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The impacts of public housing program on housing prices: The case of South Korea

Jinsoo Ko[1] and Chunil Kim[2*]

[1]Associate Professor, Department of Urban Planning and Real Estate, Kwangwoon University, 20, Gwangun-ro, Nowon-gu, Seoul, South Korea

[2]Assistant Professor, Division of Real Estate and Construction Engineering, Kangnam University, 40, Gangnam-ro, Giheung-gu, Yongin-si, Gyeonggi-do, South Korea

***Corresponding author:** ckim@kangnam.ac.kr

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A B S T R A C T

Policy interventions in the housing sector are mainly designed to stimulate the provision of affordable housing. Countries across the world, however, seem to grapple with harsh opposition to public housing developments, which local residents tend to blame for a decrease in property values and the deterioration of their neighborhoods. South Korea has continued to expand their stock of affordable housing, but aggressive opposition from surrounding residents is frequently observed. This study adds to the existing literature by conducting an impact analysis of the major public housing program in Korea using the DID (difference-in-differences) methodology. The statistical evaluation results of the selected public housing projects exhibit mixed outcomes, in terms of the impact of public housing projects on surrounding housing prices. The empirical results of this study suggest that the small-scale and scattered provision of public housing in gentrifying areas is the least likely to generate negative housing value impacts on nearby neighborhoods.

Keywords: housing policy; public housing; NIMBY; difference-in-differences

Introduction

Across the world, policy interventions in the housing sector are mainly designed to promote the provision of affordable housing. In the United States, the Low-Income Housing Tax Credit (LIHTC) program provided an average of almost 1,400 projects and 106,400 units on a yearly basis between 1995 and 2018 [1]. As of April 2018, there were about 5 million homes in the social housing sector across the United Kingdom, comprising about a sixth of the total housing stock [2]. In Asia, China has massively invested into the provision of affordable housing. The Cheap Rental Housing Guarantee Plan aimed to construct 7.5 million public housing units through the support of the central government [3] (p. 26). The Indonesian government has heavily invested in public rental housing projects, even though it is well-known that such projects have generally not been effective in meeting the demand for affordable housing [3] (p. 26). Although the direct provision of public housing by the central and local government has become unpopular, securing a portion of public housing units out of the total housing stock is still an important housing strategy [3] (p. 24).

Korea has also strived to expand its stock of public rental housing. In the 1980s, almost all urban areas were subject to speculative behaviors. In response, the Korean government initialized the supply of two million apartment units, through the construction of five new towns around Seoul [4]. Public rental housing programs also began at that time (around 1989). The construction of 500 thousand apartment units, as public housing, was planned for this megaproject. Among those, 25 thousand units were designated as Permanent Public Rental Housing, which was considered the starting point of the supply-side (equivalent to project-base in the United States) public housing program in Korea. In the early 1990s, the government announced a series of housing policy measures to cool down the overheated construction boom, and the government made public housing available for households with income slightly higher than the extremely poor.

In 1998, the central government (Kim Dae-Jung administration) initiated the National Public Rental Housing program. At the beginning of the government's inauguration, the government planned to supply 50,000 units for five years. However, housing construction drastically declined after the 1997 Asian financial crisis. After the crisis, housing prices and rent began to surge as the economy recovered. In particular, affordability problems in the rental housing market became far more serious. In response, the government pushed forward to expand the supply of National Public Housing units. The rent was set at the level of 60－70% of the market rent, in accordance with the composition of local income classes. In addition, the mandatory rental period was set to 30 years, in order to guarantee housing stability for fragile groups. Initially, the program proposed the construction of 50,000 units on a yearly basis but, in 2002, it was expanded to the construction of 1 million units. The National Public Rental Housing program is still in effect at present and has become one of the most important supply-side housing policy instruments for those who are in an urgent need of housing assistance.

The following government (Roh Moo-Hyun administration) succeeded the spirit of the previous public housing program. The government established the "Act on the Special Measures for the Construction of National Rental Housing". Through the Act, development restrictions imposed on the growth control areas adjacent to the capital city of Seoul were lifted and a massive number of National Public Rental apartment units were constructed there. As a result of the aggressive supply of public housing, the total stock of public housing exceeded the stock from the previous government; however, the massive supply of housing through building large-scale apartment complexes in a short time period caused some social problems, including the so-called "Not In My Back Yard (NIMBY)" phenomenon.

