

Article

Boon or Bane: Effect of Adjacent YIMBY or NIMBY Facilities on the Benefit Evaluation of Open Spaces or Cropland

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Abstract: This is the first study to comprehensively evaluate the benefit of urban open spaces and cropland with different adjacent public facilities seen as locally undesirable (“not in my backyard,” NIMBY) or desirable (“yes in my backyard,” YIMBY). The total benefit increases or decreases for urban open space and cropland with adjacent NIMBY or YIMBY facilities in a municipality in Taiwan. The results show that for the city as a whole, the current arrangement of NIMBY and YIMBY in different zones decreases the total benefit of urban open spaces in highly urbanized zones and increases the total damage to cropland in extremely rural zones. This indicates a need to avoid further installing NIMBY or YIMBY facilities in already occupied urban open spaces. The results also demonstrate that locating NIMBY or YIMBY facilities near cropland fails to highlight the benefit of YIMBY facilities and magnifies opposition to NIMBY facilities. For individual housing units, the total damage is 1.87% of the average housing price for cropland-type open space with adjacent NIMBY or YIMBY facilities, and the total benefit is 7.43% of the average housing price for urban-type open space in a highly urbanized area. In contrast, the total benefit for open space with adjacent NIMBY or YIMBY facilities is a 2.95%-13.80% increase in the average housing price for areas with mixed urban open space and cropland.

Keywords: Spatial Durbin model; local polynomial regression; YIMBY facilities; NIMBY facilities; willingness to pay; total benefit

1. Introduction

The openness and public nature of urban open space and cropland offer the functions of agricultural production, ecological conservation, landscape aesthetics, and outdoor recreation and have gained considerable importance due to their ability to act as a carbon sink and their educational value [1]. This has made urban open space and cropland consistent with one of the Sustainable Development Goals (SDGs) of the United Nations, to “provide universal access to safe, inclusive and accessible, green and public spaces” [2]. Most functions of urban open space and cropland have positive benefits, but there is no monetary market to reveal these benefits. Their importance is inevitably underestimated in region planning of urban open space and/or cropland [3].

In general, if housing is surrounded by open space with diverse vegetation, good facility maintenance, and a large area, there is a positive impact on its price [4]. In contrast, lower quality, or quantity of open space with poor public security or mosquito-breeding areas due to poor maintenance will negatively affect housing prices [5, 6]. Previous studies evaluating the benefits of open space have either ignored cropland or have not treated these types of spaces separately, resulting in insufficient planning information. A study found that peripheral urban open space has greater benefits than developed private cropland [7]. This finding suggests that the benefits of urban open space and cropland need to be evaluated differently [8]. Under global liberalization and rapid industrial development, the impacts of these types of spaces on the agricultural

sector are critical. Society attaches great importance to the multifunctionality of cropland because it serves production functions as well as providing openness [9].

Moreover, previous studies have used the distance between housing and urban open space to evaluate the benefits of the latter [10, 11]. Few studies consider public facilities embedded in or adjacent to urban open space or cropland [10]. It is clear that some facilities positively affect surrounding housing, with a “yes-in-my-backyard” (YIMBY) effect, while others have negative impacts, with a “not-in-my-backyard” (NIMBY) effect; other facilities might have both YIMBY and NIMBY effects on housing prices [12, 13]. For instance, it was found that libraries were the most popular YIMBY facility [14]. In contrast, proximity to facilities such as waste landfills have higher risk and depresses housing prices. It was specifically found that if the distance between a housing unit and a waste landfill site increases from 0.5 miles to 3.25 miles, the housing price will increase 17%-20% [15]. This finding provides guidelines for the amount of compensation that should be provided to those living near landfill sites.

Nevertheless, it was found that housing closer to a nuclear power plant is pricier in California because many plant employees live nearby, indicating that a NIMBY facility might have a positive effect on surrounding housing prices [16]. Without accounting for the NIMBY and/or YIMBY effects, housing prices may be over- or underestimated. The impact on housing prices from urban open space or cropland depends on the interaction of YIMBY or NIMBY facilities and urban open space or cropland [13, 17–19]. Such adjacent effects complicate the benefit evaluation of urban open space and cropland. This information is not only essential for the landscape planning, land use, or allocation of NIMBY or YIMBY facilities in certain regions but is also important in assessing their effect on housing prices [13].

Although previous study indicated that appropriate evaluation is necessary when open space is adjacent to different facilities, no empirical evidence indicates the possible harm or benefit [13]. A study takes one step further to examine housing prices under the interaction of open spaces and facilities [19]. However, that study neither takes into account the impacts of open space with adjacent NIMBY or YIMBY facilities located at different distances from housing nor considers the total area of such open space within a specific radius of a housing unit. It is imperative that all such dimensions be considered when evaluating the benefits or harms of open space and cropland.

Taiwan’s comprehensive National Spatial Land Planning Act (NSLPA) of 2016 distinguishes national land into urban and nonurban land [20]. One major type of nonurban land is cropland. Enforcement of this act ensures food security, balances the development of rural and urban areas, and resists climate change. Furthermore, the development of cropland is irreversible [21]. This act suggests that urban open space and cropland should be viewed as equally important in evaluating benefits or harms for national land planning. Under the NSLPA in Kaohsiung City, the municipality with the greatest land area in Taiwan, the city proposed six development zones. Among these, approximately 90% of the population is centralized in the business metropolitan living development zone, causing enormous population pressure for the zone. This situation highlights the importance of urban open space in this specific zone and in the city. Cropland covers 16% of the city, but it has not received equivalent attention. The promotion or arrangement of multiuse public facilities on urban open space or cropland can help determine the increase or decrease in benefits for these spaces with adjacent facilities.

This study is the first to comprehensively evaluate the benefit of urban open space and cropland with different adjacent public NIMBY or YIMBY facilities. A comparison is made to identify the total increase or decrease in benefits for urban open space or cropland with different combinations of NIMBY or YIMBY facilities. The benefit in terms of the increase or decrease in average housing price is concurrently assessed. For these purposes, this study employs a spatial Durbin hedonic price model (SDM) to evaluate the related benefits for urban open space and cropland with adjacent NIMBY or YIMBY facilities. This model accounts for the spatial dependence arising from both housing prices and attributes affecting housing prices [22-23]. Local polynomial regression is

employed to determine the scope of impact of a facility and any spatially related attribute [24, 25]. In summary, the important aspects of this study are threefold. First, it uses a very advanced spatial methodology. Second, it comprehensively analyzes the outcomes of benefits evaluation for urban open space and cropland with adjacent YIMBY and NIMBY facilities when these facilities are normally ignored. Third, the analyzed results are suitable for use in allocating the abovementioned facilities within a city. This research sheds light on the planning and design of a specific city and brings together the multiple disciplines of sociology, economics, and management.

The remaining sections of this paper are arranged as follows. Section 2 explains the necessity of evaluating the benefit for urban open space and cropland with adjacent NIMBY or YIMBY facilities. Section 3 presents the study area and evaluation model. Section 4 explains the data sources and variable selection. Section 5 presents the results and discusses the evaluation results and implications. The final section concludes this study.

2. The Necessity of Evaluating the Benefit for Open Space or Cropland with Adjacent NIMBY or YIMBY Facilities

There is no consensus on the definition of open space. It seems reasonable to define it as a space that is open and accessible; however, the specific types vary by the definitions of particular countries. The most popular types are parks, green lands, rivers, forests, greenbelts, wetlands, public squares, beaches, protected zones, and cropland [26]. The urban growth boundary (UGB) forms under urbanization when urban sprawl invades rural areas. To a certain degree, cropland functions to cut off urban expansion. Although both urban open space and cropland have living functions, cropland typically has other functions, such as ecology and production. Among these, food security is ensured by the production function of cropland [27]. Its multifunctional value has further made cropland a crucial cushion space for land planning arrangement [28–30].

