Land Use Policy
Volume 82, March 2019, Pages 832-840

Where does floating TDR land? An analysis of location attributes in real estate development in Taiwan

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https://doi.org/10.1016/j.landusepol.2018.12.029

Highlights

- "Floating" TDR represents a closer alignment between transfer design and market conditions.
- TDR gravitates toward growing neighborhoods.
- TDR is more likely to be used in neighborhoods with higher household income.
- TDR prefers parcels with a slower increase in land price.
- TDR avoids locations in close proximity to urban parks and mass transit stations.

Abstract

This article examines how the attributes of an urban location contribute to private property developers' use of transfer of development rights (TDR) in Taiwan. We use "floating TDR" to describe a deliberate design feature of the Taiwanese program—the lack of legal requirement for planning designation of the receiving areas. The result is that planners have little control over where TDR takes place in the city even though TDR density bonus has been widely used in real estate development. A logistic regression model finds that TDR projects gravitate toward locations of certain attributes: growing neighborhoods, neighborhoods with higher household income, parcels with a slower increase in land price, and locations at a further distance from public

facilities such as urban parks
development volume and a smaller site are also more likely to use TDR density bonus. This article concludes by reaffirming the important role of planning in the design and use of TDR as a market-enabling tool.

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Keywords

TDR; Density bonus; Location attributes; Real estate development; Taiwan

1. Introduction

This article aims to examine how the attributes of an urban location contribute to private property developers' decisions on whether or not to use transfer of development rights (hereafter TDR) in Taiwan. Conventionally, the operational design of TDR involves three basic elements: a sending area whose development potential is restricted by zoning regulations, a receiving area designated by planning that encourages compact and higher-density development, and a trading mechanism that commodifies development rights (in floor area) and allows them to be transferred from the former to the latter (Costonis, 1974). The central idea of TDR is to harness the forces of real estate markets in the receiving area in order to serve planning goals in both sending and receiving areas. Since its inception in the 1970s, both the planning application and the market dynamics of TDR have evolved significantly. On the one hand, the application of TDR has expanded to include a wide range of planning goals in the sending areas, including historical preservation (Costonis, 1974), farmland and natural resource protection (Pizor, 1986), and low-income housing provision (Putters, 2008). On the other hand, in recent years, planning scholars have observed a distinct shift in which TDR programs focus more closely on and align with market conditions in receiving areas (Linkous and Chapin, 2014; Linkous, 2016).

In this study we use "floating TDR" to describe the design feature of the Taiwanese program in which the monetary trading and spatial transfer of development rights remain intact, but the legal requirement for the planning designation of the receiving areas is absent. Existing scholarship on TDR has identified an increasing diversification of locations involved in TDR transfer, which may take place between adjacent parcels, within specified districts, and through cross-jurisdiction, rural-to-urban, and even rural-to-rural transfers (Been and Infranca, 2013; Linkous, 2016; Machemer and Kaplowitz, 2002). The growing flexibility in transfer methods reflects the idiosyncrasy of each TDR program, but also undoubtedly indicates the importance of aligning the program design with a density-demanding real estate market in the receiving area, the location of which may require long-distance transfers or more complex transfer modalities. Nevertheless, planning designation of receiving areas still matters greatly for both preventing urban sprawl and concentrating urban growth (Nelson et al., 2012). While recognizing that TDR needs to be market-enabling, planning scholars and practitioners have also emphasized the importance of coordinating TDR with local comprehensive planning goals so that TDR is also planning-guided

TDR, however, is oriented to enhance market flexibility with regard to receiving areas in particular. Legally, the enabling statute at the central government level does not require planning authorities to designate specific areas as receiving areas eligible for higher-density developments. At the municipal level, local governments' TDR regulations adopt a negative listing approach that prevents environmentally sensitive areas, such as agricultural zones and water catchment areas, from receiving TDR density, but leaves most locations open for higher-density developments.[1] In practice, real estate developers have the freedom to pursue TDR projects in most of the city's built-up areas. As a result, planners have little control over where higher-density developments take place in the city even though a TDR density bonus has been widely used in real estate development. Since the early 2000s, a total of 3764 development projects have utilized TDR in Taiwan, and these have generated 807 ha of buildable floor area in excess of existing FAR (floor-area ratio) regulations. Among them, 43.22% of the total TDR projects (1760 cases) and 37.65% of the total additional floor area (324 ha) are in New Taipei City (Construction and Planning Agency, Ministry of Interior, 2018), which, housing almost four million people, is the most populous city in Taiwan.

This study examines what attributes of an urban location contribute to the use of TDR density bonuses in real estate development projects in the absence of planning-designated receiving areas in the city. This research question has important implications for land use planning and policy. First, existing studies have identified factors important to the success of TDR programs (Machemer and Kaplowitz, 2002; Pizor, 1986; Pruetz and Standridge, 2009). These studies, however, only compare TDR programs, and do not compare TDR and non-TDR programs. Their evaluations therefore do not distinguish between the factors contributing to TDR use from those affecting non-TDR programs. Moreover, planned designation of receiving areas is a premise of those TDR programs examined in the literature. Existing studies, therefore, have yet to account for a TDR mechanism that does not conform to the conventional design principles, such as Taiwan's floating TDR. Second, Taiwan's floating TDR can be seen as a highly deregulated form that maximizes market flexibility in determining where higher-density developments take place. Identifying what location attributes influence the use of TDR will generate a nuanced understanding of the dynamics between the spatiality of TDR and market conditions. The study will also help planners gain a better understanding of TDR's possible impact on urban spaces in the city. Finally, existing studies rarely quantify the preexisting conditions of a location prior to development, such as the land price, growth potential, and neighborhood demographics of receiving areas. This study includes variables that measure these pre-development conditions. A longer view will help generate a more dynamic analysis that sheds light on how TDR utilizes profitable locations in the city.

