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Land assembly for urban development in Taipei City with particular reference to old neighborhoods

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ABSTRACT

Taipei, the capital city of Taiwan, has suffered a scarcity of land supply. The size of residential development sites over the past 20 years falls in the range of 500 and 700 square meters. Furthermore, the size of development sites varies widely depending on the sites' locations within the city. Given that the size of a development site is a rational economic decision, this study sets out to unveil the determinants. Residential development projects completed between 1994 and 2015 are examined by regression analysis. Results show that residential development sites tend to be larger along a major road and smaller when they are closer to a metro station. Also, residential development sites are likely to be smaller when they are located in areas where ownership of land is relatively fragmented. Finally, a larger residential development site often results from the assembly of several smaller sites. We further selected one of the oldest neighborhoods in Taipei City, the Wan-Hua Station areas for a case study. Analysis of the reliable data sets of land title registration and building use permits between 1970 and 1988 indicates that a significant amount of time and resources has been expended for land assembly activities. That is to say, small sites and fragmented land ownership are among the primary contributing factors to the inert supply of housing. Nevertheless, there does not seem to be an apparent solution to the land assembly problems.

1. Introduction

Taipei, at the end of 2017, accommodated 2,683,257 inhabitants among approximately 1.05 million households over an area of 271.8 km^2, leading to a density of 9872 inhabitants per km^2. One of the present challenges faced by Taipei City is its skyrocketing housing prices. The Sin-Yi Realty price index for housing has risen from 163.46 in 2008 to 267.73 in 2017. (Sin-Yi Realty http://www.sinyi.com.tw) However, the housing stock over the same timeframe has increased by 62,645 units, which only accounts for approximately 6.6% of the total stock. (Real Estate Information Platform, Ministry of the Interior https://pip.moi.gov.tw/V2/Default.aspx)

There are a variety of reasons concerning both demand and supply that contribute to rising housing prices. The majority of previous studies paid the most attention to demand-side factors, and those pertaining to the supply-side have been largely ignored. Glaeser and Ward (2009) observe a rapid increase in housing price and at the same time an inert supply of new housing in the Greater Boston area. Therefore, they suggest stringent land use regulations as the major institutional contributing factor. A similar conclusion was found in Glaeser and Gyourko (2005), which also involved a city context. In fact, decades ago, this line of argument was proposed on a national level in the United Kingdom (Evans, 1991).

Unlike the case in Greater Boston, the Taipei City Government has never been particularly anti-development. On the contrary, government-led land development schemes, such as land readjustment and urban renewal, among others, are always a major driver to facilitate urban development or redevelopment. It is however noted in Lin (2014) that small and fragmented land parcels are largely responsible for the slow redevelopment in Taipei. As of 2015, the size of individual privately-owned land parcels in the city is on average 441.47 m^2. The land parcels in Neihu district, with an average size of 1152 m^2, are the largest among the 12 districts in the city. Neihu is on the more recently developed eastern part of the city, where numerous large-scale land development projects were implemented by the government. In contrast, land parcels in Datong and Wanhua districts, on the early developed western part of the city, are only on average 88m^2 and 91m^2, respectively (Dept. of Land Administration, Taipei City Government). This evidence appears to suggest that how land parcels are reconfigured, either assembled or partitioned over time, is essential to the

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consequent housing supply and price, and also to the pattern of urban development.