This study calls both urban open space and cropland “open space.” Urban open space and cropland are used separately when necessary. Previous studies of the benefit evaluation of open space have treated open space alone without taking into account all types of adjacent NIMBY or YIMBY facilities of open space. Open space and its adjacent facilities are a new type of open space [13]. Thus, open space with adjacent facilities might have higher or lower benefits than that without depending on the types of facilities and/or people’s preference for the facilities. The existence of NIMBY or YIMBY facilities normally arises from the needs of society. These facilities can be used to segregate all types of pollutants, as a buffer to reduce risks of different types of damage, or as a space for greening [17]. Examples include buffer zones along highways, protection areas beside nuclear waste landfills, cemetery greening, large outdoor squares, and parks. This type of use makes a facility a substitute for or complement to an open space. In many circumstances, it is difficult to know the order of arrival of an open space and a facility. As such, open space with adjacent NIMBY or YIMBY facilities is treated as a new object [13, 31–32].

Various benefit evaluations regarding open space, including parks, greenbelts, wetlands, forest conservation areas, and cropland, through housing transactions have been reviewed by [26]. They evaluated the targeted open space shown as (A) in **Figure 1**. The benefit of open space is evaluated as if it has no adjacent NIMBY or YIMBY facilities or these facilities are neglected either intentionally or unconsciously. The benefit of open space should be evaluated together with the compounded NIMBY or YIMBY facilities to reflect the interaction of open space and facilities when housing is located near NIMBY or YIMBY facilities or within the NIMBY or YIMBY impact radius, such as that shown in (B) of **Figure 1** [13].

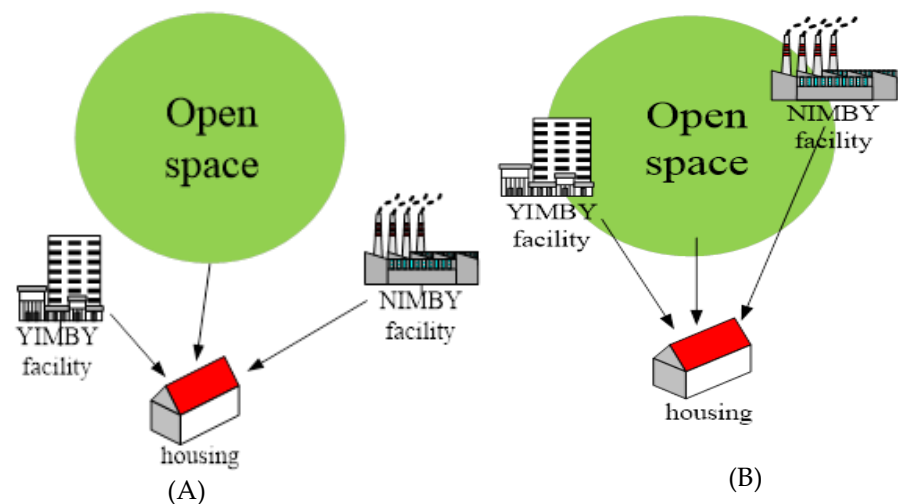


Figure 1. Impact of urban open space or cropland with or without adjacent YIMBY or NIMBY facilities on housing unit

How does the benefit of open space change when such space has NIMBY or YIMBY facilities? The answer depends on the implementation of related policies or actions. If there is a compensation scheme or tax cut for those living close to the NIMBY facility, such as a cemetery or any type of waste landfill site, this not only increases the acceptance of residents living nearby but also has high potential to increase the benefit of the original open space [15, 18]. Similarly, the benefit of urban open space may not be reinforced as expected with adjacent YIMBY facilities, or damage may result from urban open space with adjacent YIMBY facilities due to noise, air pollution, and other disturbances during the construction of a YIMBY facility. To balance the development of rural and urban areas, locating YIMBY facilities such as public libraries or local culture galleries close to cropland may be possible. Specific evaluation is required to determine the extent of the change in benefit for a united open space and NIMBY or YIMBY facility.

3. Results Study Area and Evaluation Model

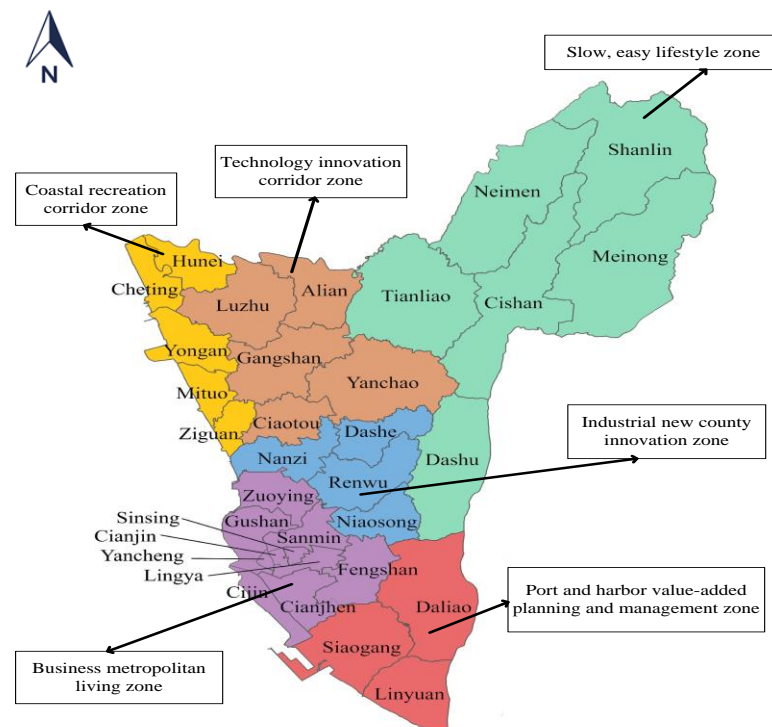
3.1. Study Area

Kaohsiung City is in southern Taiwan and has been the second-largest municipality since 1979. There are 38 districts under its administration. The total land acreage of the city is 2,948 square kilometers, making it the largest municipality in Taiwan in terms of size. Of this area, urban open space accounts for 36.51 square kilometers, mainly in the business metropolitan development zone and the industrial new county innovation development zone under the NSLPA. The total area of these zones accounts for only 1.24% of the city's land area but contains 90% of the population of the city [33].

There are 473.7 square kilometers of cropland spread throughout the other four development zones. This mainly includes the coastal recreation corridor zone, the port and harbor value-added planning and management zone, the technology innovation corridor zone, and the slow, easy lifestyle zone. It is obvious that there is great population pressure on the urban district and unbalanced development between the rural and urban districts. Thus, the city is confronted with a transition issue for further development. The size of cropland obviously exceeds that of urban open space. However, no attention has been paid to the existence of cropland, resulting in much cropland being shifted to other purposes. Illegally switching to manufacturing facilities is the most common phenomenon, resulting in high-quality cropland mixed with factories. This causes unexpected pollution damage to the vegetation and makes land planning difficult.

Under the NSLPA guidelines, land planning for Kaohsiung mainly focuses on the concept of “one core, two centers, and three axes.” “One core” refers to the development of the economic and business core for the old district of the city. The “two centers” are the development of the northern part of the city, mainly for living, production and tourism. The “three axes” refer to forest and agricultural production, industrial innovation, and coastal value added. The new arrangement of the six new development zones presented above is shown in **Figure 2** [34].

Along with the development of each zone, different types of public facilities have been promoted and installed by various acts since 1978. These acts encourage Kaohsiung’s establishment of facilities such as public libraries, cultural institutions, gas stations, circuit towers and substations, cemeteries, landfills, and sewage treatment facilities adjacent to urban open space or cropland. YIMBY facilities are normally located in the core area of an urban division, and NIMBY facilities are on the fringes or outside of an urban division. Public facilities such as Weiwuying National Kaohsiung Center for the Arts and various public libraries that have been constructed within the past 10 years are typical examples.