In the following two sections, we first review the existing scholarship on TDR and that of Taiwan's floating form of TDR in particular. In the subsequent section we use a logistic regression model to analyze the use of TDR in the real estate market in Sanchong district in New Taipei City. New Taipei City's use of TDR, both in terms of frequency and amount, ranks the highest in Taiwan. Sanchong district is the city's fourth most populous district and has an active real estate market. Existing studies have shown that Sanchong is among those districts that have the highest numbers of TDR cases in the city (Lin, 2007). These factors make Sanchong an appropriate and representative area for study. The analysis model includes eight variables measuring different location attributes and three

project itself (Table 1). The three project-specific variables take into account the important variations between development projects that may affect the decision on TDR use. The logistic model measures whether, and if so how much, each variable contributes to the likelihood of using TDR in real estate development. The analysis results show that the design of Taiwan's floating TDR allows for an easier capture of increase in land value in locations where land cost is low and development potential is high. Worrisome spatial patterns also exist, however, as with the negative association between the proximity to public facilities and the use of TDR density bonuses. We conclude with a discussion of the importance of planning intervention in reforming the present form of floating TDR.

Table 1. Variable Definitions and Descriptive Statistics.

Variables	Variable definition	Mean	S.D.	Min.	Max.
Dependent variable					
TDR	Whether TDR density bonus is used or not	0.3333	0.4723	0.0000	1.0000
Independent variable					
Land cost					
Land price	Price of a land parcel 3 years prior to development (unit: NTD)	52712	23088	22300	176000
Land price ratio	y_2/y_1 y_2, y_1 = prices at the beginning and end of a 3-year period prior to development	1.8721	0.6799	0.5481	6.5127
Growth potential					
H.H. growth rate	$(y_2-y_1)/y_1$ y_2, y_1 = number of households at the beginning and end of a 3-year period prior to development in an administrative neighborhood (*li*)	0.2492	0.3844	−0.0417	2.1508
Devt density	Number of new residential housing units divided by land area in an administrative neighborhood (*li*) 3 years prior to development	0.0019	0.0025	0.0000	0.0214
M.H. income	Average median household annual income of an administrative neighborhood (*li*) 3 years prior to development (unit: 1000 NTD)	515	52	425	759
H.P.I. growth rate	$(y_2-y_1)/y_1$ y_2, y_1 = housing price index at the beginning and end of a 3-year period prior to development in New Taipei City	0.4758	0.1836	0.0079	0.8227

Variables	Variable definition	Mean	S.D.	Min.	Max.
Access to public facilities					
MRT	Whether a project is within 500 m	0.1780	0.3833	0.0000	1.0000
Park	Whether a project is within 500 m	0.9015	0.2985	0.0000	1.0000
Project characteristics					
Site area	Area of a development site (unit: m^2)	1413.46	2163.43	32.09	15572.32
Ln floor area	Total buildable floor area of a project (unit: m^2)	8.0544	1.5494	4.6105	11.3664
Street	Whether a project fronts a street wider than 8 m or a narrow lane	0.6818	0.4667	0.0000	1.0000

2. Transfer of development rights: a market-enabling and planning-guided tool

In the U.S., TDR is designed to respond to the challenge of regulatory taking when planning restricts development on private land. Regulatory taking occurs when zoning restrictions are considered too severe, even if an actual taking of property is absent (Alterman, 2010). In the first TDR case in 1978, *Penn Central Transp. Co. v. City of New York*, the Supreme Court ruled that New York City's Landmarks Preservation Program was not an example of regulatory taking because TDR programs "undoubtedly mitigate whatever financial burdens the law has imposed on appellants" and that the city's action was a legitimate exercise of police power (Juergensmeyer et al., 1998, p. 442). In order to compensate affected landowners through TDR mechanisms, there needs to be a real estate market that is vibrant enough to generate an actual demand for additional density. Therefore, in places where development pressure is high, TDR has greater potential to be a market-enabling tool through which planners leverage market forces to achieve planning goals. In the several decades since the *Penn Central* case, the market-based compensatory mechanism of TDR has been used to facilitate a wide range of planning goals, from the protection of natural resources to the retention of low-income housing (Nelson et al., 2012). In the international context, in addition to serving similar planning goals as those in the U.S., TDR has also been used to facilitate on-site rehousing in slum redevelopment in India (Mukhija, 2003), provision of public facilities in Italy (Micelli, 2002), and a wide range of rationales specific to local contexts and planning systems (Janssen-Jansen et al., 2008).

The expansion of TDR applications has been accompanied by a recognition of the importance of aligning TDR receiving areas with the right market conditions (Machemer and Kaplowitz, 2002; Pizor, 1986; Pruetz and Standridge, 2009). As Van Der Veen et al. (2010) argue, TDR is a non-financial instrument "designed with the market in mind as to have sufficient potential to balance demand and supply and in so effectively creating a financial incentive" (p. 1011). Observing two early TDR programs in Montgomery County, Maryland and in the New Jersey Pinelands, Pizor proposed seven conditions for successful TDR programs and argued that "[t]he linchpin in TDR is whether the increased densities provided by the development rights are in demand" in the receiving areas (1986, p. 209).

echoed in other studies. Building on fourteen TDR programs, Machemer and Kaplowitz developed an evaluative framework consisting of thirteen elements (Machemer and Kaplowitz, 2002). Among them, at least three evaluative elements are directly related to receiving areas, including “sense of place,” “rapidly growing area,” and “appropriate receiving area”. A sense of place refers to community residents appreciating the benefits associated with the growth of higher-density building in the receiving area (or preservation of resources in the sending area). A rapidly growing area indicates that TDR programs work best when a large real estate market is present to create demands for developers to utilize TDR. An appropriate receiving area means that it needs to be politically acceptable (i.e., the residents do not oppose higher-density building), physically feasible (i.e., there is existing infrastructure capable of accommodating the higher density), and financially profitable so that developers want to purchase a density bonus. Pruetz and Standridge’s study finds similar results (2009). Assessing the twenty most successful TDR programs from a total of 191 in the U.S., they identified five essential factors to success. Among them, two factors rank the highest: developers must want a density bonus through TDR, and the receiving area must encompass a real estate market that developers perceive as suitable for higher density. The important and multiple considerations involved in TDR receiving areas is recognized in the planners’ observation that “[d]esignating the receiving areas can be the trickiest part of setting up a TDR program” (Hanly-Forde et al., 2018).