Supply-oriented public housing projects often bring about concerns and opposition in impacted neighborhoods. Opponents argue that, from socio-economic perspectives, public housing exerts negative impacts on the existing communities [5, 6]. In the economic perspective, public rental housing is an inferior good to homes that are provided in the private real estate market. The NIMBY phenomenon has been one of the main obstacles towards providing affordable and adequate housing. In Korea, local residents have been shown to have negative responses to public housing built in their neighborhoods [7]. Kean and Ashey [8] reported that the NIMBY Syndrome includes concerns regarding a significant decrease in housing values, neighborhood deterioration, and congestion on local public infrastructure and services. The existing residents worry that drastic socio-demographic changes could occur, due to supply-oriented or tenant-based housing policies [9-11].

Do subsidized housing developments negatively affect proximally located home values? Empirical studies have reported different results. Measuring the impacts of housing policy tools on surrounding neighborhoods is not an easy task, and the nature of the relationship between public housing and existing housing prices depends upon various factors, such as the timing of the research, sample size, study area, the type of the housing program, and so forth. This study adds to the existing literature by conducting an impact analysis of the major public housing program in Korea, through which the government continues to expand the stock of affordable housing, and towards which aggressive opposition from surrounding residents is frequently observed. Statistical evaluations of our public housing project cases exhibit mixed results, when it comes to the impacts of such projects on surrounding housing prices. We provide policy implications derived from those results and suggest policy directions for the effective expansion of affordable housing stock

Happy House Program

As of 2015, the stock of public housing was about 604,000 units in the Seoul metropolitan region, which consists of the capital city of Seoul, Incheon metropolitan city, and Gyunggi province. Whereas urban areas near Seoul suffered from a severe shortage of affordable housing, satellite cities experienced an oversupply of public housing through “housing site development projects” (massive land development projects for housing supply, which were generally initiated by the central government).

This spatial imbalance originated from the central government’s impatience and uncoordinated approach in meeting their housing goals. In most housing site development projects, the central government designates a certain portion out of the total housing units as public housing. In old urban areas where low-income families are concentrated, the process of land development is highly complicated, causing a significant delivery lag. Therefore, the central government switched its gears for housing development towards underdeveloped rural areas around the capital city. In the history of housing development in Korea, the governments have responded to the housing shortage in Seoul by designating undeveloped rural areas near Seoul as “Housing Development Districts” and building public housing there. In order to mitigate holdout problems in land development, the governments have exerted the right to expropriate rural land [12].

Although such a method could promote the supply of public housing in a short period of time, it was in question whether this approach would be of practical help to low-income people. These central government-led large-scale public rental housing development projects lacked consideration on local conditions. The central government-dependent supply system focused mainly on meeting the quantitative goals, causing an imbalance between the supply of and demand for public rental housing. Location was also problematic: Low-income families living in public housing at the edge of the city must commute longer distances to central urban areas. Furthermore, the spatial concentration of such developments increased the possibility of social problems. In order to tackle those problems, the Happy Housing program emerged as an effort to avoid the supply to the outskirts of Seoul and to supply rental housing in government-owned, underused land parcels in populated areas.

The Happy House program was initiated by the Park Geun-hye administration (February 2013 – March 2017), in order to curb the skyrocketing rents and to enrich affordable rental housing. In areas around Seoul, the land purchase cost accounted for about 60 – 70% of the total delivery cost and, thus, it was difficult to increase the stock of affordable housing. There was a growing criticism that a significant portion of urban population were not provided with an adequate standard of living, especially young households. The Happy House policy was created to cope with the affordability crisis for those households. This supply measure was stipulated in Article 2 of the Enforcement Decree of the Special Public Housing Act. The main purpose of the Happy House program was to accomplish job – housing balance and to provide the opportunity of wealth accumulation for the younger generation by providing decent living environments at lower cost in the public land parcels in or close to urban centers.

As for tenant selection, the eligible groups were mainly newlyweds, young wage earners, and college students. The rent was set at about 60 – 80% of the nearby market price. Whereas previous public housing programs targeted very low-income households, the Happy House program ensured increases in income eligibility limits, in order to gradually expand the benefits of public housing assistance to those who were not eligible for the previous housing program but were still in need of affordable housing.

Happy House faced strong opposition from existing residents around the pilot project areas. When the Mokdong pilot area was designated in the Yangcheon District in Seoul, not only residents but also local politicians and officials opposed the Happy House development, raising issues regarding traffic congestion and school overcrowding. The Yangcheon local government continuously demanded the withdrawal of the central government-led Happy House construction plan. The "Residents Emergency Countermeasure Committee Against the Construction of Mokdong Happy House" was organized. The committee collected about 100,000 petition signatures against the Happy House construction. Finally, the Ministry of Land, Infrastructure, and Transportation canceled the Mokdong plan.

