatives: The Case of Seoul

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**Abstract:** Over the past two decades, Seoul has been in a transitional period in terms of urban renewal approaches. Housing is a fundamental element of citizens' lives and the built landscape, thus, it deserves thoughtful scrutiny. As such, this study empirically investigates the dynamics of the spatial and temporal characteristics of housing stock within the context of new urban renewal policies in Seoul. A fine-grained and multifaceted analysis shows that the supply of new apartments has decreased over time, revealing that denser housing redevelopment in the inner city has become more difficult. In addition, an exploratory spatial data analysis indicates that although spatial clustering of old housing units has been reduced, new housing units have become more spatially distributed and outwardly dispersed over time. Since the physical and locational changes of housing stock are closely related to urban renewal initiatives, this study suggests that the city government needs to incorporate the concept of sustainable urban growth management into its housing supply and renewal policies.

**Keywords:** housing; urban renewal; exploratory spatial analysis; urban growth management

## 1. Introduction

The topic of restructuring cities has attracted the attention of many urban scholars and planners. In the early stages of the post-industrial era, urban spatial structures featured a central business district (CBD) consisting of high-rise office buildings, and the inner city provided residential space to working-class communities [1]. Rife with dilapidated, low-rise housing, inner-city areas have long suffered from poor housing services, clustered poverty, and high crime rates [2,3]. While some cities face a continued population march to peripheral areas [4,5], many others have embarked on large-scale inner-city redevelopment projects in order to upgrade urban environments that can attract new residents and retain old ones via housing reform [6–8]. In particular, the increase in inner-city apartment stock in denser residential developments has reflected a growing demand on the part of residents to be close to the city center in order to shorten commute time and enjoy vibrant city amenities and services [8,9].

Seoul, the capital of South Korea (hereafter Korea), has experienced significant restructuring in the past twenty years. Starting in the early 2000s, government leadership in Seoul initiated inner city redevelopment projects to promote high-rise residential development in urban centers and upgrade old, dilapidated housing units in those areas. These projects often required large-scale clearance of low-rise residential areas and redevelopment into high-rise apartments. Since the clearance and redevelopment approach produced negative externalities, such as community destruction, displacement of incumbent residents, and loss of affordable housing [9–11], the city government announced a new approach to housing renewal in 2012 called the New Town Exit Strategy [12]. The New Town Exit

Strategy has pursued rehabilitation, spot demolition, and infill programming within old, low-rise residential areas in lieu of clearance and redevelopment. The effort made it more difficult to overhaul previously developed areas with denser high-rise development plans.

Recognizing that Seoul has taken several turns over the past two decades in terms of its restructuring approaches, this paper attempts to holistically understand the spatial and temporal features of the housing stock in Seoul. Although Seoul's planned approach for urban renewal has vacillated, denser residential development in inner city areas has long been considered a key component of smart growth and sustainable development [13,14]. However, realizing successfully dense development projects is neither simple nor straightforward, as the process of disinvestment and reinvestment in the built environment involves uneven space and geographical diversity [15,16]. While existing studies have examined the dynamics of spatio-temporal patterns of housing in various urban contexts, few have investigated how the housing market and urban renewal policy are intertwined. This paper attempts to furnish an in-depth review of urban spatial patterns with a fine-grained and multifaceted analysis with the perspective that sustainable urban growth management requires an integrated, area-specific planning approach at local levels [17,18].

This paper aims to provide a holistic review of the dynamic of spatial and temporal features of housing units, with a particular focus on urban renewal initiatives. Taking Seoul as a case study, this paper first looks into the change in housing stock that has occurred in the past decades. Then, it explores whether and how locational clustering patterns of old and new housing units have changed over time. Lastly, it addresses the question of how physical and locational changes in housing stock relate to Seoul's urban renewal initiatives. The paper is organized as follows: Section 2 explores the history of planned intervention for Seoul's urban renewal initiatives over the past two decades. Section 3 elaborates the study area, dataset, and methodology. Section 4 provides analysis of the changes in the spatial and temporal characteristics of housing in response to new urban renewal policies. Finally, Section 5 summarizes the findings and their implications for housing and urban renewal policies.