The evolving form of TDR also reflects the increasing importance of market dynamics in TDR program design. In New York, TDR has evolved from transfers between adjacent parcels (i.e., lot mergers), to transfers across a street intersection (i.e., landmark transfers), and further to more distant transfers between designated sending and receiving districts in the same neighborhoods (i.e., special district transfers) (Putters, 2008; Been and Infranca, 2013). As Been and Infranca argue, the purpose of the expansion of the spatial distance of transfers is to “potentially expand the market for both potential sellers and buyers of TDRs” (2013, p. 446). In the rural context, TDR programs have increasingly designated receiving areas in the urban fringes and in the form of new town development (Walls and McConnell, 2007). This change in location of TDR receiving areas to suburban subdivision development results from the fact that there is little opposition to higher densities from current residents, and market demand for them is high (Linkous and Chapin, 2014; Walls and McConnell, 2007). Tailoring TDR design to market conditions has also given rise to cases such as Florida’s “rural TDR” that redistributes development rights across rural areas outside the urban growth boundaries (Linkous and Chapin, 2014; Linkous, 2016). Linkous argues that rural TDR represents a clear shift in focus to facilitate intensification of land development in receiving areas (2016). The result is that rural TDR generates “remarkable amounts of growth in areas previously off limits to anything resembling urban development” (Linkous and Chapin, 2014, p. 265). The existing scholarship shows that TDR is both a market-enabling and planning-guided tool and that planning has an important role to play in balancing the tension between the two.

3. TDR and its floating form in Taiwan

The inception of TDR in Taiwan in the late 1990s was similarly triggered by the planning authority’s need for a market-based and non-financial compensatory mechanism. The reserved land issue has given birth to a TDR form that is tailored for market flexibility in Taiwan. The legal

term *reserved land* refers to th
public facilities such as roads, schools and parks, and therefore stripped of development potential, but whose owners have yet to receive compensation because of the government's lack of budgetary funding. The reserved land issue has been a serious legal and political challenge to the planning authority since the 1970s. It is estimated that reserved land amounted to a total of 26,321 ha in 2018 (Construction and Planning Agency, Ministry of Interior, 2018). Taiwan's TDR program helps resolve the reserved land issue through the following mechanisms. First, sending areas consist of reserved land parcels that are scattered in the city.[2] Second, private developers purchase reserved land parcels directly from the owners of the reserved land and transfer the parcels to the municipal government in exchange for a density bonus. The density bonus (in floor area) serves as the development rights to which an owner of reserved land is entitled. The volume of the density bonus is determined by three factors: the area of the sending site, the FAR of the receiving site, and the ratio between the assessed land value of the sending site and that of the receiving site.[3] The price paid for the reserved land parcel by the private developer serves as a form of compensation for the landowner's loss of development potential. The amount of money that a landowner receives for the reserved land parcel is determined by negotiating with the developer. Because developers began to buy reserved land early on, even before the TDR policy was fully in effect, many original owners of reserved land had yet to appreciate the value of TDR density bonuses in generating high-density, high-priced real estate development. Developers' early entry into the trading market of reserved land, market savvy, and financial power often enabled them to pay the owner of reserved land lower prices. A 2013 investigative report published by the central government stated that because of the free-market trading mechanism, most profit is channeled to developers rather than to the original owners of reserved land (The Control Yuan, 2013).[4] Third, real estate developers use density bonuses to build market-rate housing units in real estate development projects. As this circular mechanism plays out, the local government captures nothing of financial value but finds a market-based solution that responds to the sociopolitical challenge of the reserved land issue (Shih et al., 2018).

In this article, we use "floating TDR" to highlight a deliberate design feature in the above-mentioned TDR mechanism—the lack of planned designation of receiving areas. Because the pressing goal is to resolve the reserved land issue through real estate market forces, the TDR mechanism is designed to give the greatest degree of market flexibility for using development rights (Shih and Chang, 2016). The law legislated by the central government requires TDR to take place within the same urban planning area but does not require receiving areas to be designated by planning within that area. Municipal planners, who are financially strained and politically pressured, do not venture to regulate where receiving areas will be located except excluding TDR in zones protected for their environmental sensitivity. As a result, real estate developers can build TDR projects in almost any location within each planning area according to market-based decisions.[5] Floating TDR has been a significant source of uncertainties for city planning and growth management. In the absence of planning-designated receiving areas, planners have little control over where TDR projects take place in the city. Moreover, as urban housing prices have been soaring in Taiwan, TDR has become a common practice by real estate developers to increase their profit margin (Shih and Chang, 2016; Yang and Chang, 2018). It has been widely established, both by journalistic reporting and government investigation, that the real estate sector has come to control a significant amount of reserved land through developers' direct trading with the original owners of the reserved land (

hold onto the reserved land and only transfer it to municipalities in exchange for TDR density bonuses when the real estate market is booming. The lack of planning in designating receiving areas, coupled with the opportunist and profit-driven nature of the real estate market, can undermine the planning system's ability to predict and control where, and when, high-density developments occur in the city.