Literature Review on Neighborhood Impacts of Housing Programs

The effects of public rental housing on house prices are context dependent. Cummings and Landis [13] tested the validity of the NIMBY argument by examining the price movements of 3000 single-family houses through 1985 – 1992 in the San Francisco Bay Area. Among six BRIDGE projects, two were in San Francisco County, three in San Mateo County, and one in Alameda County. The empirical results revealed that a project of 104 apartments in San Francisco County positively affected nearby house prices within 1/8 mile. Another project, with 125 apartment units, had a negative effect on housing prices within 1/2 mile, but with no significance within 1/4 or 1/8 mile. If the NIMBY mechanism exists, the negative effects should become bigger as nearby houses get closer to the public housing. Therefore, they concluded that they found no evidence for the NIMBY problem.

The existence and direction of the impact of public housing depend on the radius setting of the impact area and the types of the assistance programs. Lyons and Loveridge [14] explored the effects of federally subsidized housing on nearby residential property values in Ramsey County. The data contained 120 subsidized housing projects with 128,010 adjacent home transactions. In terms of the closeness of each project to adjacent houses, the authors experimented with the distances of 300 feet, 1/4 mile, 1/2 mile, 1 mile and 2 miles. It turned out that there was no significant effect on house prices within 300 feet, while they found a negative impact within the ¼ mile radius. Furthermore, this negative effect was more apparent in suburban areas, where the average house price is relatively higher than in the city center. The paper concluded that housing policies related to public housing need to focus on the dispersal of affordable housing, in order to minimize the negative impacts. Differing from the result of Lyons and Loveridge [14], Lee et al. [15] found that federally assisted housing programs positively affected nearby real estate prices in Philadelphia.

Galster and Williams [16] investigated the effect of dwellings occupied exclusively by severely mentally disabled (SMD) tenants on the sales prices of nearby houses. The single-family home sales from 1989 to first quarter of 1992 in Newark and Mt. Vernon were evaluated using hedonic price modeling. They found that SMD dwellings within two blocks had no significant impact on the sales prices. Two HUD Section 202 apartment complexes caused a decrease in sales prices of nearby homes by 40%, while the others did not. The results were subject to limitations, however, in that the analysis could not tell whether the price fall was due to the presence of small apartments such as HUD Section 202, or due to the presence of SMD tenants.

Goetz et al. [17] tested for whether multi-family subsidized housing built by local non-profit community development corporations (CDC) caused a decrease in residential property values, an increase in crime rate, and neighborhood deterioration by the concentration of the poor. Their study focused on 3,600 affordable multi-family housing built by over 100 CDC projects in Minneapolis. The study found that houses developed by non-profit organizations increased property values at a rate of $0.86 per foot. On the other hand, public housing and privately-owned publicly subsidized housing units exerted negative impacts, -$0.46 per foot and -$0.82 per foot, respectively. These negative effects were more significant for the assisted houses managed by public institutions, abandoned houses, and houses that violated building codes.

Some studies have focused on scattered housing programs [18-20]. Briggs et al. [18] examined the socioeconomic effects of scattered-site public housing (SSPH). Their research data contained housing transactions and survey responses on neighborhood attitudes and expectations in Yonkers, New York, where there was a strong negative sentiment with respect to the effects of public housing. The study compared adjacent sales prices and survey data obtained from households near public housing, as well as analyzing the impacts of racial and ethnic compositions. Their results showed that there was no significant negative effect of SSPH on the neighborhoods. The earliest and largest complex among seven—the O'Rourke site—had no negative impacts. The study concluded that the construction of public housing resulted in efficient housing management and police enforcement which, in fact, alleviated the worries of existing homeowners regarding the negative consequences of public housing. Joice [19] also found that traditional public housing in Louisville, Kentucky increased neighborhood crime, whereas scattered-site public housing did not exert any negative impact. Santiago et al. [20] studied the impacts of the dispersed subsidy housing program on single-family houses in Denver during the 1990s. The study initially posited that there might be a decrease in nearby property values. Exploring the property value changes of single-family houses near dispersed public housing, the study found a positive impact of the project on adjacent property values, with the exception that there was a negative effect if the ratio of black population was higher than 20%. This implied that the increase in nearby housing values created through subsidized housing construction had been offset by the negative effects of the concentration of the poor.