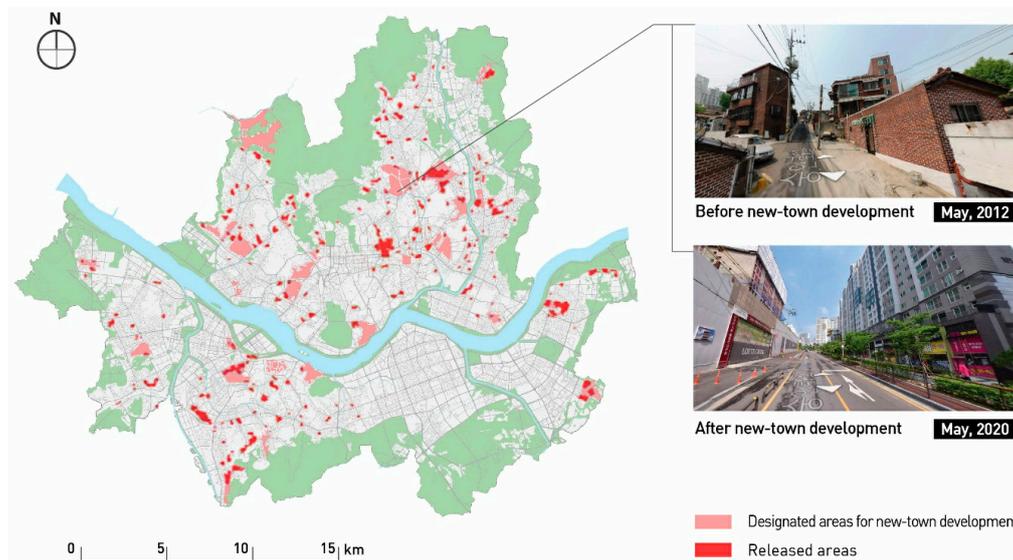
## 2. Housing Development and Renewal Policies

Korea occupies a unique place in housing and urban development. In response to rapid economic growth and urbanization processes, private-driven housing development has received wide advocacy to create a mass housing supply and improve residential communities [19,20]. In particular, Seoul, the capital city, has accommodated an enormous influx of residents from other regions of the country. In the 1960s, 2.44 million people resided in Seoul. The population doubled within 10 years and quadrupled in 30 years, housing 10.60 million residents by 1990. As the city's population rapidly grew, the government constructed more and more apartments to accommodate the tremendous inbound migration of rural Koreans [21,22]. During this building boom, the total quantity of high-rise apartments increased as a percentage of total housing stock from 3.9% in 1970 to 31.0% in 1990.

Despite the massive construction efforts that took place in Seoul, the housing supply rate, as measured by the ratio of the number of housing units to the number of households, was still just 57.9% in 1990 [22]. It was against this backdrop that the Korean government embarked on its Two-Million House Construction Drive (1988–1992) to develop five new towns on the outskirts of Seoul. This initiative was regarded as a serious attempt to increase the supply of new housing on a large scale [20]. Since the towns were developed by converting agricultural land to residential land with a master plan approach, the newly developed areas boasted high-quality residential environments with abundant green spaces. However, since those new towns were located far from the city center, residents faced longer commutes, which raised concerns about the negative impacts of excess energy consumption and environmental pollution.

In response to these side effects, the Seoul government announced plans to introduce inner-city redevelopment initiatives in October 2002. The initiatives embraced new in-city town developments in the form of high-rise apartments and cleared away old, low-rise houses, as described in Figure 1. Since these projects were mainly carried out by the private sector, the government's role in the process

of demolition and redevelopment was limited to area designator. With electoral stakes in mind, the government designated areas for the new town development projects. Within ten years, the target areas of the new town development were slated to account for 10% of the total area of Seoul [23,24]. Due to this large designation, many undeveloped areas were suspended in an incomplete state, which raised concerns about vacant housing and crime in these areas.



**Figure 1.** Designated and released areas for the new town development projects. Source: The Seoul Institute [24]; road views were retrieved from <https://map.naver.com>.

Intending to usher in a paradigm shift for housing renewal, on 30 January 2012, the Seoul government announced its New Town Exit Strategy, as summarized in Table 1. In place of large-scale clearance and redevelopment, the New Town Exit Strategy pursued rehabilitation, spot demolition, and an infill program within the old, low-rise residential areas [12,24]. This gradual rehabilitation plan was backed by several pieces of legislation. The Act on the Improvement of Urban Areas and Residential Environments (revised in 2012) promoted and supported small-scale infill redevelopment, and the Special Act on the Promotion of and Support of Urban Regeneration (signed into law in 2013) aimed to rehabilitate the aging residential environment without displacing tenants. While these projects received criticism for their ineffectiveness at improving residential quality, others supported them for establishing residential stability. Additionally, the government tightened regulation standards around apartment redevelopment. The original consideration timeframe for redevelopment, 20 years, was increased to 20–40 years based on construction year.