Haila once used "density rent" to refer to the profits generated by intensifying land use in erecting high-rise buildings (2016, pp. 21, 60). The "rent gap," to paraphrase Neil Smith's original explanation, is the difference in profit between what a piece of undeveloped land potentially holds (i.e., potential ground rent) and what is actually capitalized after land development (i.e., actual ground rent) (Smith, 1979). By granting higher building density and creating greater density rent, the Taiwanese TDR program has no doubt enlarged the rent gap for real estate developers, as Yang and Chang recently argue in their study (2018). It is this mechanism that makes the Taiwanese TDR model a market-savvy and politically pragmatic tool.

A spatial understanding of how the floating form of Taiwan's TDR helps enlarge the rent gap, however, is still lacking in the existing scholarship. In the absence of designated receiving areas, do real estate developers prefer certain locations in the city over others? What attributes do those preferred locations of TDR development hold? The above-mentioned studies on Taiwan's TDR mechanism suggest that our analysis model needs to consider variables that measure the potential for capturing the rent gap. We therefore design two variables: one measures the land price prior to TDR development (*Land price*) and the other measures how fast (or slow) the price increases (*Land price ratio*). In the following section, we use a logistic regression model to analyze factors that contribute to the use of TDR density bonuses under Taiwan's floating TDR mechanism.

4. Methods and analysis results

4.1. Data

This study builds on five data sources. First, a building permit data set contains records of all development projects approved for construction and completed for use from 2004 to the present in New Taipei City. Each record includes information on every development project's site area, total floor area, location, zoning status, number of apartment units built, year of construction, and use permits issued. Second, a TDR data set includes all development projects that have used a density bonus through the TDR policy in the city since 2004. Each record details the year in which TDR was used, the amount of density bonus (in floor area) granted, locations of sending and receiving sites, and zoning status. Both data sets are maintained by New Taipei City. Because both data sets contain parcel coordinates, we are able to combine the two by geocoding each data point at the parcel level (Fig. 1). The merger of the two data sets therefore allows us to identify whether a particular development project uses a TDR density bonus and if so, how much. Between 2004 and 2016 there were, in total, 264 development projects in Sanchong district. We have made sure that all of them are qualified for the TDR program. Among them, 88 projects, or 33.33%, used a TDR density bonus. As shown in Fig. 2, with the exception of the first year, each remaining year contains both TDR and non-TDR development projects, allowing us to use a logistic regression model to assess the effect of each variable on the use of density bonuses. A third data set contains

annual assessed land values f
is the basis for taxation on the increase in land value when a land sale takes place. On average, between 2000 and 2018, the assessed land value is about 85% of the market value of land. We use these assessed land values as approximate land prices.[6] Fourth, a household registration data set provides the number of households, population and average household median income of the administrative neighborhood (*li*) where a development project is located. Currently, neighborhood (*li*) is the smallest administrative and spatial unit for which historical demographic data are available in Taiwan. In this article, the term "neighborhood" refers to the administratively defined area. Both the third and the fourth data sets are maintained by the Ministry of Interior. Fifth, a housing price index data set provides quarterly price indexes for new housing units transacted in major cities from 1993 to the present. This data set is suitable for our analysis of TDR developments, which also generate new housing units. These price indexes are citywide measurements (i.e., New Taipei City), allowing us to measure the overall housing market trends, such as upturns or downturns, in the city.[7]