More advanced methodologies have been developed and applied for investigating spillover effects, overcoming the limitations of the canonical DID (difference-in-differences) method [21-23]. Galster et al. [21] developed a spatial version of interrupted time-series modeling and examined the sale prices of single-family houses surrounding Section 8 sites in Baltimore County, focusing on the price trends between 1991 and 1995. Their research claimed that attributes such as residential characteristics and apartment management status mainly affected sales prices, not the existence of Section 8 sites. They found that there was a strong positive effect on surrounding housing prices within 500 feet from Section 8 sites in high-valued white neighborhoods. They conjectured that this positive effect was due to the physical improvements at the time of Section 8 occupancy. However, in dense and low- to moderate-valued neighborhoods, the impact was negative within 2,000 feet, which had led to a decline in real estate value since 1990. They explained this decline in three aspects: (1) The anti-social behaviors of Section 8 residents, (2) social stigma on Section 8 residents, and (3) poor maintenance and management of the residential environment. Koschinsky [22] utilized an adjusted−interrupted time-series model to test for the impact of subsidized rental housing on nearby property prices in Seattle, and found evidence on the upgrading effects in lower-value areas.

A handful of studies have tested for crowd-out or spillover effects of project- and tenant-based programs [23-27]. Sinai & Waldfogel [27] found that subsidized housing units increased the total number of private housing units, although one government-financed unit added less than a unit to the total housing stock. In addition, there was less crowd-out in more populated regions and more crowd-out in places with less excess demand for affordable housing. A seminal paper by Eriksen & Rosenthal [25] examined the crowd-out effect of the LIHTC (Low-Income Housing Tax Credit) program and found that LIHTC developments reduced the supply of private rental units, even though the magnitude of the impact was small. Focusing on New York, Ellen and Voicu [24] found that building more LIHTC units generated a greater positive effect on the surrounding neighborhood. Similarly, the positive effect of the LIHTC program was found in the case of Dallas County by Ezzet-Lofstrom and Murdoch [26]. Woo [23] examined the relationship between LIHTC and neighborhood housing turnover in Charlotte and Cleveland, finding that LIHTC developments stabilized adjacent housing markets.

In the Korean context, Moon et al. [28] found no evidence of a negative impact of public housing on surrounding land prices in the city of Busan. Hong and Lee [7] found that the nearby apartment prices within a 500-meter radius of public rental housing projects did not decrease. Kim and Choi [29] applied hierarchical linear models and found no significant relationship between the construction of rental housing complexes on the surrounding housing prices. Park and Kim [30] showed that public rental housing negatively affected the prices of newly-built apartments within a 600 m range. Kim [31] found that the size of the effect of public housing on a neighborhood is closely related to the location of the public housing projects.

In summary, the empirical results of studies on the impact of public rental housing vary with the type of housing program, the definition of impact and control areas, and the geographic scope of the study. Even though existing residents sometimes protest against the construction of public housing, based on the belief that public housing would have negative impacts, the empirical findings suggest that the well-managed and coordinated provision of public housing in certain locations can even create positive externalities. In built-up areas with relatively affluent homeowners, small-scale and dispersed public housing developments would be the best policy option, in order for the government or housing authorities to expand the stock of affordable housing.

Methodology and Case Selection

Difference-in-differences (DID)

One commonly-used strategy to estimate the impact of policy intervention is the difference-in-differences (DID) method. This method takes a quasi-experimental approach, designed to compare the changes in outcomes of a response variable of interest between two time periods (i.e., pre and post) between an impacted group (the treatment group) and a group that is not impacted (the control group) from a specific intervention or event. The DID hedonic regression model used this study can be expressed as follows:

$$Y_i = \beta_1 + \beta_2 T_i + \beta_3 P_i + \delta(T_i \times P_i) + \theta(T_i \times P_i \times M_i) + \tau(T_i \times P_i \times D_i) + \sum_{j=1}^{l} \lambda_j X_j + \epsilon_i, \tag{1}$$

where Y_i is the natural logarithm of price per square meter of nearby apartment unit i; $T_i = 0, 1$, where 0 indicates apartment units that are sold beyond the impact area (the control group) and 1 indicates units that are sold in the impact area (treatment group); P_i is a dummy variable, which equals 1 for apartment units sold after the construction of a Happy House project (post-treatment) and 0 otherwise (pre-treatment); $(T_i \times P_i)$ is the interaction term of T_i and P_i; M_i is the monthly sales time trend; and D_i is the distance from the Happy House project to nearby apartment units sold. Therefore, θ and τ capture the temporal and spatial effects in the impact area due to the construction of the project; X, indexed by $j = 1, \ldots, l$, represents the other k variables that affect apartment prices; and ϵ_i is the error term. X includes neighborhood dummy variables to control for the possible locational heterogeneity in sales prices. We considered the smallest administrative geographic area ("Dong" in Korean), which roughly corresponds to a census tract in the United States. The estimator δ measures the instantaneous change in apartment prices in the impacted radius due to the arrival of Happy House. Rewriting Equation (1) yields

$$Y_i = \beta_1 + \beta_2 T_i + \beta_3 P_i + (\delta + \theta M_i + \tau D_i)(T_i \times P_i) + \sum_{j=1}^{l} \lambda_j X_j + \epsilon_i. \tag{2}$$

As the dependent variable is the natural logarithm of sales price, the treatment effect can be expressed as $100 \times (e^{(\delta + \theta M_i + \tau D_i)} - 1)\%$. This formula, in a log-linear regression, originated from the work of Halvorsen & Palmquist [32]. Notice that the treatment effect is not a scalar but, instead, a function of the distance from and time duration of the Happy House project.