Sources: [35].

Figure 2. Development zones for Kaohsiung under National Spatial Land Planning Act

3.2. Spatial Durbin Hedonic Price Model

Open space has multifunctional value. However, there is no market to reflect the usage value gained by people. Thus, the value of open space should be evaluated by nonmarket evaluation methods, such as the commonly used hedonic price method (HPM). Rosen [36] provided a theoretical background for the HPM, and McConnell and Walls [26] reviewed many studies of various types of nonmarket goods using the HPM. The differentiation of housing prices is a composition of the dissimilar characteristics of housing and its surrounding characteristics. Housing characteristics can be specifically divided into the structures, surrounding characteristics, and natural or environmental specialties of housing. Thus, the concept of hedonic price seeks to maximize the utility function as (1) and thus derive the marginal implicit price of a specific attribute of hous-

ing. The utility for a specific consumer k gained from the purchase of a housing unit is expressed as (1) below:

$$U_k = U(\mathbf{G}, \mathbf{H}, \mathbf{N}, \mathbf{S}), \quad (1)$$

where U_k is the utility k that the consumer gains from purchasing a specific housing unit. \mathbf{G} is a vector consumed other than housing, \mathbf{H} is a vector of housing structures, \mathbf{N} is a vector of housing surrounding characteristics, and \mathbf{S} is a vector of special characteristics such as NIMBY or YIMBY facilities for a specific housing unit. Under utility maximization, the equilibrium price of housing i is written as (2):

$$P_i = f_i(\mathbf{H}, \mathbf{N}, \mathbf{S}) + \varepsilon_i, \quad (2)$$

All transacted housing normally has a problem of spatial dependence, either the existence of autocorrelation or spatial heterogeneity of the independent variable of housing prices or the dependent variables of all types of housing attributes. The value of Moran's I is used to determine the degree of spatial dependence among housing prices and any housing characteristics \mathbf{H} , \mathbf{N} , or \mathbf{S} , designated as \mathbf{X} [22, 37]. If there is spatial dependence for any independent variables, then $\mathbf{W}\mathbf{X}_k$ is the lag for those variables, denoted as $\mathbf{W}\mathbf{X}$. The spatial Durbin model (SDM) was developed to correct the dependence occurring in both transacted housing prices and any housing characteristics [22]. $\mathbf{W}\mathbf{X}_k$ is used to explain the spillover effect of independent variables with spatial dependence. SDM is as in (3) below [22, 38, 39]:

$$P_i = \rho \mathbf{W}P_i + \beta_0 + \beta_H \mathbf{H} + \beta_N \mathbf{N} + \beta_S \mathbf{S} + \gamma_k \mathbf{W}\mathbf{X}_k + \varepsilon_i, \quad \varepsilon_i \stackrel{i.i.d.}{\sim} N(0, \sigma^2), \quad (3)$$

The definitions of all the variables are the same as those stated above. Additionally, $\mathbf{W}P_i$ is a spatial housing price weighted matrix; ρ is its corresponding coefficient; β_0 is the intercept term; β_H , β_N and β_S are the vectors of coefficients to be estimated for characteristics \mathbf{H} , \mathbf{N} , and \mathbf{S} stated above; and ε_i is the error term.

The functional form (3) for SDM can further be rearranged as in equation (4) below:

$$P_i = (\mathbf{I}_n - \rho \mathbf{W})^{-1} \beta_0 + (\mathbf{I}_n - \rho \mathbf{W})^{-1} (\beta_H \mathbf{H} + \beta_N \mathbf{N} + \beta_S \mathbf{S} + \gamma_k \mathbf{W}\mathbf{X}_k) + (\mathbf{I}_n - \rho \mathbf{W})^{-1} \varepsilon_i, \quad (4)$$

$$\varepsilon_i \stackrel{i.i.d.}{\sim} N(0, \sigma^2 \mathbf{I}_n),$$

where n is the number of housing units and \mathbf{I}_n is a matrix of $n \times n$. The marginal implicit price for a specific characteristic X_k can be computed from (5). This is equivalent to the total impact from the change of a specific independent variable k with spatial dependence on the housing price:

$$\frac{\partial P}{\partial X_k} = (\mathbf{I}_n - \rho \mathbf{W})^{-1} (\mathbf{I}_n \beta_k + \gamma_k \mathbf{W}), \quad (5)$$

If the independent variable is not spatially dependent, then the total impact will be simplified to $(1 - \rho)^{-1} \beta_k$. The marginal implicit price is treated as an indication of residents' willingness to pay (WTP) for a specific housing attribute [4, 39, 40].

3.3. Determination of the Impact Radius for Open Space with and without Adjacent NIMBY or YIMBY Facilities and Other Surrounding Characteristics

The impact radius is used to determine the potential impact of NIMBY or YIMBY facilities on housing prices. A survey for this distance determination from a study was done by [12]. Some studies, such as Tsai et al. [10], Lai et al. [41], Wu et al. [39], Xue et al. [48], and Bai et al. [50] use the acceptable walking distance. However, determination of the impact radius from the above methods lacks an empirical basis. The local polynomial regression proposed by a numerical evidence to determine the impact radius for a typical type of open space with or without NIMBY or YIMBY facilities on a transacted housing

unit [25]. Local polynomial regression is a nonparametric analysis method using the means-square error to have the curve best fit the actual data [42, 43].

Once the impact radius for NIMBY or YIMBY facility f on housing unit A , R_{Af} or any surrounding housing attribute is determined, the impact of any NIMBY or YIMBY facility on the housing unit is reflected by a proxy variable $SP_{Af}(D_f)$. **Figure 3. (A)** shows that the impact is the difference between the impact radius of R_{Af} , and the shortest distance between the housing unit and facility f is D_f . That is, using a NIMBY or YIMBY facility as an example, a proxy variable representing the impact of a facility is represented as $SP_{Af}(D_f) = R_{Af} - D_f$ when the shortest distance is smaller than that of the impact radius. A facility might reinforce or weaken the impact of open space on housing prices by its total surrounding open space area. Under such circumstances, failure to take into account the impact of NIMBY or YIMBY facilities on housing might distort the influence of open space area on housing prices. On the other hand, when the shortest distance between the transacted housing unit and the facility is larger than the impact radius, then the proxy variable of NIMBY or YIMBY, $SP_{Af}(D_f)$ is zero, as shown in **Figure 3. (B)**

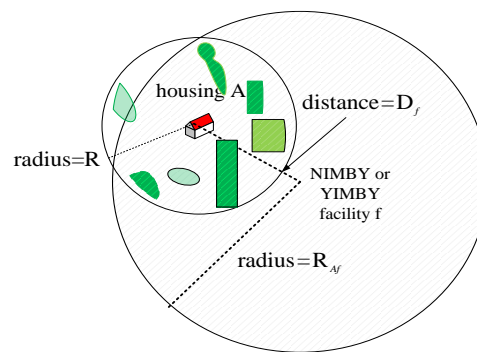


Figure 3. (A) Open space with nonzero proxy variable of NIMBY or YIMBY facilities for housing unit

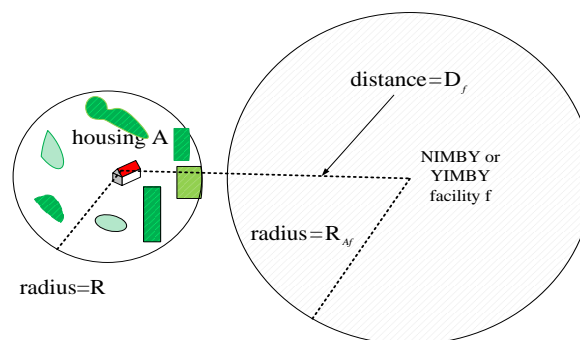


Figure 3. (B) Open space with zero proxy variable of NIMBY or YIMBY facilities for housing unit

The longer the shortest distance between a transacted housing unit and an open space with or without facilities is, the smaller the impact of the facility on the housing price is. There is no impact once the shortest distance is beyond the impact radius of the open space with NIMBY or YIMBY facilities. The impact radius R_{Af} is found to be 1,350 meters for the distance between a specific housing unit and urban open space or cropland and any NIMBY or YIMBY facility. The proxy variable is represented as (6) below:

$$SP_{Af}(D_A) = \begin{cases} 1,350 - D_f, & D_f < 1,350 \\ 0, & D_f > 1,350 \end{cases} \quad (6)$$

where f is the transacted housing unit and A indicates different types of open space with any NIMBY or YIMBY facility. Different impact boundaries for all other housing characteristics are determined in the same manner as in equation (6). The results are listed in **Table 1**.