**Table 1.** Summary of New Town Exit Strategy.

- Mayor Park announced new renewal initiatives after 3-month public hearing and discussion.
- Focus moving from owners to residents; from profit-based demolition to community building.
- Establishment of tenant resettlement systems (reinforcement of housing rights).
- Reinvestigation designated numerous new town development areas (610 areas) in Seoul.
- Reclassification of designated new town areas after collecting residents' opinions:
  - Released areas—converted to rehabilitation project based on community wishes.
  - Continued new town areas—simplified processes with administrative supports.
- Operating residential regeneration support center dedicated to mediating conflicts.
- Changes in fundamental perspectives on renewal projects from business to human rights.

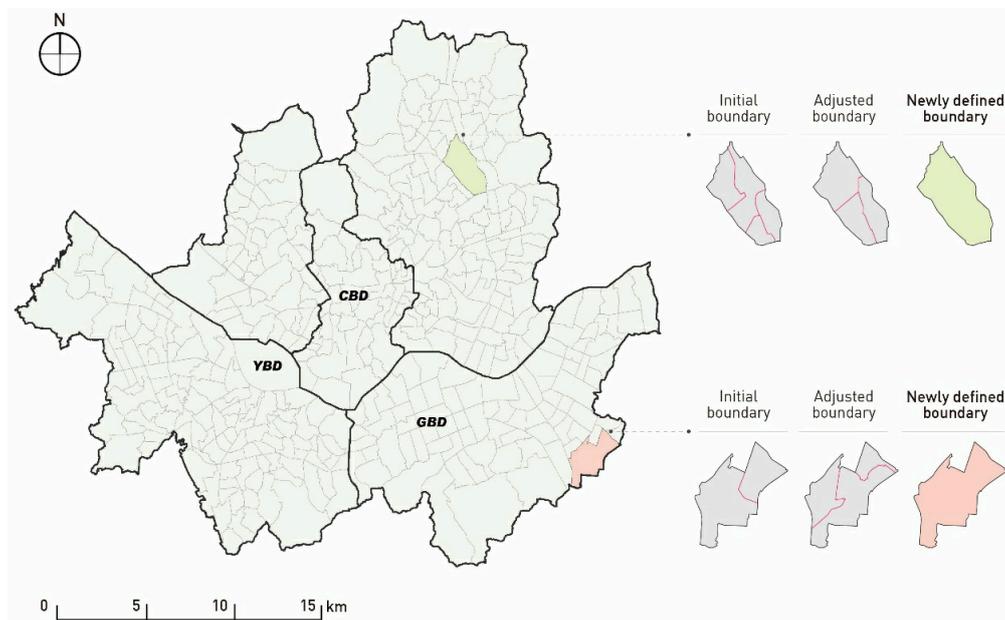
Source: Press release by Seoul Metropolitan Government (30 January 2012).

Seoul has undergone considerable change over the past two decades. In the 2000s, the shift toward urban and housing renewal was encapsulated in the in-city new town development strategy (2002) and the follow-up New Town Exit Strategy in 2012. Based on the changes created by these urban renewal initiatives, I now attempt to empirically assess the dynamics of the spatial and temporal characteristics of the housing stock between 2000 and 2018 and discuss the effects that inner-city renewal initiatives have had on Seoul's housing stock.

### 3. Analytical Research Design

#### 3.1. Study Area and Data

The study area, Seoul, currently accommodates 10 million residents and 5.3 million economically active people. As described in Figure 2, Seoul has three business districts: the Central Business District (CBD), the Yeouido Business District (YBD), and the Gangnam Business District (GBD). To understand the spatial and temporal housing characteristics of Seoul in the 2000s, I attempted to secure a housing inventory by exploring two types of publicly released datasets. I first considered the building registry data provided by the Ministry of Land, Infrastructure and Transport. Although the dataset yielded detailed information on residential buildings, such as physical characteristics and year of construction based on legislative address, the data was only available from 2014 onward. This is too short a period to capture housing stock changes over the time frame in question. Therefore, I chose to utilize non-aggregated housing census data from 2000 to 2018, which was accessed through Microdata Integrated Services with the approval of Statistics Korea.