2. Land assembly and its possible consequences

What distinguishes land from other production factors is its fixed location and fairly slow adaptation to outer changes. When land is developed or redeveloped, developers must consider how lot size and configuration affect value as well as how they affect costs so as to maximize profit (Colwell and Scheu, 1989). When no plots on the market fit the required size of profit maximization, the rebundling or reconfiguration of rights over plots is necessary. In a market dominated by small plots, land assembly is prevalent. Land assembly refers to the process of assembly of multiple individually-owned parcels into one larger, single-owned parcel (Brooks and Lutz, 2016). Shoup (2008) likened the many small parcels of land with different owners involved in a development project to the anticommons problem of cooperation and coordination. Heller (1998) stated that the tragedy of anticommons can occur when too many individuals have exclusive rights of a scarce resource. The tragedy is that rational individuals, acting separately, may collectively waste the resource by under-consuming it compared with a social optimum. Buchanan and Yoon (2000) also suggested that anticommons will lead to potential economic devaluation, ultimately leading to resource under-utilization. In the anticommons, persons may, by reducing inputs to the common facility via price, reduce the rent available to others who also exercise potential exclusion rights. The authors proposed that the tragedies of commons and anticommons are symmetric, and their size of opportunity loss is an increasing function of the number of persons assigned simultaneous rights.

If subdividing land into smaller parcels and assembling it into larger parcels were free of costs, the price of land per unit of area would not depend on the size of a site. However, with significant costs involved in land assembly, Colwell and Munneke (1999) found a higher price per square foot for residential land in the city center of Cook County, Illinois. Tabuchi (1996) and Lin and Evans (2000) reached the same conclusion that land price per unit of area increases with plot size in Osaka, Japan and Taipei, Taiwan. It is noted that the areas examined in the two cities are not confined only to the city center; the finding is a city-wide phenomenon. Lin (2005) provided a detailed account of how parcels are assembled in a land readjustment project at the outskirts of Taipei. Developers not only purchased contiguous parcels, but they also bought the parcels auctioned by the government which were next to parcels they already owned. Because many parcels are jointly owned, developers frequently purchase all the shares of a parcel at the same time to secure sole ownership. Furthermore, parcels did not appear to be selected for development randomly. Developers tended to favor larger parcels with fewer joint-owners over smaller parcels with many joint-owners.

Cunningham (2013) studied the sales prices of properties transacted between 1991 and 2007 in Seattle, Washington, USA. During that time period, the city experienced a rapid increase in land prices. A total of 92 instances of land assemblage were identified in which 151 parcels were sold 214 times within 3 years prior to redevelopment. Land bought in the process of a successful assembly commanded a price premium of 18 percent. Brooks and Lutz (2016) examined the land assembly in Los Angeles and found that assembly land sells at a 15–40 percent premium relative to non-assembly land. Furthermore, a 10 percent increase in the size of a parcel increases the probability of it being assembled at some point in the future by 0.1 percent. In the most recent study, Lindenthal et al. (2017) examine land assembly in Amsterdam over a period of 183 years. It is found that small lots and lots with suboptimal shapes are more likely to get redeveloped. In addition, social ties by sharing a joint religion or profession between owners increase the odds of land redevelopment.

To put land assembly in a wider policy context, Heller (1998) ascribed the slow reconstruction of Kobe after its catastrophic earthquake in 1995 to the blockage of some land owners. The prevalence of overly small land parcels were said to be created by the land laws enacted after World War II. Sim et al. (2002) offered the experience of how Singapore averted the tragedy of the anticommons. Before the introduction of the Land Titles (Strata) Act of 1999, all owners in the estate or building had to agree for an en bloc sale to go through. Naturally, the 100% consent requirement was fairly difficult to achieve. It also posed problems in redeveloping land to cater to the housing needs of a dense population. The new 1999 Act replaced the unanimous rule with a majority rule in which a respective 90% and 80% of owners need to agree to the en bloc sale for a development project that is less than and more than 10 years old, respectively. In the case of the Kim Lin Mansion project, which was blocked by three owners, the Act resolved the objection and helped release 88 million dollars to be shared by the owners. Despite possible controversy over minority protection and attenuation of property rights, the authors argued that the availability of private housing for the majority should take precedence in land-scarce Singapore. Zhu (2012) examined the urban development of Ho Chi Minh City, Vietnam. Zhu argued that the city's current unsustainable form of development primarily stems from fragmented land holdings in a densely populated area. A typical plot of allocated housing land in the city is a 30–50 square meter rectangle, 3.5–4.5 meters wide and 10–15 meters long. The constraint of a very small building site, coupled with the preference to self-build, led to the prevalence of 1- or 2-story low rises with site coverage as high as 80–90%.