Table 1. Impact radius between housing unit and different adjacent YIMBY or NIMBY facilities for urban open space and cropland and surrounding spatial characteristics.

Type of open space	Type of facility	Kind of facility	Type of open space and its adjacent facilities	Impact radius (m)
Adjacent YIMBY or NIMBY facilities				
Open Space (urban open spaces or cropland)	YIMBY	1. public library	urban open space with adjacent public libraries	1,000
		2. cultural institutions	urban open space with adjacent cultural institutions	2,400
	NIMBY	3. gas stations, circuit towers, and substations	urban open space with adjacent gas stations, circuit towers, and substations	250
		4. cemetery	urban open space with adjacent cemeteries	600
		5. landfill and sewage treatment plant	urban open space with adjacent landfill and sewage treatment plants	2,000
	-----	none of above five kinds	urban open space without any adjacent YIMBY or NIMBY facilities	1,350
Housing surrounding characteristics				
	convenience store	number of convenience stores		1,350
	public transportation	mass rapid transit (MRT) stations		1,500
		bus stops and passenger transport stops		950
	School	primary, junior and senior high schools		1,050
	commercial institution	commercial banks, post offices		1,900

4. Data Sources, Variable Selection, and Treatments

4.1. Sources of Transacted Housing Data

To evaluate the benefit of urban open space and cropland with and without NIMBY or YIMBY facilities, a set of data for housing transactions in Kaohsiung is required. The data are obtained from the “Web Service of Actual Real Transactions of Real Estate” prepared by the Ministry of the Interior from August 1, 2012, to June 30, 2018 [44]. The original data comprise 98,192 transacted housing units with complete attributes required in the analyses. Among these, 13,460 transactions are deleted because they are not for residential housing purposes and are the top 1% and bottom 1% housing-price outliers [24]. The final number of transactions is 84,732. Since all transacted housing prices are the nominal price of each year, the potential for price inflation must be taken into account. Thus, all the transacted housing data recorded from August 1, 2012, to June 30, 2018, are deflected by the housing price index of Kaohsiung in 2016. The advantage of using the housing price index for Kaohsiung compared to the consumer price index is that the housing price index reflects the housing differentials among cities.

4.2. Variable Selection and Treatment

Three categories of characteristics have a potential impact on housing prices. One category is housing structures. This includes the total number of floors of the building,

the floor that a specific transacted housing unit is on (*floor*), the size of the transacted housing (*housearea*), the age of the transacted housing (*age*), the number of living rooms (*hall*), the number of bathrooms (*bath*), and whether the housing includes a parking space (*Dparking*) [10, 45]. Previous studies indicate that housing prices vary by the type of housing [38]. Thus, five types of housing are included: “large building of 10 or more floors with elevator(s) (*Dtype1*),” “building of 9 or fewer floors with elevator(s) (*Dtype2*),” “apartment of 5 or fewer floors without elevator (*Dtype3*),” “townhouse (*Dtype4*),” and “studio apartment with one room, one bathroom, and one living room (*Dtype5*).” The housing age is the difference between the completion date of construction and the housing transaction date, measured in years.

There are six development zones under Kaohsiung’s NSLPA. Among these six zones, the business metropolitan living zone is a high-urbanization area. All the other areas are urban and rural mixed areas and have multiple development nuclei. Thus, the following analyses are conducted for the business zone as one type with a dummy variable $Dd1 = 1$ used to represent the housing units located in this zone. In contrast, a dummy variable $Dd1' = 1$ for the other five development zones is used as the other group. The urban open space in these six zones includes urban parks, squares, green spaces, playgrounds, and gymnasium land use in the urban planning district; recreational areas in the nonurban planning district and cropland are mainly in the nonurban planning district [33].

With regard to the category of YIMBY or NIMBY facilities, YIMBY facilities include public libraries and cultural institutes, while NIMBY facilities include gas stations, circuit towers and substations, cemeteries, and landfill and sewage treatment plants. All facilities use June 2018 data with TWD97 coordinates for specific locations [46]. With the spatial join tool in geographic information systems (GIS) by ArcMap, the impact radius of five types of adjacent NIMBY or YIMBY facilities is found for urban open space and cropland, respectively. The impact radius for a transacted housing unit of 1,350 meters for either type of open space with any adjacent YIMBY or NIMBY facility is listed in **Table 1**.

Impact boundaries are also determined for all types of housing surrounding spatial characteristics, i.e., MRT stations ($SP(MRT)$); primary, junior, or senior high schools ($SP(Sch)$); financial institutions ($SP(Bank)$); and bus stops ($SP(Bus)$). The impacts of characteristics surrounding housing are reflected by their proxy variable SP. The ubiquitous convenience stores play various functions in Taiwan. They enable shopping for goods and serve as a one-stop center for all types of fee payments, cash withdrawals and deposits, and mail and parcel delivery. Thus, the number of convenience stores belonging to the four largest chains within an impact radius for a specific transacted housing unit, variable ($4cmkt$), is measured. The number of convenience stores within 1,350 meters of each transacted housing unit is 28.92. All notations, definitions, and the mean value of each attribute in the estimation are listed in **Table 2**.

Table 2. Notations, definitions, and mean values of all the variables used in the estimation.

Variable	Definition	Mean	Standard error
Independent variable			
Price	transacted housing price (TWD)	8,192,354	7,548,467
Housing structures			
Age	age of the transacted housing (year)	14.37	12.22
Floor	floor of the transacted unit	6.92	4.89
Housearea	total transacted area (m^2)	149.44	81.16
Hall	number of living rooms	1.74	0.61
Bath	number of bathrooms	2.11	1.21
Dparking	dummy variable, 1 if the transacted housing has a parking space, 0 if not	0.386	0.487
Dtype1	dummy variable, 1 if housing is a large building	0.561	0.496