Data and case selection

The apartment sales data used in this study were obtained from the Open System for Real Estate Prices (https://rt.molit.go.kr/), managed by the Ministry of Land, Infrastructure, and Transport (MOLIT). Basic information on housing sales should be reported to the government within 60 days from transaction in Korea. The MOLIT posts the basic characteristics of transactions on the system. These include selling price, street address, dwelling size, the time of transaction, floor level, and so forth. The building-level variables were retrieved from the Building Register data set, which contains information on the floor area ratio (FAR) and the number of units in each apartment complex. The two data sources were merged using the parcel number unit (PNU). The distance from each apartment unit to the nearest subway station was calculated using a GIS program.

The combined data were further modified, in several ways, for the sake of data cleaning. Apartment units which were located underground were removed. Buildings with FAR less than 1.0 were removed. Observations were dropped if the number of units in the apartment complex was less than 30. These removals were conducted as such apartments are very rare in Seoul, or could simply be non-apartment housing. Observations below the 1st percentile and above the 99th percentile for dwelling size and sales price were removed. Santiago et al. [20] excluded the highest and lowest 2% of observations by sales price for the purpose of data cleaning. In this study, we chose to use 1% cutoff values, as the data used in this study were collected by the government by law and, thus, we believe that our price data are more reliable.

For the radius of the impact area, we chose 500 meters, which is closely related to the boundary of neighborhood unit proposed by Perry [33] and considering the typical walking distance to basic urban activities in the urban planning context of Korea. The control area was beyond the 500 m boundary to the 1000 m radius from the Happy House project.

After data processing, we ended up with three Happy House projects that were valid for the purposes of this study. They were the *Ga-Jwa station, Daenong-Sinan, O-ryu station* projects (hereafter, "*GJ*", "*DS*", and "*OR*", respectively; see Table 1). There are several Happy House projects currently placed in service or planned in Seoul; however, these three are the only projects which contained at least 10 observations in each cell in the 2 by 2 table for the treatment group dummy (T_i) and post-Happy House dummy (P_i) variables after data processing was completed. The *GJ* and *OR* projects were developed on disused railway sites in the outskirts of Seoul, which had been owned by a public development corporation (Korea Land & Housing Corporation) and the central government, respectively. The *DS* project was provided in a different way. The government approved a large-scale property regeneration project in one of the sub-center areas in Seoul. In return, the regeneration project developer (the owner's association) agreed to build Happy House units in the regeneration area. The *GJ* and *OR* projects are relatively large-scale and visible, whereas the number of apartment units in the *DS* project is smaller and the project is visually enclosed by the boundary of the larger property redevelopment project.

Table 1. Selected Happy House projects

Project name	No. of units	Month and year project placed in service	Site	District
Ga-Jwa station [34]	362	December 2016	Disused railway	*Mapo*
Daenong-Sinan [35]	114	September 2018	Within a property regeneration site	*Dongdaemoon*
O-ryu station [36]	890	March 2018	Disused railway	*Guro*

Results

Variable definition

Detailed definitions of the variables used in the DID regressions are presented in Table 2. The variable *UP* is the apartment price per dwelling size near the Happy House project. Its log form is the dependent variable—that is, Y_i —in Equation (1). *T* takes on a value of 1 if an apartment unit was sold within a 500 m radius from the Happy House project. *P* is a dummy variable, which was set as 1 if an apartment unit was sold after the Happy House development. *TP* is the interaction term of *T* and *P*, which corresponds to ($T_i \times P_i$) in Equation (1). Its regression coefficient, δ, reflects the instantaneous price change between the impact and control areas due to the Happy House project construction. *TPD* is the interaction term of *T*, *P*, and the distance from the Happy House project to nearby apartment units sold, which corresponds to ($T_i \times P_i \times D_i$) in Equation (1). *TPM* is the interaction term of *T*, *P*, and the monthly sales time trend, which corresponds to ($T_i \times P_i \times M_i$) in Equation (1). The following are other variables determining apartment prices, corresponding to X_j in Equation (1): *DSIZE* is the dwelling size of an apartment unit sold, measured in square meters; *FLR* is the floor level of an apartment unit; *HHPL* is the number of