The concern involved with the failure of land assembly is that a value-enhancing activity that could leave every party better off than the status quo will fail to occur as a result of strategic holdout behavior and other transaction costs. In other words, the market produces too little land assembly. In consequence, some parcels are misallocated to suboptimally dense uses (Brooks and Lutz, 2016). Where rights over land are fragmented, land tends to be underused in the sense that if it were assembled for redevelopment, it would be worth more than enough to fully compensate all the original owners for giving up their property (Shoup, 2008). In other words, the anticommons tragedy is plausible only when good substitutes are rare or absent. When no good substitutes are available in land assembly, the structure of bargaining among players is in spirit similar to the bilateral monopoly (Cohen, 1991). From the efficiency perspective, the difficulties associated with assembling small parcels into a large one also hinder the materialization of the economies of scale in production.

Review of past studies on land assembly suggests that assembly of numerous contiguous parcels is commonplace in cities, particularly in old neighborhoods where redevelopment is in great demand. Although small and large landowners are mentioned in passing in many studies, they are often not rigorously defined. If a small land owner is defined as one whose parcel is too small in itself for an economically viable development, land market in Taipei would be overwhelmingly dominated by small land owners. In this regard, supply of land for those small land owners is an all-or-nothing decision (Evans, 1986). Small land owners would either sell all their land or not sell at all. Prevalence of small land owners will greatly direct market outcome towards one in which large-scale development is difficult to take place.

All in all, if the arguments of land assembly and anticommons are valid, assembly of small parcels into a larger and developable one will be difficult. In other words, one shall observe that larger development sites tend to be ones resulting from assembly of smaller ones. Also, the size of developed parcels tends to be larger than that of undeveloped ones. Finally, the assembly activity tends to have taken years, likely through a series of acquisition of small sites. In order to empirically examine the predicted phenomenon, we first look at the new residential development sites across Taipei City to identify the rationale behind determining the sizes of development sites. This macro-city-wide study is followed by a micro-neighborhood study. We select one of the oldest neighborhoods in the city to detail the process of land reconfiguration and its relation to later development. It is hoped that additional

empirical evidence of land assembly will facilitate further dialogue on its consequences and possible policies.

3. Size determinants of residential development sites across Taipei City

Taipei city adopts a land use zoning system in which all parcels of land are located in a specified zone such as residential, commercial, industrial, administrative, educational and culture, infrastructure, and specific-purpose. (Department of Urban Development, Taipei City Government http://www.udd.gov.taipei) The residential zone is further sub-zoned into Grade 1, 2, 3 and 4. The allowable development density is lowest in Grade 1 and highest in Grade 4. The site coverage ratios for Grade 1–4 are 30%, 35%, 45% and 50%, respectively. The floor area ratios for Grade 1–4 are 60%, 120%, 225% and 300%, respectively. Taking a site of 100 m^2 in Grade 3 as an example, a maximum of 45 m^2 of the site can be covered by buildings and the total floor spaces on this site cannot exceed 225 m^2. The ceilings on the two ratios in turn set a limit on the height of a building. Besides, the height of a building also cannot exceed 1.5 times the combined width of the road in front of the building and its front yard.

In addition to limits on development density, there is also restriction on allowable conforming uses. Non-residential conforming uses are not allowed in Grade 1, but a group of pre-specified industrial and commercial uses are allowed in Grades 2, 3 and 4. In principle, the restriction on allowable non-residential conforming uses in Grade 4 are least restrictive, and the degree of restriction rises in Grade 3 and then further higher in Grade 2. The land use zoning hierarchy is in an inclusive (mixed-use) instead of exclusive form.