**Figure 2.** Cartographical approach to redefine spatial boundaries in Seoul (2000–2018).

Constructing the spatio-temporal dataset from the housing census consisted of two steps. First, I calculated the number of old and new housing units from each administrative district based on a summation of household data. Using the Microdata Integrated Services, I generated a cross-analysis table of housing characteristics separated by administrative spatial level for each year in 2000, 2005, 2010, 2015, and 2018. Since less than five values in the cross table were masked in the process of extraction, the classification was minimized. Due to the fact that high-rise apartments are the main type of housing in Korea, housing type was divided into two categories: apartment and non-apartment, where apartments are defined by housing over five stories high. Old housing stock was measured by the number of housing units present more than 30 years after construction. Since the legal age

constraint for redevelopment was originally set at a minimum of 20 years, I also measured the number of extant housing units more than 20 years after construction for comparison purposes. New housing stock was measured by the number of housing units constructed within the past five years.

Second, I used a cartographical approach to spatially join the five-year data based on administrative districts. Studying the spatial structure first required defining the spatial unit with an understanding of spatial arrangement [25]. During the analysis period from 2000 to 2018, the administrative spatial boundary in Seoul changed three times. It was 522 districts in 2000 and 2005, changed to 425 districts in 2010, and has been 424 districts since 2015. The spatial district boundaries were redefined as indicated in Figure 2 below. When two or more administrative districts were integrated into one district, I used the newly established spatial boundary as a criterion to link and add the housing characteristics over time. However, when an existing administrative district was eliminated or a new administrative district was established, new boundaries were defined to cover both the initial boundary and the adjusted ones. In sum, I made 419 spatial boundaries to link the housing stock data between 2000 and 2018.

### 3.2. Methodological Approach

This paper attempts to provide a holistic review of the spatio-temporal features of housing stock with a particular focus on urban renewal strategies employed in Seoul over the past twenty years. I first investigate how the housing type ratio (non-apartments to apartment units) and the ratio of old to new housing units has changed in the past several decades. Then I ask whether and how locational clustering patterns of old and new housing units have changed over time. Lastly, by assessing the evolving spatial relationship between new housing supply and old housing stock, I address the question of whether the supply of new housing units has come from a large quantity of old housing stock. This study uses descriptive statistics, exploratory spatial data analysis, and rank correlation analysis to explore these questions.

With the aid of descriptive statistics, I conducted an exploratory spatial data analysis to examine the spatial location and extent of statistically significant spatial clusters of old and new housing units. Applying Getis-Ord statistics, I detected global and local spatial autocorrelation. The Getis-Ord statistics have been used in prior studies to analyze spatial patterns of crime or accident occurrence [25,26], accessibility to grocery stores within residential areas [27], and urban vitality based on bicycle-sharing data [28]. I first used the global G statistic to evaluate whether old and new housing units are significantly clustered at different time periods. Then, to determine the location and the extent of spatial clusters, I used hot spot analysis based on the local  $G_i^*$  statistic and mapped it to show high and low positive spatial autocorrelated regions, which are referred to as hot spots and cold spots [25,29].

In addition, rank correlation analysis was used to explore the spatial relationship between new housing supply and old housing stock. Spearman's rank correlation analysis is used to explain the extent to which the ranks of two variables of interest are correlated. Since this correlation analysis operates based on the rank of the data rather than the raw values, this method is relatively insensitive to outliers and useful for verifying a monotonic association between two variables [30,31]. The Spearman rank correlation coefficient is calculated as the Equation (1), where  $n$  is the number of items, or the number of spatial units in this study, and  $d_i$  is the difference in ranking between the variables of interest in district  $i$ . As the rank correlation coefficient has a value between  $-1$  and  $+1$ , a greater positive coefficient means a stronger correlated association between the two variables. In this study, spatial association in ranking between old and new housing stock was estimated in each year to compare the tendency to supply new housing units in areas with many old and dilapidated housing units.

$$\rho = 1 - \frac{6 \sum_{i=1}^n d_i^2}{n(n^2 - 1)} \quad (1)$$

## 4. Empirical Results

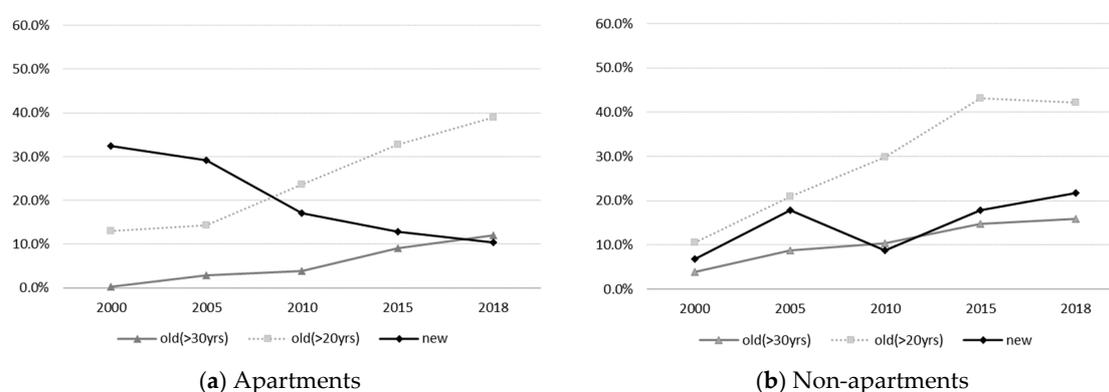
### 4.1. Temporal Variations of Housing Units