Table 2. Definitions of variables

Variables	Description
UP	Apartment price per dwelling size (m^2) of a unit sold, in 10,000 Korean Won (KRW)
T	Indicator which equals 1 if an apartment unit was sold in the impact area
P	Indicator which equals 1 if an apartment unit was sold after the Happy House project construction
TP	Interaction term of T and P, which corresponds to ($T_i \times P_i$) in Equation (1)
TPD	Interaction term of T, P, and the distance from the Happy House project to nearby apartment units sold, which corresponds to ($T_i \times P_i \times D_i$) in Equation (1)
TPM	Interaction term of T, P, and the monthly sales time trend, which corresponds to ($T_i \times P_i \times M_i$) in Equation (1)
DSIZE	Dwelling size of an apartment unit sold, in square meters (m^2)
FLR	Floor level of an apartment unit sold
HHPL	Number of units in the apartment complex, divided by the lot size. Proxy for the residential density
AGE	Age of the apartment building when sold (in years)
NDIST	Distance to the nearest subway station in meters (m)
MTRD	Sales time trend variable, in months
Q2	Indicator which equals 1 if sales occurred in the second quarter
Q3	Indicator which equals 1 if sales occurred in the third quarter
Q4	Indicator which equals 1 if sales occurred in the fourth quarter

units in the apartment complex, divided by the lot size of the complex (this variable was a proxy for the residential density); *AGE* is the age of the apartment property, which was calculated as the duration between sales date and building use date in months, then converted to years; *NDIST* is the distance from an apartment sold to the nearest subway station in meters; and *MTRD* is the sales time trend variable in months. The quarter variables *Q2*, *Q3*, and *Q4* were used in the regressions, in order to capture the seasonality of sales price fluctuations.

Descriptive analysis

Table 3 presents the descriptive statistics of apartment characteristics for the three Happy House project areas. Within the 1000 m boundary from the *GJ* Happy House project, 59% of the total sales were located in the impact area. This figure was 66% in the *DS* project area, and only 18% in the *OR* project area. Apartments adjacent to the *DS* project area were relatively expensive (8.80 million Korean Won). The level of residential density was also the highest in the *DS* project area (0.0669 units per square meter of apartment complex lot size). The average dwelling

Table 3. Descriptive statistics

Variablegs	N	Mean	Std. Dev.	Min	Max
Ga-Jwa					
UP	2,944	666	148	274	1,417
T	2,944	0.59	0.49	0	1
P	2,944	0.35	0.48	0	1
DSIZE	2,944	82.42	18.38	26.70	136.47
FLR	2,944	9.99	6.39	1.00	35.00
HHPL	2,944	0.0254	0.0067	0.0198	0.0837
AGE	2,944	8.54	4.74	0.08	21.67
NDIST	2,944	373.44	178.29	46.47	742.28
Daenong-Sinan					
UP	119	880	174	327	1,306
T	119	0.66	0.48	0	1
P	119	0.43	0.50	0	1
DSIZE	119	57.73	30.52	14.82	143.64
FLR	119	9.85	5.30	1.00	24.00
HHPL	119	0.0669	0.0563	0.0225	0.1725
AGE	119	8.08	4.60	0.75	24.08
NDIST	119	155.01	84.40	17.44	433.13
O-ryu					
UP	563	540	106	227	910
T	563	0.18	0.39	0	1
P	563	0.44	0.50	0	1
DSIZE	563	79.51	18.38	33.16	142.05
FLR	563	10.78	6.26	1.00	25.00
HHPL	563	0.0294	0.0079	0.0217	0.1731
AGE	563	10.40	5.57	1.25	25.58
NDIST	563	428.08	198.17	120.33	981.24

size, however, was the smallest (57.73 m^2). These numbers clearly indicate that the *DS* area was the most populated neighborhood, with small-sized apartment units enjoying better access to subway stations (the average distance to the nearest subway station was 155.01 meters). Apartments in the *OR* area seemed to be oldest upon transaction, on average (10.40 years), but the standard deviation of the building age was also the greatest for the *OR* area (5.57 years). The residential environment around the *OR* project area showed a lower level of density, mixed with older and newly built apartment properties.