Over the years, residential development in Taipei exhibits two distinct patterns. Development projects in the city outskirts tend to be larger in size and a noticeable percentage of them are located in the government-initiated development areas such as land readjustment or zone expropriation (Land Development Agency, Department of Land Administration, Taipei City Government https://www.lda.gov.taipei/cp.aspx?n=D2E1D9AEA59A9979) In contrast, development projects in the inner city tend to be smaller in size. Besides, land development at the inner city, compared to those in the outskirts, tends to occur on previously developed sites. (Lin, 2014: 252)

Land designated for Grade 3 residential use is the primary source of residential development sites. For an individual site in Grade 3 residential zone to be able to develop, the minimum width and minimum depth of this site are 4.8 m and 9.6 m, respectively. The average size of Grade 3 residential development sites in Taipei fluctuated between 1994 and 2015 (see Table 1). However, land assembly activity seems to always be in place and intensifies, as evidenced by the gradual widening gap between the smallest and largest sites.

Residential development projects built on Grade 3 zone are identified through records of building use permits of Taipei City. The record of building use permit consists of information regarding the year of construction, location of the building site, land use zone, total floor areas and type of building, among others. Whether a building is along a major road is determined by the postal address. In addition, the distance to the nearest metro station is measured on the digitized map of the road networking provided by the Ministry of Transportation and Communications through ArcGIS.

It is believed that the size of residential development sites is a rational decision. A number of possible factors are therefore proposed to empirically test the underlying determinants. First, the value of land affects site size for residential development. The site size is expected to be smaller when land is pricey. Lin and Jhen (2009) estimated that the land value accounted for approximately as high as 75% of the total value of residential properties in Taipei. Cost of land is naturally a major concern in determining the size of a development site. The huge amount of money needed for purchasing a large parcel of land will be a constraint. Due to the lack of information of market price of the sites, we use the assessed present land value per square meter as the proxy variable. Every parcel of land in Taiwan is assessed every year for the purpose of taxing land value increment tax upon land transactions. The assessed value tends to be lower than the market price. But the former remains a certain percentage of the latter. For a residential development project in which more than one parcel is involved, the highest assessed value among those parcel is used for this variable.

Also, locational factors shall be considered when a site size is determined. We select two location-related variables; they are, respectively, if a site is along a major road and the accessibility to the nearest metro station. According to Land Use Zoning Codes of Taipei City, retailing activities are allowed on the lower floors of a building that is within Grade 3 residential zone and along a major road. The potential use of a site for commercial activities likely incentivizes the developers to acquire a larger site along the major road to exploit the economies of scale in site size. We therefore classify the development projects front on to a road with the width of eight meters or above as one along a major road. The majority of development projects not along a major road are located behind the roads. In addition, an easy access to metro stations is appealing to house buyers in Taipei. Recent studies (Oliver et al. (2013); Shyr et al. (2013) and Chiang et al. (2017), along with many prior ones reconfirmed the noticeable effects of the distance to metro stations on house prices. Despite of the apparent impact of metro station accessibility, we are not certain if the distance will affect the size of development site in a positive or negative way. On the one hand, developers are expected to seek a larger site near the metro station to exploit the benefits of accessibility. On the other hand, the price premium demanded for land closer to a metro station sometimes forces developers to downsize the development site. In consequence, the final size effects of the distance to the nearest metro station remains to be seen empirically.

Factor that are of particular interest to this study is the effects of

Table 1
Size Distribution of Grade 3 Residential Development Sites in Taipei over Time.
Source: Land Administration Dept., Taipei City government.

Years	Average Size (in m^2)	Minimum	Maximum	Years	Average Size (in m^2)	Minimum	Maximum
1994	504.06	66.41	1692.00	**2005**	682.88	114.00	2710.00
1995	550.66	88.78	1844.00	**2006**	624.71	115.00	2014.00
1996	547.93	83.00	1833.28	**2007**	590.25	79.81	2089.03
1997	541.12	66.13	2096.00	**2008**	686.96	91.00	2453.98
1998	421.63	81.00	2175.82	**2009**	653.37	80.00	2267.00
1999	432.73	43.21	1422.00	**2010**	539.47	71.00	1795.00
2000	642.46	91.00	2102.00	**2011**	575.10	75.00	2189.30
2001	550.97	86.00	1816.00	**2012**	675.67	79.00	2460.00
2002	618.20	119.47	1986.12	**2013**	837.33	66.90	3300.00
2003	540.14	57.00	1800.00	**2014**	660.29	98.00	4924.00
2004	771.00	122.00	2521.00	**2015**	877.55	71.00	9026.91