<i>Dtype2</i>	of 10 or more floors; 0 otherwise dummy variable, 1 if housing is a large building of 9 or fewer floors; 0 otherwise	0.075	0.263
<i>Dtype3</i>	dummy variable, 1 if housing is an apartment; 0 otherwise	0.052	0.222
<i>Dtype4</i>	dummy variable, 1 if housing is a townhouse; 0 otherwise	0.278	0.448
<i>Dtype5</i>	dummy variable, 1 if housing is a studio apartment; 0 otherwise	0.034	0.181
Housing surrounding characteristics			
<i>SP(MRT)</i>	distance, if distance between the transacted housing unit and the nearest MRT station is over 1,100 me- ters, then $SP(MRT)=0$; otherwise, $SP(MRT)=(1,500 - \text{the distance between the two})$ (m)	421.48	475.35
<i>SP(Bus)</i>	distance, if distance between the transacted housing unit and the nearest bus stop is over 950 meters, then $SP(Bus)=0$; otherwise, $SP(Bus)=(950-\text{the}$ distance between the two) (m)	795.43	148.93
<i>SP(Sch)</i>	distance, if distance between the transacted housing unit and the nearest primary, junior, or senior high school is over 1,050 meters, then $SP(Sch)=0$; otherwise, $SP(Sch)=(1,050-\text{the distance between}$ the two) (m)	623.29	225.70
<i>SP(Bank)</i>	distance, if distance between the transacted housing unit and the nearest commercial institution is over 1,900 meters, then $SP(Bank)=0$; otherwise, $SP(Bank)=(1,900-\text{the distance between the two})$ (m)	1,456.41	419.58
<i>4cmkt</i>	number of convenience stores within a 1,350-meter radius of a transacted housing unit	28.92	18.52
<i>Dd1</i>	dummy variable, 1 if the zone is a business metro- politan living zone, 0 if not	0.627	0.484
<i>Dd1'</i>	dummy variable, 1 if the zone is not a business metropolitan living zone, 0 if not	0.373	0.484
NIMBY and YIMBY facilities			
<i>D1</i>	dummy variable, 0 if the distance between the transacted housing unit and the nearest public library is over 1,000 meters; 1 otherwise	0.519	0.500
<i>D2</i>	dummy variable, 0 if the distance between the transacted housing unit and the nearest cultural institution is over 2,400 meters; 1 otherwise	0.736	0.441
<i>D3</i>	dummy variable, 0 if the distance between the transacted housing unit and the nearest gas station, circuit tower, or substation is over 250 meters, 1 otherwise	0.190	0.392
<i>D4</i>	dummy variable, 0 if the distance between the transacted housing unit and the nearest cemetery is over 600 meters, 1 otherwise	0.054	0.227
<i>D5</i>	dummy variable, 0 if the distance between the transacted housing unit and the nearest landfill and sewage treatment plant is over 2,000 meters, 1 otherwise	0.207	0.405
<i>SP(OS₁)</i>	proxy variable, if the distance between the transacted housing unit and the nearest urban	167.15	264.99

	open space with adjacent public libraries is over 1,000 meters, then $SP(OS_1)=0$; otherwise, $SP(OS_1)=(1,000\text{-distance between the two})(m)$		
$SP(OS_2)$	proxy variable, if the distance between the transacted housing unit and the nearest urban open space with adjacent cultural institutions is over 2,400 meters, then $SP(OS_2)=0$; otherwise, $SP(OS_2)=(2,400\text{-distance between the two})(m)$	1,044.88	823.22
$SP(OS_3)$	proxy variable, if the distance between the transacted housing unit and the nearest urban open space with adjacent gas stations, circuit towers, and substations is over 250 meters, then $SP(OS_3)=0$; otherwise $SP(OS_3)=(250\text{-distance between the two})(m)$	17.98	49.92
$SP(OS_4)$	proxy variable, if the distance between the transacted housing unit and the nearest urban open space with adjacent cemeteries is over 600 meters, then $SP(OS_4)=0$; otherwise $SP(OS_4)=(600\text{-distance between the two})(m)$	10.10	58.75
$SP(OS_5)$	proxy variable, if the distance between the transacted housing unit and the nearest urban open space with adjacent landfills and sewage treatment plants is over 2,000 meters, then $SP(OS_5)=0$; otherwise $SP(OS_5)=(2,000\text{-distance between the two})(m)$	53.67	237.38
$SP(OS_6)$	proxy variable, if the distance between the transacted housing unit and the nearest urban open space without any adjacent NIMBY or YIMBY facilities is over 1,350 meters, then $SP(OS_6)=0$; otherwise $SP(OS_6)=(1,350\text{-distance the two})(m)$	1,173.05	176.19
$SP(AG_1)$	proxy variable, if the distance between the transacted housing unit and the nearest cropland with adjacent public libraries is over 1,000 meters, then $SP(AG_1)=0$; otherwise $SP(AG_1)=(1,000\text{-distance between the two})(m)$	7.10	62.06
$SP(AG_2)$	proxy variable, if the distance between the transacted housing unit and the nearest cropland with adjacent cultural institutions is over 2,400 meters, then $SP(AG_2)=0$; otherwise $SP(AG_2)=(2,400\text{-distance between the two})(m)$	16.40	129.12
$SP(AG_3)$	proxy variable, if the distance between the transacted housing unit and the nearest cropland with adjacent gas stations, circuit towers, and substations is over 250 meters, then $SP(AG_3)=0$; otherwise $SP(AG_3)=(250\text{-distance between the two})(m)$	4.94	26.02
$SP(AG_4)$	proxy variable, if the distance between the transacted housing unit and the nearest cropland with adjacent cemeteries is over 600 meters, then $SP(AG_4)=0$; otherwise $SP(AG_4)=(600\text{-distance between the two})(m)$	19.22	83.18
$SP(AG_5)$	proxy variable, if the distance between the	48.80	219.05

	transacted housing unit and the nearest cropland with adjacent landfills and sewage treatment plants is over 2,000 meters, then $SP(AG_5)=0$; otherwise		
$SP(AG_6)$	$SP(AG_5)=(2,000-\text{distance between the two})(m)$ proxy variable, if the distance between the transacted housing unit and the nearest cropland without adjacent NIMBY or YIMBY facilities is over 1,350 meters, then $SP(AG_6)=0$; otherwise $SP(AG_6)=(1,350-\text{distance between the two})(m)$	777.84	434.18
$OSArea$	Area of urban open space within 1,350-meter radius of a transacted housing unit (m^2)	269,524	128,394
$AGArea$	Area of cropland within 1,350-meter radius of a transacted housing unit (m^2)	258,863	457,912

Note*: The reference housing type is type1, a large building of 10 or more floors.

5. Evaluation Results and Discussion

5.1. Model Specification

The log transformation of dependent housing prices can not only reduce the impact of extreme values but also reduce possible heteroscedasticity. Moreover, the change in the transformed variable can be explained as a percentage change to avoid the impact of different unit measurements [4]. A similar transformation is applied to the independent variable, the transacted housing price. This is a mixed log-linear function appropriate for the characteristics of the data [47]. The value of Moran's I among housing prices is 0.657. The age of the transacted housing unit (age) and townhouse type 4 housing ($Dtype4$) have a Moran's I of 0.6. This means that an SDM model in (7) is appropriate for estimation:

$$\begin{aligned} \ln price_i = & \rho W_{\ln price_i} + \alpha_0 + \alpha_1 Age_i + \gamma_1 W_{Age_i} + \alpha_2 Floor_i + \alpha_3 \ln housearea_i + \alpha_4 Hall_i + \alpha_5 Bath_i + \\ & \alpha_6 Dparking_i + \sum_{T=2}^5 \alpha_{5+T} Dtype_{Ti} + \gamma_2 W_{Dtype4_i} + \alpha_{11} [\ln SP(MRT)]_i^2 + \alpha_{12} [\ln SP(Bus)]_i^2 + \alpha_{13} [\ln SP(Sch)]_i^2 + \\ & \alpha_{14} [\ln SP(Bank)]_i^2 + \alpha_{15} 4cmkt_i + \sum_{F=1}^6 \alpha_{15+F} [\ln SP(OS_F)]_i^2 \times Dd1 + \alpha_{22} \ln OSArea \times Dd1' + \varepsilon_i + \sum_{F=1}^5 \alpha_{22+F} D_F \times \\ & \ln OSArea \times Dd1 + \sum_{F=1}^6 \alpha_{27+F} \ln SP(OS_F) \times Dd1' + \alpha_{34} [\ln OSArea]_i^2 \times Dd1' + \sum_{F=1}^5 \alpha_{34+F} D_F \times [\ln OSArea]_i^2 \times Dd1' + \\ & \sum_{F=3}^6 \alpha_{37+F} \ln SP(AG_F)^2 \times Dd1 + \alpha_{44} [\ln AGArea] \times Dd1 + \sum_{F=1}^5 \alpha_{44+F} D_F \times [\ln AGArea]_i^2 \times Dd1 + \\ & \sum_{F=1}^6 \alpha_{49+F} [\ln SP(AG_F)]_i^2 \times Dd1' + \alpha_{56} [\ln AGArea]_i^2 \times Dd1' + \sum_{F=1}^5 \alpha_{56+F} D_F \times [\ln AGArea]_i^2 \times Dd1', i = 1, \dots, 84,732 \end{aligned} \quad (7)$$

In (7), i indicates the transacted housing unit, α_0 is the constant, α_1 to α_{61} are the coefficients to be estimated, and ε_i is the error term. $W_{\ln price_i}$ is log housing prices, and ρ is the corresponding coefficient to be estimated. Similarly, W_{age_i} and W_{Dtype4_i} are the lag housing age and lag housing type 4 with spatial dependence, and γ_1 and γ_2 are the corresponding coefficients to be estimated for these two lag independent variables.