Impacts of Happy House projects on nearby housing prices

The DID regression results for the three Happy House project areas are presented in Table 4. The R^2 metrics were 0.84, 0.64, and 0.75 for the *GJ*, *DS*, and *OR* regressions, respectively. The overall fit statistics were, thus,

Table 4. DID regression results

	Ga-Jwa			***Daenong-Sinan***			***O-ryu***		
Variables	Coefficient		R.S.E.	Coefficient		S.E.	Coefficient		R.S.E.
Impact & post variables									
T	0.1299952	***	0.011	0.0158558		0.051	-0.0878075	***	0.018
P	0.0567291	***	0.009	-0.0379959		0.076	0.0372666	**	0.023
TP	-0.1320988	***	0.026	0.2231567	**	0.109	-0.3616915	***	0.077
Distance & time variables									
TPD	0.0001545	***	0.000	-0.0005806	*	0.000	0.0006873	***	0.000
TPT	0.0066197	***	0.001	-0.0227121		0.020	0.0079338		0.005
Apartment characteristics									
DSIZE	-0.0054214	***	0.000	-0.0056797	***	0.001	-0.0049192	***	0.000
FLR	0.0028126	***	0.000	0.0024171		0.003	0.0057369	***	0.001
HHPL	-4.7902810	***	0.565	-4.0512550	***	0.499	-6.3209830	***	0.643
AGE	-0.0318487	***	0.001	-0.0121336	**	0.005	-0.0237501	***	0.001
NDIST	0.0001460	***	0.000	-0.0005242	***	0.000	-0.0001252	**	0.000
Sales time variables									
MTRD	0.0092325	***	0.000	-0.0131400		0.015	0.0066293	***	0.002
Q2	0.0120203	**	0.005	-0.2244972	***	0.085	0.0002597		0.013
Q3	0.0240016	***	0.005	-0.1543092	**	0.074	0.0070440		0.013
Q4	0.0179951	***	0.005	-0.1609534	**	0.070	0.0000108		0.017
Constant	0.865915	***	0.162	16.92999		10.431	2.438403	**	1.192
Breusch-Pagan test for heteroskedasticity									
Chi^2	11.28			0.21			8.86		
$Prob>Chi^2$	0.0008			0.6468			0.0029		
N	2,944			119			563		
R-squared	0.8446			0.6444			0.7468		

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; SE and RSE stand for standard error and robust standard error, respectively. The smallest administrative neighborhood ("Dong" in Korean) fixed effects are included in all regressions.

satisfactory in capturing the variations of housing prices, without resulting in multicollinearity with other apartment characteristics in the Korean context. The Breusch−Pagan tests for heteroskedasticity were conducted to check whether the variance of the errors was dependent on the values of the independent variables. As the *GJ* and *OR* projects showed heteroskedastic variances, the robust consistent estimates of standard errors allowing for heteroscedasticity were used [37]. The coefficients of *DSIZE* were negative and significant, meaning that the unit price of housing decreased with dwelling size. In the *GJ* and *OR* areas, the higher the floor an apartment unit was located at, the more expensive the unit became. As expected, residential density (*HHPL*) negatively affected sales prices, holding other factors equal. The distance to the subway station implied two opposite effects on sales price formation. The positive effect was relevant to obtaining better access to transportation. The negative impact occurred when being closer to a subway station brought about noise and congestion in the residential environment. In the *GJ* area, the negative effect seemed to outweigh the positive one. The coefficients for building age (*AGE*) were negative in all three regressions, which reflects the functional decadence of the physical structure and is in line with the findings of previous studies [38-44].

Estimation of the effect of Happy House projects on nearby apartment prices for the *GJ* project revealed that the instantaneous treatment effect was negative (-12.37% in Table 5). This means that the apartment prices in the adjacent area to the project (0−500 m radius) decreased by 12.37%, relative to those in the further comparison area (500−1000 m ring), after the GJ project was placed in service. This instantaneous negative effect gradually dissipated as apartments became further away from the project site and as time passed after the construction of the project, albeit at a very slow pace. The *OR* project also exhibited an instantaneous negative treatment effect (-30.35% in Table 5). As the coefficient of *TPD* was positive and significant, the magnitude of the negative treatment effect became smaller with distance from the project. The time effect, however, was not statistically significant for the *OR* project.

The *DS* case showed the opposite result to the *GJ* and *OR* cases, in terms of the sign of the treatment effect. The *DS* project did not bring about a decrease in apartment prices in the adjacent locations. Rather, the apartment prices in the 0−500 m ring increased by 25.00%, relative to the outer ring, after the construction of the *DS* project. Of course, we cannot know whether this positive effect was due to the urban regeneration or the *DS* project. It could be possible that the *DS* project exerted a slight negative impact and the redevelopment project contributed to significant neighbor upgrading. So, what we observed would be the overall positive effect. In any case, the *DS* project should be an example in minimizing potential negative impacts on existing neighborhoods and circumventing local opposition to the Happy House program. Table 6 exhibits the changes in treatment effect, with respect to the distance to Happy House projects. As explained above, the instantaneous negative effects gradually decreased with the distance to the projects in the *GJ* and *OR* areas. In the *DS* neighborhood, the instantaneous effect was positive, with the magnitude becoming smaller for apartments further away from the *DS* project site.