Table 2 shows basic descriptive statistics of the housing stock in Seoul between the period of 2000 and 2018. The housing census statistics show that the city accommodates approximately three million dwelling units, although the total number of housing units has varied over time. With regard to housing type, apartments constituted only 31.66% of the total housing stock in 2000, while non-apartments, including detached and row housing, constituted 68.34%. Nearly two decades later, 54.14% of housing units are occupied by apartment dwellers, with 45.86% remaining for non-apartment dwellers. The ratios of old and new housing units were calculated each year, respectively. The number of old housing units (those constructed over 30 years ago) or the number of new housing units (those less than five years) was divided by the total number of housing units with stated construction years. The ratio of old housing units has continued to increase over time, tallying 4.45% in 2000 and 14.04% in 2018. By contrast, the ratio of new housing units has decreased from 24.04% in 2000 to 15.80% in 2018.

**Table 2.** Basic statistics of housing units.

		2000	2005	2010	2015	2018
Number of housing units		3,088,722	3,313,205	2,623,755	2,944,195	3,102,301
Ratio of housing type	Apartments	31.66%	36.79%	56.64%	55.60%	54.14%
	Non-apts	68.34%	63.21%	43.36%	44.40%	45.86%
Ratio of vintage type	Old	4.45%	6.58%	6.97%	11.71%	14.04%
	New	24.04%	22.08%	13.93%	15.18%	15.80%

In order to investigate the changes in the ratios of old and new dwelling units classified by housing type, I performed a cross table analysis between housing type and vintage type. Figure 3 shows the changes in the ratios of old and new housing units for apartments and non-apartments, respectively. The left graph shows that the share of old apartments increased from 0.3% in 2000, rose to 3.9% in 2010, and further increased to 12.1% in 2018. Similarly, the share of apartments over 20 years also showed an upward trend from 13.0% in 2000 to 38.9% in 2018. On the other hand, new apartments continued to decrease from 32.4% in 2000, down to 17.1% in 2010, and still further down to 10.4% in 2018. As a result, in 2018, out of 1,679,639 apartment units, the number of old apartments, which accounted for 203,314 units (12.1%), outpaced the number of new apartments, which accounted for 174,339 units (10.4%).



**Figure 3.** Changes in the share of old and new housing units.

The right graph in Figure 3 shows the changes in the ratios of old and new housing units of non-apartments over time. The share of old non-apartments over 30 years after construction continued to gradually rise from 3.9% in 2000 to 15.9% in 2018. The share of non-apartments over 20 years old

also increased from 10.5% in 2000 to 43.1%, with a slight decline to 42.1% in 2018. In an interesting break with this trend, the amount of new non-apartments increased over the past two decades from 6.8% in 2000 up to 8.7% in 2010, with a further increase to 21.8% in 2018. This upward trend contradicts the downward trend of the changes in the share of new apartments. Out of a total housing stock of 1,422,662 units of non-apartments in 2018, new non-apartments accounted for 309,668 (21.8%). This number outpaced the number of old non-apartments, which was recorded as 226,886 units (15.9%).

The supply pattern of new housing units showed differences depending on the housing type. New apartments have decreased since 2000, while new non-apartments have shown an upward trend. According to a national survey by Ministry of Land, Infrastructure, and Transport, more than half of survey respondents prefer apartments (53.3%), while 38.1% prefer detached houses, 5.6% prefer row houses, and 3.0% prefer other housing types [32]. However, although apartments are the most preferred housing type due to affluent communal services [22], residents who prefer new apartment services have fewer options to choose from, whereas the number of new non-apartment options has increased over time.