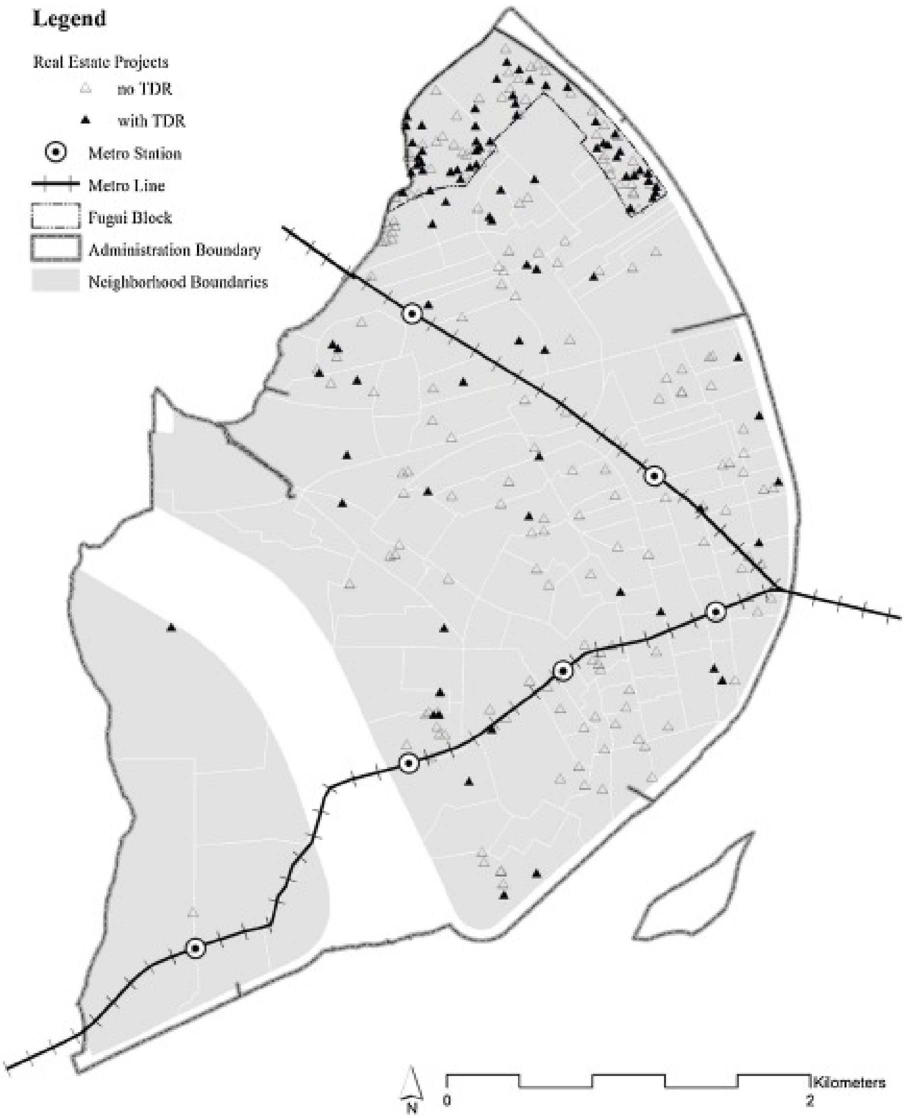

Fig. 1. Spatial Distribution of Real Estate Development Projects.

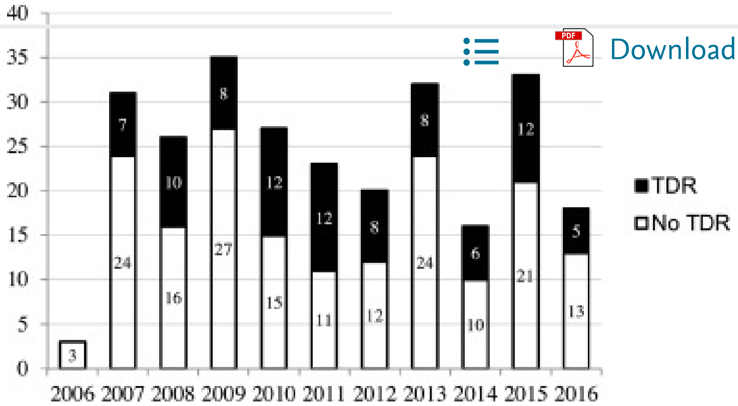

Fig. 2. Time Distribution of Real Estate Development Projects.

4.2. Logistic regression and empirical results

We use a logistic regression model to identify attributes (i.e., independent variables) that explain a developer's decision regarding whether to use a TDR density bonus or not (i.e., dependent variable). Our dependent variable is binary, and the model is formulated as the following:

$$Log_e\left(\frac{P_i}{1-P_i}\right) = b_0 + b_1x_1 + b_2x_2 + \ldots + b_nx_n + \epsilon$$

The dependent variable P_i is the probability of using TDR. We hypothesize that eleven attributes, encoded in the variables x_1 to x_{11}, have effects on whether TDR is used in a particular development project. The ratio $\left(\frac{P_i}{1-P_i}\right)$ is the odds of using TDR. The exponential of the regression coefficient b_i encodes the change in the odds as the variable x_i increases by one unit. In contrast to the linear regression model, the results are interpreted in terms of the exponentials of the regression coefficients. In the logistic model these are the odds ratios, which are the ratios of the odds after a unit change in x_i to the original odds (Miller and Rodgers, 2008).

Drawing insights from the existing scholarship reviewed in the preceding sections, the eleven variables capture four important aspects of real estate development: land cost (*Land price, Land price ratio*), growth potential (*H.H. growth rate, Devt density, M.H. income, H.P.I. growth rate*), access to public facilities (*MRT, Park*), and the physical characteristics of the development (*Site area, Ln floor area, Street*). The first six variables measure different aspects of land cost and growth potential three years before a construction permit is issued for a development project. The choice of a three-year time interval is based on the following considerations and sensitivity tests. Development patterns offer insight into how to choose a time interval to use in the model. A natural timeframe for developers is the average three-year interval between the beginning and end of construction, as shown by our data. We further conduct sensitivity tests based on two-year, three-year and four-year intervals. The three-year model has the lowest collinearity ($VIF_{2\text{-year}} = 1.59$, $VIF_{3\text{-year}} = 1.54$, $VIF_{4\text{-year}} = 1.57$). Both two-year and three-year models have the same seven significant variables and the same correct prediction percentages (74.62%). Compared to the three-year model, the four-year

model not only has a higher
model has a slightly higher correct prediction percentage (76.14%).

Land price is the price of a development site three years prior to the actual development activity. *Land price ratio* is the ratio between the land prices at the beginning and the end of the three-year period. *Land price ratio* measures how fast (or slowly) land cost has increased before development. Measuring growth potential in the same three-year period, *H.H. growth rate* is the growth rate of the number of households in a neighborhood in which a development project is located. *Devt density* measures the density of the total number of new housing units built in that neighborhood in the three-year period. We use density (i.e., dividing the total number of new units by the area of a neighborhood) but not the absolute number of new units because some neighborhoods are larger in area. This normalization makes sure data are comparable. *M.H. income* is the median household income of the neighborhood three years before a development took place. *H.P.I. growth rate* is the growth rate of the house price index at the beginning and the end of the three-year period. It measures how the overall, macro housing market conditions have changed. *MRT* and *Park* represent whether a project is within a 500-meter radius[8] of two important public facilities, a mass transit station and a park, respectively. In addition to these location attributes, three additional variables measure the physical characteristics of a development project. *Site area* tells how large a development site is; *Ln floor area* is the natural logarithm of the total volume (i.e., total buildable floor area) of the project without taking into account its TDR density bonus.[9] *Street* differentiates whether a project fronts a street wider than eight meters or is only connected to a narrower lane. Table 1 provides definitions and descriptive statistics for all the variables.