fragmentation of land parcels on the size of development site. Based on the anticommons argument that highlight the difficulties with assembling land, we propose that development sites will be smaller if they are located in areas where land ownership is fragmented. Based on the cadastral maps, we classify 12 administrative districts of Taipei into four categories in terms of the fragmentation degree of land ownership. Type 1 represents the districts (Neihu, Nangang) where the average site size is the largest. Type 2 (Shilin, Beitou, Wenshan), Type 3 (Xinyi, Zhongshan, Songshan, Daan) and Type 4 (Zhongzheng, Wanhua, Datong), respectively, represent the districts in which the average site size is in the order of second largest, third largest, and finally the smallest. Another land fragmentation-related variable is the number of land parcels involved in a development site. It is expected that more parcels would be needed for a larger-scale residential development. Lin (2005) provided one of the few empirical pieces that depicted the process of assembly of small land parcels into a large one for later industrial and residential development. Even though Lin's study area is located on the outskirts of Taipei, the need for land assembly is anticipated to be even greater in the old parts of the city.

In addition to those micro-factors, the size of development sites might also change in response to the macro-factors that are often correlated with the time trend. In order to control for the time effects, we follow Colwell and Scheu (1989) to add a variable of development year less year 1994 to indicate the time span.

Table 2 provides the summary statistics of 2308 sample sites in Grade 3 residential zone for all variables analyzed in the regression model. The development sites across the city vary widely with the largest site being more than 200 times the smallest site. Similar phenomenon applies to assessed land value with significant variation among development sites. Besides, slightly less than one quarter of the sample sites are along the major roads.

As for the standard check of regression model, no multicollinearity between independent variables is found with the test of variance inflation factor. Also, heteroscedasticity is detected and White's heteroscedasticity-corrected standard errors (Gujarati, 2003: 417) are employed. Results of regression analysis are shown in Table 3. It is not too surprising that adjusted R^2 is not high. Compared to land pricing or bargaining strategies between developers and land owners in the context of land assembly, the theory of determining the size of development sites is under-developed. It will need some time for a satisfactory theory to come out.

The assessed land value seems not to bear relationships to the size of development sites. This is likely because the assessed value is not updated in time to reflect the current market level, or fails to account for some parcel-related factors. The development sites along a major road are 20.5%, equivalent to 139 m^2, larger than those sites behind roads. In addition, development sites tend to be smaller when closer to metro stations. With regard to the factor of ownership fragmentation, the trend is clear. Compared to Type 4 districts, where land ownership is the most fragmented (average site size is the smallest in the city), the development sites in Types 3, 2, and 1 districts are larger by 11.9% (78 m^2), 31.1% (217 m^2) and 59.1% (489 m^2), respectively. In addition, development sites will on average become larger by approximately 9% if one more land parcel is included. Finally, the size of Grade 3 residential development sites has been on the rise over time since year 1994. All in all, the size of Grade 3 residential development sites is a rational decision, in which locational factors and conditions of individual parcels (land fragmentation and parcels involved) are major determinants.

One set of variables that shall be included but are missing in the present regression model are those associated with the price of housing and its production costs. Land is one of the production factors and therefore the demand for it is a derived demand. The demand for land comes from the demand for housing. The decisions regarding how large a development site is and how much shall be paid for the site is dependent on the sales price of housing and the construction costs invested. Unfortunately, that sort of data are not available. But luckily, the data gap can soon be partially filled by the mandatory registration of transaction prices for real estate introduced in August 2012 that has profoundly increased the transparency of property market in Taiwan. (Jones Lang LaSalle, 2016)

Table 2
Summary Statistics of Variables Employed in Regression Model.