#### 4.2. Spatial Clustering of Housing Growth and Deterioration

To explore the existence of the spatial clustering of old and new dwelling units, the global and local Getis-Ord statistics were applied to each time frame (2000, 2010, and 2018). To calculate the Getis-Ord statistics, an inverse distance-based weighting was applied with a distance of 2000 m in consideration of the average district scale. Additionally, in order to control for the housing market size of each district, the quantities of old housing units and new dwelling units were divided by the number of total housing units of each district. As illustrated in Figure 4, I observed statistical evidence for strong spatial autocorrelation for old housing units and relatively weak spatial autocorrelation for new housing units.

The statistics test whether an area with a high rate of old housing units is surrounded by other areas with high rates of old housing units. The global G statistics for old housing clustering are highly statistically significant, with significance levels of 0.01 for 2000 and 2010, and 0.05 for 2018. Although the ratio of old housing increased from 4.45% to 6.97% between 2000 and 2010, as described in Table 2, spatial autocorrelation was rather relaxed. The degree of spatial clustering for old housing units was recorded at 21.310 in 2005, 9.003 in 2010, and 2.445 in 2018. Meanwhile, new housing units showed relatively weak spatial clustering. The Z score values for new housing clustering were 2.281 in 2000 and 2.092 in 2018 with a significance level of 0.05, while the year 2010 failed to show statistical significance. Despite the assumption that the new housing supply ushered in by the redevelopment process would expand into adjacent communities, and therefore produce spatial clustering [15], this study only shows weak locational clustering patterns within the new housing supply.

While the test for global spatial autocorrelation indicates whether old and new housing units are statistically significantly clustered overall, it does not provide the locations or extents of the clusters. Figure 4 shows the results of hot spot analysis with the maps of the specific locations of statistically significant clusters of old and new housing units for each year. For old dwelling units, the year 2000 shows one major hot spot with a significance level of 0.01 in or around the urban center. This urban center, known as the old downtown of Seoul, contains some traditional houses called “Hanok” [33], but old and dilapidated row houses make up a fairly large portion of the housing in this area. Over time, the hot spots of old housing units began to spatially disperse, and by 2010, they had formed two clusters in the urban center. In 2018, the hot spots consisted of four clusters with a lower Z score, but the spatial autocorrelation coefficient is still statistically significant. The hot spots are located in or around the city center as well as in the south-eastern area.

The hot spots of new housing units shifted location each time and did not appear spatially concentrated but relatively dispersed in comparison with old housing units. Taking a closer look, the hot spots of new housing units in 2000 were discovered in or around the urban center as well as on the outskirts of the city. In 2010, the spatial autocorrelation of new housing units was not

statistically significant, meaning that the new housing supply was not in spatially contiguous regions. In 2018, hot spots were detected on the western and the south-eastern borders, known as the ‘Kimpo’ and ‘Wirye’ new towns, respectively. In addition, many pockets of new housing unit cold spots emerged, especially in urban centers.