5.2. Estimation Results and Discussion

5.2.1. Estimated Coefficients

The estimated results of equation (7) are listed in **Table 3**. Various values for the fitness of models AIC, SC, LIK, and LR test are significant, which indicates that SDM is a good fit for the data at hand. The signs for the estimated coefficients of characteristics surrounding housing, i.e., distance between the transacted housing and the nearest MRT station ($SP(MRT)$), the nearest bus stop ($SP(Bus)$), the nearest compulsory school ($SP(Sch)$), and the nearest commercial institution ($SP(Bank)$), as well as the number of

convenience stores within a buffer of 1,350 meters (4cmkt) all have positive and significant estimated coefficients.

As with the significance level of estimated coefficients for NIMBY or YIMBY facilities, the relevant attributes of this study located in different development zones are significantly different from zero at different significance levels, with the exception of six impact boundaries of housing with an adjacent NIMBY or YIMBY facility or the size of cropland-type open space in a business metropolitan living zone. This result reveals that it is essential to take into account NIMBY or YIMBY facilities by evaluating either urban open space or cropland.

Table 3. Results of coefficient estimations.

Variable	Estimated coefficient	Standard error	Wald
<i>W_inprice</i>	0.380802 ***	0.00295878	16564.46221
<i>Constant</i>	5.42347 ***	0.0413948	17165.71632
<i>Age</i>	-0.0145034 ***	0.00017247	7071.53174
<i>W_age</i>	0.00673155 ***	0.000224525	898.87835
<i>Floor</i>	0.000817 ***	0.00022822	12.81554
<i>Lnhousearea</i>	0.697074 ***	0.00328231	45102.29113
<i>Hall</i>	0.00818594 ***	0.00168727	23.53802
<i>Bath</i>	0.021167 ***	0.00111042	363.36366
<i>Dparking</i>	0.126596 ***	0.00253552	2492.91503
<i>Dtype2</i>	-0.0716361 ***	0.00382786	350.22877
<i>Dtype3</i>	-0.0729824 ***	0.00497689	215.04170
<i>Dtype4</i>	0.688532 ***	0.00523398	17305.40251
<i>W_Dtype4</i>	-0.436791 ***	0.00610564	5117.82852
<i>Dtype5</i>	-0.12578 ***	0.00573284	481.37676
[<i>lnSP(MRT)</i>] ²	0.000852354 ***	0.0000639	178.03565
[<i>lnSP(Bus)</i>] ²	0.0005404 ***	0.000192939	7.84498
[<i>lnSP(Sch)</i>] ²	0.0017423 ***	0.000130488	178.27857
[<i>lnSP(Bank)</i>] ²	0.00226029 ***	0.000136898	272.60652
<i>4cmkt</i>	0.00249478 ***	0.0001	622.43763
<i>lnSP(OS₁)xDd1</i>	0.000162892 **	0.0000765	4.52975
<i>lnSP(OS₂)xDd1</i>	0.00154519 ***	0.000084	338.61888
<i>lnSP(OS₃)xDd1</i>	-0.000510479 ***	0.000132088	14.93583
<i>lnSP(OS₄)xDd1</i>	0.0000571	0.000176872	0.10436
<i>lnSP(OS₅)xDd1</i>	-0.00258501 ***	0.000489612	27.87534
<i>lnSP(OS₆)xDd1</i>	0.00566217 ***	0.000483972	136.87596
<i>lnOSAreaxDd1</i>	0.00184148 ***	0.000157554	136.60701
<i>D₁lnOSAreaxDd1</i>	0.000191414 ***	0.0000322	35.37406
<i>D₂lnOSAreaxDd1</i>	-0.000258577 **	0.00010281	6.32563
<i>D₃lnOSAreaxDd1</i>	0.0000332	0.0000336	0.97462
<i>D₄lnOSAreaxDd1</i>	0.00155578 ***	0.000413608	14.14881
<i>D₅lnOSAreaxDd1</i>	-0.000711574 ***	0.0000577	151.96972
<i>lnSP(OS₁)xDd1'</i>	-0.000217308 **	0.000098	4.91261
<i>lnSP(OS₂)xDd1'</i>	-0.00146097 ***	0.000187439	60.75205
<i>lnSP(OS₃)xDd1'</i>	-0.00039787 ***	0.000089	19.96436
<i>lnSP(OS₄)xDd1'</i>	-0.000349813 ***	0.000122927	8.09795
<i>lnSP(OS₅)xDd1'</i>	-0.00461275 ***	0.000273059	285.37007
<i>lnSP(OS₆)xDd1'</i>	-0.0031219833 ***	0.000317801	96.504689
[<i>lnOSArea</i>] ² x <i>Dd1'</i>	0.00285553 ***	0.000106547	718.27752
<i>D₁x[lnOSArea]²xDd1'</i>	0.000296407 ***	0.0000847	12.26022
<i>D₂x[lnOSArea]²xDd1'</i>	0.000446687 ***	0.0000777	33.08827

$D_3x[\ln OSArea]^2 \times Dd1'$	0.000082	0.0000848	0.934138
$D_4x[\ln OSArea]^2 \times Dd1'$	-0.00101559 ***	0.000123326	67.81499
$D_5x[\ln OSArea]^2 \times Dd1'$	0.0001843 **	0.0000921	4.00656
$\ln SP(AG_3)^2 \times Dd1$	0.000904528 ***	0.000189711	22.73316
$\ln SP(AG_4)^2 \times Dd1$	-0.00410063 ***	0.000555846	54.42426
$\ln SP(AG_5)^2 \times Dd1$	0.00223932 ***	0.000523593	18.29127
$\ln SP(AG_6)^2 \times Dd1$	0.000100029	0.000156611	0.40795
$[\ln AGArea] \times Dd1$	0.0000216	0.000130005	0.02768
$D_{1x}[\ln AGArea]^2 \times Dd1$	-0.000498222 ***	0.0000565	77.69100
$D_{2x}[\ln AGArea]^2 \times Dd1$	0.0000398	0.000127886	0.09706
$D_{3x}[\ln AGArea]^2 \times Dd1$	-0.000195437 ***	0.00006	10.597890
$D_{4x}[\ln AGArea]^2 \times Dd1$	-0.00208824 ***	0.000526233	15.74725
$D_{5x}[\ln AGArea]^2 \times Dd1$	0.000768678 ***	0.0000855	80.83592
$[\ln SP(AG_1)]^2 \times Dd1'$	-0.000329351 ***	0.000178985	3.38597
$[\ln SP(AG_2)]^2 \times Dd1'$	0.00147316 ***	0.000431797	11.63967
$[\ln SP(AG_3)]^2 \times Dd1'$	0.000209611 **	0.000102502	4.18178
$[\ln SP(AG_4)]^2 \times Dd1'$	0.00034216 ***	0.000107654	10.10185
$[\ln SP(AG_5)]^2 \times Dd1'$	0.000627666 **	0.000298592	4.41878
$[\ln SP(AG_6)]^2 \times Dd1'$	0.00429081 ***	0.000355042	146.05448
$[\ln AGArea]^2 \times Dd1'$	-0.000603765 ***	0.0000931	42.04718
$D_{1x}[\ln AGArea]^2 \times Dd1'$	-0.000332436 ***	0.0000755	19.40138
$D_{2x}[\ln AGArea]^2 \times Dd1'$	-0.000277935 ***	0.000067	17.18268
$D_{3x}[\ln AGArea]^2 \times Dd1'$	-0.0000922	0.00008	1.32646
$D_{4x}[\ln AGArea]^2 \times Dd1'$	0.000485701 ***	0.0000813	35.71807
$D_{5x}[\ln AGArea]^2 \times Dd1'$	0.000218882 ***	0.0000765	8.19019
R^2	0.89		
AIC	12,083.60		
SC	12,691.2		
LIK	-5,976.8		

Note: Numbers with *, **, and *** indicate that the estimated coefficients are significantly different from zero at 10%, 5%, and 1% significance levels, respectively.