Table 5. Instantaneous treatment effects

Ga-Jwa	*Daenong-Sinan*	*O-ryu*
-12.37%	25.00%	-30.35%

Table 6. Treatment effects by distance to Happy House projects

Distance to Happy House	*Ga-Jwa*	*Daenong-Sinan*	*O-ryu*
0 m	-12.37%	25.00%	-30.35%
8 m	-12.27%	24.42%	-29.97%
16 m	-12.16%	23.85%	-29.58%
24 m	-12.05%	23.27%	-29.19%
32 m	-11.94%	22.70%	-28.80%
40 m	-11.83%	22.13%	-28.41%
48 m	-11.72%	21.57%	-28.01%

Discussion and Concluding Remarks

Providing decent and affordable housing to as many low-income households as possible is of utmost concern when designing and implementing housing policies. Governmental policy intervention on housing markets, however, can generate positive or negative spillovers in the affected neighborhoods. In some cases in the United States, there were positive impacts in some regions, whereas the “white flight” phenomenon occurred in other locations [45]. These mixed impacts also happen in other parts of the world. For example, in the case of Korea, a recent public housing program called Happy House has drawn serious opposition from surrounding residents, even though the program has been carefully designed to provide affordable housing in populous, built-up areas.

In this study, we tried to assess the neighborhood impact of the Happy House program by examining the changes in surrounding housing prices. It turned out that the negative effects became bigger for nearby houses closer to the Happy House *GJ* and *OR* projects, which seems to provide a justification for the NIMBY phenomenon, in an economic sense, even though oppositional movements from the existing residents against Happy House were not conspicuous in those neighborhoods. The government selected disused, government-owned railway sites as convenient locations for certain population groups. If the government planned to develop these sites as mixed-use urban regeneration at a greater scale, that alternative land development plan would raise the future aggregate land value of surrounding neighborhoods and the impact of the plan may, thus, show a different result. Instead, the government constructed one or two buildings of public housing on those under-valued land sites, retaining potential for the development of a high-quality urban environment in the future. We conjecture that the negative impacts of the *GJ* and *OR* Happy House projects reflect the anticipation of property market participants that the government’s current land use would limit comprehensive neighborhood redevelopment and urban regeneration around those areas, in a wider spatial scope. Such decreases in the value of property redevelopment options are then capitalized into the current nearby housing market. Therefore, the current construction of public housing in a place where redevelopment potential is high can act as a factor that crowds out future private capital investments.

The result from the *DS* Happy House regression suggested that smaller, dispersed Happy House developments are the least likely to generate negative housing value impacts on the relevant neighborhoods. The *DS* Happy House approach seemed to be a more efficient model. The government did not construct a large-scale apartment complex but, instead, capitalized on an existing urban development project for the provision of public housing. This method was a type of private−public collaboration. Urban regeneration and property redevelopment provide significant capital gains to the land-owners and positive spillover in the neighborhoods of Seoul. As such redevelopment projects should be approved by the local government, the government retains some power in negotiation with the owner's association on the land-use decision over the course of urban redevelopment. Even though there may be some worries about possible negative impacts of public housing on the neighborhood, the potential capital gains accrued by the land-owners and positive neighborhood externalities from the redevelopment outweigh the concerns regarding Happy House projects. Furthermore, the economic benefits from property redevelopment projects are more certain than the impacts of the Happy House project. Therefore, there is no particular reason for the owner's association to oppose the government's plan. Thus, the government can achieve the goal of providing public housing in populous urban areas. This Happy House housing supply model seems to work. Our empirical evaluation revealed that small-scale public housing provision through utilizing existing housing stock and urban development did not bring about a decrease in nearby housing values, whereas a new, large-scale public housing construction would result in negative externalities in surrounding housing markets.

In conclusion, it is time for housing authorities to move away from the traditional approach to the provision of affordable housing—through large-scale, brand-new land developments at the city edge or populated locations. Such mega-projects are thought to be "cataclysmic" [46] and to create concentrated poverty, thus generating severe local opposition, which is translated into a decrease in current housing values. More importantly, such projects limit the potential for property- or neighborhood-level (re)development, which otherwise could be transformed to the highest and best land-use in the future. The combination of capitalizing on neighborhood gentrification and incremental provision at a smaller scale provides a sustainable recipe for expanding the stock of affordable housing.

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