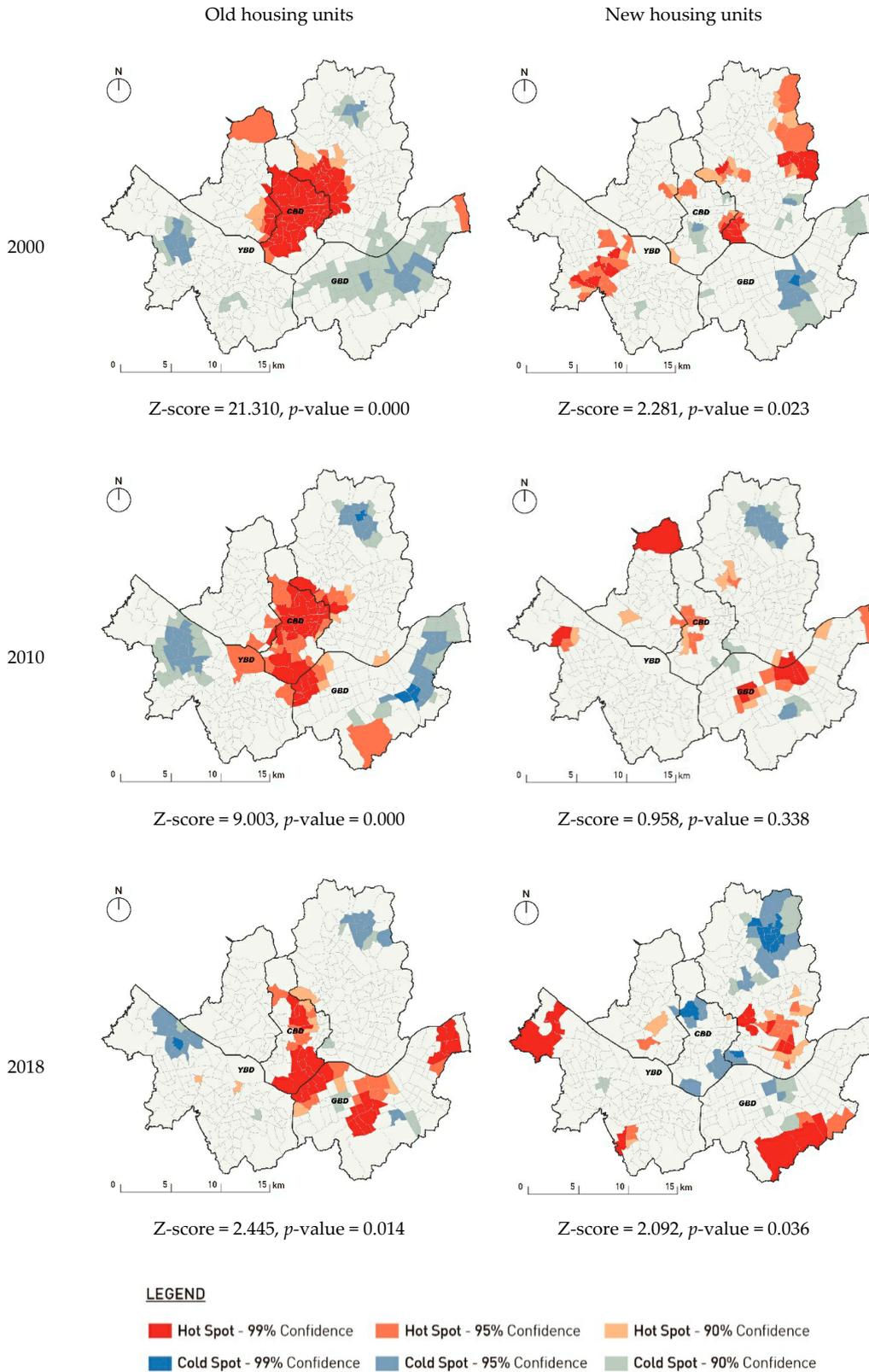


Figure 4. Hot spot analysis of old and new housing units.

So far, I have explored the temporal variations of the Seoul housing stock in terms of physical and locational characteristics. The next section brings our attention to why this change happened and how it relates to government policies for urban renewal.

#### 4.3. Urban Renewal Initiatives and Housing Stock

Based on the 419 districts, I calculated the rank correlation coefficients each year between the rankings of the share of new housing units to the total number of housing units and the rankings of the share of old housing units to the total number of housing units. In this analysis, in order to consider the time-delayed pattern to produce new housing supply, I calculated the new housing rankings for the current year in comparison with the rankings of the old housing in the past year. For example, the rank correlation of 2010 was calculated based on the new housing rating of the districts in 2010 and the old housing rating of the districts in 2005. In the case of 2018, I used the new housing units in 2018 and the old housing units in 2015. When comparing the district-by-district rankings of the old and new housing units, a high correlation existed under a significance level of 0.05. The Spearman rank correlation coefficients gradually decreased from 0.2052 in 2010, to 0.1328 in 2015, and to 0.0960 in 2018. The reduced correlation coefficients indicate that the tendency to supply new housing units in areas with many old and dilapidated housing units has been gradually decreasing over time.

Given the fact that the Seoul government announced a new strategy for housing renewal in 2012, I analyzed the Spearman correlation analysis before and after this initiative, using the absolute number of housing units of old and new housing units by each housing type. While the ratio-based analysis is useful to describe the tendency of the location of housing growth overall by controlling for the housing market size of each district, the absolute number approach provides a better understanding of the areas where new housing is supplied with regard to a shift in urban renewal initiatives. The coefficients were calculated between the rankings of the number of new housing units for apartments or non-apartment units in the current year, and the rankings of the number of old housing units for apartments or non-apartments in the past year.

Table 3 shows the results of Spearman rank correlation analysis. In 2010, in areas with many old apartments, the supply of new housing units was not significant regardless of the presence of apartments or non-apartments. Instead, both new apartments and new non-apartments significantly increased in areas with a large inventory of old non-apartments. However, after the launch of the New Town Exit Strategy, the tendency to supply new apartments in areas with many old non-apartments disappeared in 2018. This indicates that redevelopment efforts from low-rise non-apartments to high-rise apartments were effective in 2010 throughout the new town development projects, but this type of redevelopment is no longer valid in the new era of urban renewal. The installation of new renewal initiatives that have pursued spot demolition and infill programming within old, low-rise communities has resulted in a change in housing supply patterns across the city. It has made denser and higher residential development more difficult, leading to a decline in the supply of new apartments in the last decade.