5.2.2. Marginal Benefit of Surrounding Total Area for Housing Units in Each Zone

Since the boundary impacts of NIMBY or YIMBY facilities on housing prices have been determined by local polynomial regression, it is meaningful to estimate the marginal and total benefit for the area surrounding a housing unit for urban open space or cropland in any development zone. For instance, the marginal benefit for urban open space in a business metropolitan living zone (BMLZ) without accounting for NIMBY or YIMBY facilities is computed as in (8):

$$\frac{\partial price}{\partial OSarea} = \frac{2\alpha_{22}}{(1-\rho)} \overline{\ln OSarea}_{Dd1} \times \frac{\overline{price}_{Dd1}}{\overline{OSarea}_{Dd1}}, \quad (8)$$

where \overline{price}_{Dd1} is the average housing price measured in TWD and \overline{OSarea}_{Dd1} is the average area of urban open space within a 1,350-meter radius of a transacted housing unit in a BLMZ. Marginal benefit for urban open space with and without all other NIMBY and YIMBY facilities in a BMLZ can be computed consequently. A similar approach is used for cropland with and without the same facilities in the other five development zones, i.e., the nonbusiness metropolitan living zone (NBMLZ).

The results show that within a 1,350-meter radius of a specific housing unit, the housing prices will increase TWD 2.20 and TWD 3.78 for a one-square-meter increase of urban open space in a BMLZ and NBMLZ without an adjacent YIMBY or NIMBY facility. They are shown as shaded orange and blue bars with numerical circles in squares in

Figure 4. The same procedure is conducted to compute the marginal benefit within a 1,350-meter radius of a specific housing unit for cropland-type open space. The marginal benefit is TWD 0.14 and the marginal damage TWD 0.28 for a one-square-meter increase in cropland in the BMLZ and NBMLZ, respectively; these are shown as green and yellow bars with numerical circles in squares in **Figure 4**.

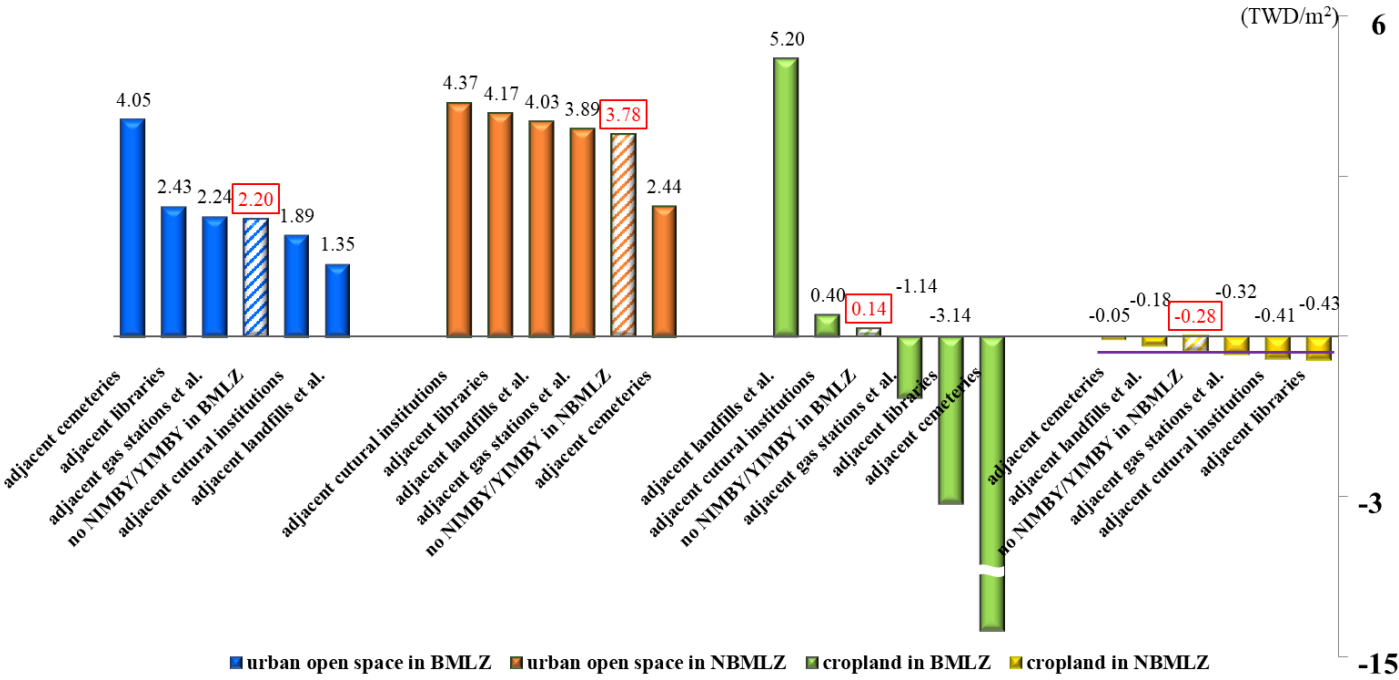


Figure 4. Marginal benefit/marginal harm for urban open space and cropland with/without NIMBY or YIMBY facility in BMLZ or NBMLZ

The above four magnitudes are used as references to compare the marginal benefit or marginal harm for either urban or cropland-type open space, accounting for adjacent YIMBY or NIMBY facilities in the BMLZ or NBMLZ. The urban open space and adjacent YIMBY libraries and cultural institutions generate 5 marginal benefits or marginal harms in the BMLZ and NBMLZ, respectively. Similarly, NIMBY facilities such as cemeteries, gas stations, circuit towers and substations, and landfills and sewage treatment plants generate the other 5 different marginal benefits or marginal harms in the BMLZ and NBMLZ, respectively. The marginal benefit and marginal harm for urban open space and cropland with and without accounting for the NIMBY or YIMBY facilities in the BMLZ and NBMLZ form four groups, as shown in **Figure 4**.

In addition to the reference bar for each group, each group of other bars represents the marginal benefit or marginal harm for urban-type or cropland-type open space in the BMLZ and NBMLZ, accounting for the adjacent YIMBY or NIMBY facility. The bar located on the right-hand side of each reference bar indicates that the marginal benefit is overestimated, or the marginal harm is underestimated without accounting for the adjacent NIMBY or YIMBY facilities. Taking the group of blue-colored bars as an example, the marginal benefit is overestimated by 0.31 (0.22-1.89) when it fails to account for this type of adjacent YIMBY facility for urban open space in the BMLZ. All the other groups have similar explanations as above. A purple horizontal line is drawn on the top of the reference bar for each group. This makes it easy to observe the amount of underestimation or overestimation when the adjacent YIMBY or NIMBY facility is ignored in the evaluation.