Overall, the eleven variables included in the logistic model correctly explain 74.62% of the outcome (Table 2).[10] Table 3 shows the results of logistic regression analysis. At a 90% confidence level, seven variables are statistically significant, covering all four aspects of real estate development. As explained in the beginning of this section, the results are interpreted in terms of odds ratios: an odds ratio smaller than 1.00 suggests that the variable in question is negatively correlated with the odds of using TDR, and vice versa. The odds ratio of 0.60 on *Land price ratio* shown in Table 3 indicates that a slower land price increase in the three years before development took place is correlated to greater odds of using a TDR density bonus in the future for that land parcel. For example, a site experiencing an increase in land price by a factor of 1.5 is 1.29 times more likely to host a TDR project than a site seeing an increase by a factor of 2. *H.H. growth rate,* with an odds ratio of 2.47, suggests that household growth rate strongly and positively affects the odds of using TDR. For example, a neighborhood experiencing a 50% growth rate is 1.57 times more likely to host a TDR project than a neighborhood undergoing no growth at all. The odds ratio of 1.01 (1.0074) on *M.H. income* suggests that development projects in a neighborhood of a higher average median household income are associated with a higher likelihood of utilizing TDR than those in a poorer neighborhood. If median household income increases by 50,000 NTD a year, the odds of using TDR increase by 43%.[11] The dummy variable *Park,* with an odds ratio of 0.38, suggests that when a project is within 500 m of a park, the odds of using TDR bonus are 62% lower. With an odds ratio of 0.29, just like *Park, MRT* has a negative effect on the use of TDR, and the odds of using TDR within a 500-m radius of a mass transit station are 71% lower. With an odds ratio of almost 1.00 (0.9999), one unit (i.e., 1 m^2) of change in *Site area* hardly matters to the odds of using TDR. If we consider, however, a 1500-m^2 site as opposed to a 2000-m^2 site, the former is 10% more likely to use TDR than the latter. The increased odds associated with a smaller site area are a result of the odds ratio being larger the volume, the greater the odds ratio of using TDR. For example, a 50% increase in the total building floor area will see a 35% increase in the odds of using TDR.

Table 2. The Observed and the Predicted Frequencies for TDR Use.

	Observed			
Predicted	**TDR**	**No TDR**	**total**	**% correct**
TDR	45	24	69	65.22%
No TDR	43	152	195	77.95%
total	88	176	264	
Correctly classified: 74.62%				

$65.22\% = 45/(45 + 24) \times 100\%$.

$77.95\% = 152/(43 + 152) \times 100\%$.

Table 3. Logistic Regression Results.

Variable	**Odds Ratio**	**Robust Std. Err.**	**Coefficient**	**Robust Std. Err.**
Intercept	0.00013***	0.00025	−8.95333***	1.93264
Land cost				
Land price	0.99999	0.00001	−0.00001	0.00001
Land price ratio	0.60165*	0.16171	−0.50808*	0.26877
Growth trend				
H.H. growth rate	2.47474**	0.90088	0.90613**	0.36403
Devt density	0.00000	0.00000	−70.57737	60.94806
M.H. income	1.00738***	0.00242	0.00736***	0.00241
H.P.I. growth rate	2.96926	2.97354	1.08831	1.00144
Project characteristics				
Site area	0.99988*	0.00006	−0.00012*	0.00006
Ln floor area	2.07585***	0.31571	0.73037***	0.15209

Variable	Odds Ratio	Robust Std. Err.	Coefficient	Robust Std. Err.
Street	1.68626	0.62640	0.52251	0.37147
Access to public facilities				
MRT	0.29256*	0.19660	−1.22908*	0.67199
Park	0.37627**	0.16717	−0.97746**	0.44428
Number of observations =	264			
Likelihood ratio chi-square (df) =	74.63(2)***			
Pseudo R^2 =	0.2221			

Note:

1. Intercept estimates baseline odds.

2. Significance levels: *<0.1; **<0.05, ***< 0.01.

3. Robust Standard Error is adjusted for 78 clusters in administrative neighborhoods.

5. Discussion and conclusions

The logistic regression model generates an important understanding of how location attributes and project characteristics contribute to the use of TDR density bonuses in Sanchong district. First, areas of high growth potential are where TDR density bonuses are most often utilized. TDR projects gravitate toward growing neighborhoods that experience a faster increase in the number of households, as indicated by the positive association between *H.H. growth rate* and TDR use. As suggested by the positive effect of *M.H. income*, a neighborhood with a higher median household annual income is also more likely to see TDR projects. When we consider the two together, they help explain a distinctive spatial pattern of TDR use in Sanchong district. 55% (or 48 cases) of the total 88 TDR projects are located in the district's northern corner, called Fugui Block (Fig. 2). Fugui Block was rezoned from agricultural to residential use in 1996 and has recently become a new frontier of real estate development. Fugui Block is a growing area, as it includes parts of the two fastest growing neighborhoods between 2005 and 2016.[12] These two neighborhoods also have very high levels of median household income.[13] While our analysis builds on one single case study of a locality, our findings are in agreement with the existing literature emphasizing the importance of aligning rapidly growing areas with TDR programs.