**Table 3.** Spearman correlation analysis by housing type.

	2010		2018	
	New Apartments	New Non-Apts	New Apartments	New Non-Apts
Old apartments	0.0798	−0.0116	0.0666	−0.1279 ***
Old non-apts	0.1083 **	0.3105 ***	0.0618	0.3206 ***

Note. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

## 5. Conclusions and Discussion

The city government of Seoul changed its urban renewal initiatives in the early 2000s. In 2002, the in-city new town development strategy embraced the form of high-rise apartments and cleared away old, low-rise houses. However, the follow-up New Town Exit Strategy in 2012 pursued

rehabilitation, spot demolition, and an infill program in lieu of large-scale clearance and redevelopment. Given the fundamental importance of housing in cities, this paper has attempted to provide an in-depth review of the temporal variations of housing stock in terms of physical and locational characteristics. Using a fine-grained and multifaceted analysis, this study has sequentially looked at how the physical and locational features of housing stock have changed over time and how this relates to changes in Seoul's urban renewal initiatives.

First, the results of temporal variations of housing units show that even if the share of new housing supply in relation to the total housing stock remains at a similar level over several years, there is a big difference depending on the housing type. In particular, the share of new apartments has decreased from 32.4% to 10.4% over two decades, while the share of new non-apartments has increased from 6.8% to 21.8% during the same period. Unlike the housing supply patterns, the share of old housing units showed a similar increasing trend regardless of housing type. These numeric data identify a phenomenon wherein on an individual level, the option of choosing a new apartment has decreased although apartments are the most preferred housing type. Moreover, on a city-wide level, denser housing development with high-rise apartments has become more difficult over the past years. As Seoul's approach for urban renewal has avoided clearance and redevelopment, it has consequently resulted in a housing stock that is far from market expectations.

Second, looking at the spatial clustering of housing growth and deterioration, the global  $G$  statistics showed a relatively weak spatial autocorrelation for new housing units, but a strong spatial autocorrelation for old housing units. More specifically, the clustering maps based on the local  $G_i^*$  statistics showed that new housing units have become more spatially distributed and dispersed outward over time. In recent years, the hot spots of new housing supply were detected on the outskirts of the city, while cold spots have emerged in the urban center. For the old housing units, the degree of spatial clustering has decreased over two decades, while a strong hot spot of old housing units in the urban center has become smaller and moved to the southeast.

Third, this study revealed that the physical and locational changes of housing stock are related to urban renewal initiatives. The decrease in rank correlation coefficients between old and new housing units over time indicates that the tendency to supply new housing units in areas with many old and dilapidated housing units has gradually decreased. Furthermore, after the launch of the new strategy for urban renewal in 2012, which avoided large-scale clearance and redevelopment and pursued spot demolition and infill programming, the tendency to supply new apartments in areas with many old non-apartments disappeared. This empirical result verifies the fact that redevelopment from low-rise housing to high-rise apartments is no longer valid in the new era of urban renewal.

Based on these findings, this study concludes that Seoul's renewal plans have actually led to the spatial dispersion of new housing supply and a decrease in the new supply of high-rise apartments. This phenomenon, discovered in the last decade, runs contrary to the academic discussions on sustainable compact planning and development. As the housing market and urban renewal policy are significantly intertwined [34], sustainable urban management requires continuous monitoring to strike a balance between housing deterioration and new growth at local and city levels. Given the fact that successful urban renewal urges strategic spatial planning to reduce the social costs associated with urban activities [35,36], this study suggests that the city government needs to embrace the concept of sustainable urban growth management in formulating its renewal policies. It is also important to develop a spatial decision support system and to identify the locational features of housing stock in the early planning phases of urban renewal projects.

Despite the fruitful findings provided in this study, further studies need to consider two aspects. First, this study uses housing census data to explore housing deterioration and new growth at the same time. Further efforts could focus on expanding data sources such as housing, building permits, and demolition data to establish a deeper and clearer understanding of the dynamics of the housing market. Second, this study only focuses on physical changes, despite the importance of social and economic changes [37,38]. It needs to address the potential for exclusionary displacement

and housing affordability problems with urban renewal processes. Those efforts will enrich the literature of spatial temporal housing dynamics by linking them to urban renewal policies.

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