It is abnormal to have a higher marginal benefit for urban open space with adjacent cemeteries. This is because Kaohsiung’s government has restructured the appearance of the city to promote travel and tourism and has better utilization of land resources since the 2010 merger of old Kaohsiung City and Kaohsiung County into a municipal city.

Thus, the reallocation of public cemeteries proceeded until June 2018. Among 165 public cemetery sites, 132 are prohibited from being used as burial places and are arranged as parks [49]. This makes housing purchasers expect that these lands will become large parks or even forest parks. Urban open space with adjacent cultural institutions has lower marginal benefit than space without such entities. This may arise from a higher preference for cultural institutions *per se* rather than adjacent facilities within an urban open space.

The results also indicate that although residents view housing surrounded by cropland as negative, the type of open space with adjacent NIMBY facilities, such as cemeteries or landfills and sewage treatment plants, will reduce the harm. That is, compared to cemeteries or landfills and sewage treatment plants adjacent to cropland, the harm caused by pure cropland is lesser. On the other hand, when cropland has YIMBY adjacent libraries or cultural institutions, this makes the harm greater than that caused by cropland only. This indicates that it is difficult to increase the benefit of libraries or cultural institutions on cropland.

5.3. Total Benefit of Urban Open Space or Cropland with Different Adjacent NIMBY or YIMBY Facilities in Each Zone

According to the marginal benefit or harm listed in **Figure 4**, the total benefit for urban open space and cropland with and without accounting for an adjacent NIMBY or YIMBY facility for the BMLZ and NBMLZ can be computed. It can be observed from **Table 4** that the total benefit for the business metropolitan living zone in the BMLZ is overestimated and the total harm for the slow, easy lifestyle zone in the NBMLZ are underestimated when we do not account for adjacent NIMBY or YIMBY facilities. This indicates that the allocation of NIMBY or YIMBY facilities in these two zones is inappropriate as the benefit of urban open space with either adjacent type of facility will be reduced and the harm of cropland with either adjacent type of facility will be increased. For the other four zones, i.e., the NMBLZ, the total benefit is underestimated if an adjacent NIMBY or YIMBY facility is ignored within the impact radius of the transacted housing unit. The NIMBY or YIMBY facilities allocated in the NMBLZ will then increase the total benefit of the open space within 1,350 meters surrounding the transacted housing unit.

Table 4. Total benefit of urban open space and cropland with and without different kinds of adjacent NIMBY or YIMBY facilities in different development zones

Open space with adjacent NIMBY or YIMBY facilities	Total benefit of development zone (TWD)*					
	business metropol- itan living zone	technology innova- tion corridor zone	industrial new county innovation zone	coastal recrea- tion corridor zone	port and harbor val- ue-added planning and management zone	slow, easy lifestyle zone
Total benefit to urban open space with different adjacent NIMBY or YIMBY facilities (A)	31,462,289,750	3,675,981,027	15,419,698,934	870,540,368	6,010,662,344	244,199,550
Total benefit to urban open space without accounting for adjacent NIMBY or YIMBY facilities (B)	36,639,888,325	3,093,113,393	13,558,856,766	823,638,604	5,601,991,546	228,726,589
Total benefit to cropland with different adjacent NIMBY or YIMBY facilities (C)	4,717,086,912	-1,757,428,220	-1,485,208,316	-455,309,289	-2,014,279,094	-356,700,483
Total benefit to cropland without accounting for adjacent NIMBY or YIMBY facilities (D)	366,889,179	-1,448,016,809	-1,266,972,606	-600,895,200	-1,758,955,565	-315,929,200
Total benefit to urban open space and cropland with different adjacent NIMBY or YIMBY facilities (E)=(A)+(C)	36,179,376,662	1,918,552,807	13,934,490,618	415,231,079	3,996,383,259	-112,500,933
Total benefit to urban open space and cropland without different adjacent NIMBY or YIMBY facilities (F)=(B)+(D)	37,006,777,504	1,645,096,584	12,291,884,160	222,743,404	3,843,035,981	-87,202,611

Note*: The exchange rates for US\$ to TWD on December 31 in 2012, 2013, 2014, 2015, 2016, 2017 and June 30 in 2018 were, respectively, 29.05, 29.89, 31.61, 32.87, 32.43, 29.71, and 30.51. The average exchange range for these seven years was approximately 30.87.

5.4. Share of total benefit or harm for open space to the average housing price

Computing the benefit for urban open space and cropland to the average housing price in each zone indicates how much open space is worth for each transacted housing unit. The average benefit of open space for each housing unit in a BMLZ is approximately TWD 681,000. This represents 7.43% of the average housing price in a highly urbanized and active business zone. The average benefit is also computed for the NBMLZ, and the results are shown in **Table 5**.

The slow, easy lifestyle zone has a negative total benefit of open space and cropland, i.e., total harm of TWD 70,000, or 1.87% of the average housing price in this zone. The average benefit of urban open space and cropland to the average housing price for the other four zones is positive except for the slow, easy lifestyle zone. These results indicate that the average benefit of the total area of surrounding urban open space and cropland within the impact radius with adjacent NIMBY or YIMBY facilities accounts for 2.95% to 13.80% of the average housing price. Surrounding NIMBY or YIMBY facilities indeed increase or decrease the benefit of open space.

Table 5. Share of benefit or harm with adjacent NIMBY or YIMBY facilities for the average housing price in each different zone

Development zone	Number of transacted housing units	Average housing price (TWD per housing unit)	Total benefit for open space with adjacent NIMBY or YIMBY facilities for each zone (TWD)	Average benefit or harm for each housing unit with adjacent NIMBY or YIMBY facilities (TWD per housing unit)*
	(A)	(B)	(C)	(D)=(C)/(A)
Business metropolitan living zone	53,129	9,160,854	36,179,376,662	680,972 (7.43%)
Technology innovation corridor zone	5,658	7,708,265	1,918,552,807	339,087 (4.40%)
Industrial new county innovation zone	13,950	7,240,300	13,934,490,618	998,888 (13.80%)
Coastal recreation corridor zone	2,602	5,409,910	415,231,079	159,582 (2.95%)
Port and harbor value-added planning and management zone	7,795	5,482,790	3,996,383,250	512,685 (9.35%)
Slow, easy lifestyle zone	1,598	3,765,386	-112,500,934	-70,401 (1.87%)

Note *: Number in parentheses is the share of benefit or harm per housing unit in each zone.

6. Conclusions

This is the first study to comprehensively evaluate the benefit or harm to urban-type and cropland-type open space associated with different types of adjacent NIMBY or YIMBY facilities. The urbanized zone in Kaohsiung shows that without accounting for these adjacent facilities, the total benefit is overestimated for urban-type open space and underestimated for cropland-type open space. Moreover, the total benefit for areas with mixed urban-type and cropland-type open space will be higher if their adjacent NIMBY or YIMBY facilities are accounted for. The situation is reversed because the total cropland-type open space accounts for more than 80% in the zone. The results suggest

that NIMBY or YIMBY facilities located in an area with a larger share of urban-type open space will significantly increase the positive impact of YIMBY facilities and mitigate the negative impact of NIMBY facilities. These results serve as a guideline for further arrangement of different NIMBY or YIMBY facilities in each zone with different proportions of urban-type and cropland-type open space in the city.

From the viewpoint of the individual housing unit, the total harm for cropland-type open space with an adjacent NIMBY or YIMBY facility is equivalent to 1.87% of the average housing price for areas with a high percentage of cropland. The total benefit for urban-type open space with adjacent NIMBY or YIMBY facilities is equivalent to 7.43% of the average housing price for highly urbanized areas. In comparison, the total benefit accounts for 2.95%-13.80% of the average housing price for areas with mixed urban-type and cropland-type open space. This clearly indicates that failure to account for either type of open space with adjacent NIMBY or YIMBY facilities will result in the overestimation or underestimation of housing prices by a substantial amount, especially given high average housing prices in Taiwan.

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