Second, our analysis further shows that developers, in addition to seeking neighborhoods experiencing faster growth, prefer locations in Sanchong district that are slower appreciating prior to development, as indicated by the negative effect of *Land price ratio* on TDR use. This means that the slower the land price increase in the past, the more likely it is that the developer will proceed with TDR development in that location in the future. Since TDR density bonuses increase the economic rent a development project can generate, gravitating toward locations with such a preexisting condition of slower land price appreciation further enlarges the rent gap that the development project may eve

verifies the general concept of rent gap in the TDR mechanism by generating a place-specific spatial understanding of where the capture of the rent gap takes place in that locality (Haila, 2016; Yang and Chang, 2018). In the urban development context in Taiwan, emerging areas of growth are usually on the fringe of the city, where small-scale farming and manufacturing have been giving way to new real estate residential development since the late 1980s. Economically, land prices in these areas have yet to soar. Spatially, these areas often feature a highly mixed land use where warehouses, home-based workshops, and small factories are interspersed with vacant lots awaiting new construction and more intensified developments. Fugui Block experienced such an urbanization process, and it boasts high-end, luxurious real estate development today. Consistent with the rent gap thesis, our finding suggests that floating TDR gravitates toward areas where the potential for capturing the rent gap is high.

Third, in Sanchong district urban parks and mass transit stations do not hold locational gravity for TDR projects. This finding is supported by the negative association between two variables for public facilities, *Park* and *MRT*, and TDR use. Locally, this is an important and worrisome finding that requires planners' further investigation into whether floating TDR has negatively impacted local traffic conditions and urban compact development. In many Asian cities, parks are a valuable urban amenity, especially given the high population density and city residents' desire for greenery and open spaces. A closer proximity to a park therefore is often associated with higher land costs and housing values. Similarly, mass transit stations are important public facilities that drive up the real estate values of nearby locations. The positive effects of urban parks and mass transit stations on housing prices in Taiwan have also been empirically established (Shih et al., 2017). In Sanchong district, however, developers are in fact less likely to use TDR when their projects are closer to parks and MRT stations, as the analysis model shows. This finding supports the second point, discussed above, that TDR projects seek locations with cheaper land costs. This finding suggests that the floating form of TDR can be a double-edged sword. While more market-oriented regulations of receiving sites have helped to address the reserved land issue, they may also contribute to the sprawling of urban development. Since municipalities are likely to continue to rely on TDR as a major compensatory mechanism, planners should consider a stronger planning intervention to increase or reduce the amount of TDR density bonus that a development project is eligible to receive on the basis of its proximity to and impact on public facilities. To prevent sprawling development patterns, planners can designate specific districts where the use of TDR density bonuses should be concentrated. This approach, however, is likely to face the challenge of political feasibility as it would tighten the TDR market while the reserved land issue still persists in the city.

Finally, pencil-like, high-rise buildings are likely to appear under current TDR policy for two reasons. On the one hand, a project with a greater building volume (*Ln floor area*) is more likely to use a TDR density bonus. On the other hand, a project with a smaller development site (*Site area*) also has an increased likelihood of using a density bonus. This is because developers try to compensate for less salable floor area due to the small site area by building taller. This analysis result echoes the landscape locally called "narrow lane, towering building (*zaixiang gaolou*)," which refers to extremely vertical developments relative to site area that can be easily observed in the city. Particularly given the negative association between TDR projects and their distance to mass transit

facilities, planners should ca
local traffic conditions.

In conclusion, building on a case study in Sanchong district, our analysis identifies the locational attributes toward which floating TDR gravitates and the resulting specific spatial patterns. Vertical real estate developments enabled by TDR density bonuses tend to take place in growing areas where lower land costs promise a higher potential for developers to capture a rent gap. In Taiwan, the urban fringes are often where a combination of these factors occurs, as indicated by the concentration of TDR projects in Fugui Block in Sanchong district. While Taiwan's TDR program is market savvy, institutionally innovative and politically pragmatic, our analysis has shown certain worrisome local impacts that warrant planning intervention. It suggests that regulations need to be enacted to address floating TDR's distance from mass transit stations. Particularly, more community-level traffic impact analysis should be conducted to inform planners about the relationship between density bonuses and traffic conditions as well as about how to adjust the granting of density bonuses as a function of TDR's impacts. More research needs to be done to carefully examine floating TDR's impact on different localities in order to chart a fuller picture that will provide guidance for Taiwanese planners to reform floating TDR toward a more planning-oriented mechanism.

Acknowledgments

The authors would like to thank Yu Chen Liu and Li-Yan Chang for their excellent research assistance.

Appendix A. Sensitivity Test

1. **Two-year model and results**

Variable	Odds Ratio	Robust Std. Err.	Coefficient	Robust Std. Err.
Intercept	0.00037***	0.00068	−7.89506***	1.83802
Land cost				
Land price	0.99999	0.00001	−0.00001	0.00001
Land price ratio	0.39753**	0.17339	−0.92248**	0.43616
Growth trend				
H.H. growth rate	2.36815*	1.04042	0.86211*	0.43934
Devt density	0.0000	0.00000	−22.67453	57.21687
M.H. income	1.0074***	0.00258	0.00738***	0.00256
H.P.I. growth rate	1.33251	1.39892	0.28707	1.04984
Project characteristics				

Variable	Odds Ratio	Robust Std. Err.	Coefficient	Robust Std. Err.
Site area	0.99987**	0.00006	–0.00013**	0.00006
Ln floor area	2.07975***	0.29731	0.73225***	0.14295
Street	1.7693	0.67418	0.57058	0.38104
Access to public facilities				
MRT	0.31407*	0.21145	–1.15815*	0.67325
Park	0.33914**	0.14231	–1.08134**	0.41961
Number of observations =	264			
Likelihood ratio chi-square (df) =	74.71(2)***			
Pseudo R^2 =	0.2223			

2. Three-year model and results

Variable	Odds Ratio	Robust Std. Err.	Coefficient	Robust Std. Err.
Intercept	0.00013***	0.00025	–8.95333***	1.93264
Land cost				
Land price	0.99999	0.00001	–0.00001	0.00001
Land price ratio	0.60165*	0.16171	–0.50808*	0.26877
Growth trend				
H.H. growth rate	2.47474**	0.90088	0.90613**	0.36403
Devt density	0.00000	0.00000	–70.57737	60.94806
M.H. income	1.00738***	0.00242	0.00736***	0.00241
H.P.I. growth rate	2.96926	2.97354	1.08831	1.00144
Project characteristics				
Site area	0.99988*	0.00006	–0.00012*	0.00006
Ln floor area	2.07585***	0.31571	0.73037***	0.15209
Street	1.68626	0.62640	0.52251	0.37147
Access to public facilities				
MRT	0.29256*	0.19660	–1.22908*	0.67199
Park	0.37627**	0.16717	–0.97746**	0.44428

Number of observations =	264
Likelihood ratio chi-square (df) =	74.63(2)***
Pseudo R^2 =	0.2221

3. Four-year model and results

Variable	Odds Ratio	Robust Std. Err.	Coefficient	Robust Std. Err.
Intercept	0.0002***	0.00044	–8.5417***	2.23510
Land cost				
Land price	0.99999	0.00001	–0.00001	0.00001
Land price ratio	0.66891	0.16880	–0.40211	0.25236
Growth trend				
H.H. growth rate	2.57582**	0.99801	0.94617**	0.38745
Devt density	0.0000	0.00000	–30.0718	57.28858
M.H. income	1.00525*	0.00287	0.00523*	0.00286
H.P.I. growth rate	5.85831	8.90588	1.76786	1.52021
Project characteristics				
Site area	0.99989*	0.00006	–0.00011*	0.00006
Ln floor area	2.01405***	0.30574	0.70015***	0.15180
Street	1.53602	0.56590	0.4292	0.36842
Access to public facilities				
MRT	0.30989*	0.20581	–1.17155*	0.66415
Park	0.39816**	0.16742	–0.9209**	0.42047
Number of observations =	264			
Likelihood ratio chi-square (df) =	71.37(2)***			
Pseudo R^2 =	0.2123			

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1 See Regulation of Urban Building Capacity Transfer, Ministry of Interior. Also article 3 of New Taipei City Urban Building Capacity Transfer Review Guidelines (http://web.law.ntpc.gov.tw/Scripts/newsdetail.asp?no=1C0150015). These regulations focus on site-specific conditions, such as parcel size and adjacent road width, but not on the location of receiving sites.

2 In this article, we only consider TDR use for the reserved land. TDR is also used for purposes of historical preservation in Taiwan. There is only a scatter of TDR cases for the latter use.

3 The calculation formula is $\mathbf{Density bonus} = \mathbf{Area}_{\mathbf{sending}} \times \frac{\mathbf{Assessed land value}_{\mathbf{sending}}}{\mathbf{Assessed land value}_{\mathbf{receiving}}} \times \mathbf{FAR}_{\mathbf{receiving}}$

4 The highest supervisory agency of the Taiwanese government.

5 In New Taipei City there are 16 urban planning areas, of which Sanchong district is one (New Taipei City Government, 2017). Prior to 2010, New Taipei City was Taipei County, where towns constituted their individual urban planning areas. Taipei City, the capital city, constitutes one single planning area.

6 In Taiwan, official registration of land sale prices was not made mandatory until 2011. Because assessment of land value is conducted annually and nationwide, it is a reliable proxy for land sale prices. Source: https://www.land.moi.gov.tw/chhtml/content.asp?cid=14&mcid=194, accessed on 9 October 2018.

7 The data set is maintained by Taiwan Real Estate Research Center at National Chengchi University and Cathy Real Estate Development Corporation. The Ministry of Interior has only begun to collect and publish housing price index data since 2012, and its timeframe does not cover our research period from 2006 to 2016. The housing price index data set used in this study has been widely cited both by the government and the industry as a reliable source for housing market analysis in Taiwan. For example, see the 2011 Financial Stability Report published by the Central Bank of the Taiwanese Government (https://www.cbc.gov.tw/lp.asp?ctNode=970&CtUnit=524&BaseDSD=7&mp=2, accessed on 14 October 2018).

8 A 500-meter distance is a common parameter used in evaluating the effect of mass transit and urban amenities on land and housing prices both internationally and in Taiwan (Calthorpe, 1993; Kestens et al., 2004; Feng et al., 1994).

9 The variables encoding site and floor area exhibit fairly large ranges, hence it would be natural to transform them to log form in a regression model. However, using both variables in log form results in a very high degree of collinearity, rendering the regression model unreliable. Therefore we can use only one of them in log form. If *site area* takes the log form (i.e., *Ln site area*) as opposed to *floor area*, this combination leads to a higher collinearity (VIF = 1.70) in comparison to the smaller one (VIF = 1.54) given by the combination of *Ln floor area* and *site area*.

10 All variables were tested for problems of multicollinearity. The minimum and maximum values of VIF (variance inflation factor) is 1.08 and 2.20. The mean VIF is 1.54.

11 The unit for *M.H. income* is 10,000 NTD. Therefore, the effect is still quite large even though the odds ratio is closer to 1.

12 Fugui Block includes parts of Bihua neighborhood and Fugui neighborhood. Between 2005 and 2010, the household growth rates in Bihuu and Fugui were 59.19% and 30.61%, ranking as the first and second fastest growing neighborhoods in Sanchong district. Between 2011 and 2016, the growth rates were 48.89% and 24.70%, with Bihua the third fastest growing neighborhood and Fuigui the fifth in the district. Data source: https://www.ca.ntpc.gov.tw/home.jsp?id=222&parentpath=0,2,43,219.

13 Bihua and Fugui consistently rank among the top three neighborhoods for highest median household income. Data source: https://www.fia.gov.tw/News.aspx?n=7769B1BD01306B45&sms=BD450CA810662F3D&_Query=bc3f871c-3f57-4046-a58d-d423f9834dae.