	Minimum	Maximum	Average	Standard Deviation
Size of Development Site (m^2)	43.21	9,026.91	603.55	547.98
Assessed land value / m^2(dollars)	17,500	455,535	125,078.3	47,144.51
Along major road (yes = 1, no = 0)	0	1	0.23	–
Distance to metro station (m)	32.13	10,596.46	1,337.92	1,709.81
Type 1 districts	0	1	0.13	–
Type 2 districts	0	1	0.42	–
Type 3 districts	0	1	0.31	–
Type 4 district	0	1	0.14	–
No. of Parcels involved	1	38	2.91	3.01
Development year- 1994	0	21	10.06	6.27

Table 3
Size Determinants of Grade 3 Residential Development Sites.

Dependent variable	ln (site size)		
Independent variables	Non-standardized coefficients	t-value	p-value
Constant	6.295	9.159	0.000***
ln (assessed land value)	−0.071	−1.207	0.228
Along the major road	0.205	5.651	0.000***
Inverse of distance to the metro station	−17.500	−2.200	0.028**
Type 1 districts of land fragmentation	0.591	9.112	0.000***
Type 2 districts of land fragmentation	0.311	6.388	0.000***
Type 3 districts of land fragmentation	0.119	2.585	0.010***
No. of land parcels involved	0.093	16.474	0.000***
Year-1994	0.009	3.255	0.001***
Adjusted R^2	0.231		
Observations: 2308			

Note: ***, **, * indicates significance level of 1%, 5%, and 10%, respectively.

4. Reconfiguration of land parcels – Wanhua train station areas

The regression analysis of size determinants of Grade 3 residential development sites has evidenced, although implicitly, the significance of land assembly activity in Taipei as a whole. However, this activity is expected to be more intense and frequent in the old parts of a city where is the major concern of this study. We, therefore, look into the neighborhood of Wanhua train station (see Fig. 1) in the Wanhua district to provide detailed information as to how land parcels are reconfigured in relation to their later development.

The history of Wanhua can trace back to at least 300 years ago and is the earliest developed areas of Taipei.(Taipei City Government http://tcgwww.taipei.gov.tw/ct.asp?xItem=1078966&ctNode=27846&mp=100002) The land of Wanhua is primarily zoned for residential (29.8%) and commercial (17.5%) uses. (Statistics of Areas for Various Land Use Zones, Department of Urban Development) The average housing age in Wanhua is 35.2 years as of 2015Q1. As of 2015, 48% of housing stock in Taipei is over 30 years old (Dept. of Budget, Accounting and Statistics, Taipei City Government). The Taipei City

Fig. 1. Wanhua Train Station Area.
Source: Image map provided by Taiwan MAP service

Government identified 4- to 5-story buildings that were over 30 years old as the main targets of urban regeneration. Besides, Wanhua was ranked the last but one in terms of the number of development projects on Grade 3 residential zones between 1994 and 2015. (Construction Management Office, Taipei City Government https://dba.gov.taipei) Moreover, as of year 2014, the average size (90.79 m^2) of development sites in Grade 3 residential zone in Wanhua was the second smallest, only marginally larger than in Datong (88.14 m^2). (Department of Land Administration, Taipei City Government). All pieces of evidence suggest that land redevelopment is urgently needed in Wanhua where land fragmentation is however also most severe.

Wanhua train station area was where Taipei first developed. This area has nevertheless witnessed long-term deterioration, and the city government has endeavored to revitalize this area. The stated purposes of the redevelopment plan of the Wanhua rail station area announced by the city government in 1997 was "…to raise living standards, implement urban regeneration, and stimulate local redevelopment." The Wanhua train station area is one of the earliest developed neighborhoods in the city, and thus serves an ideal area to examine the process of land reconfiguration to meet future needs. This study area is composed of a total of 39.5 ha in size. Approximately 23 ha are allocated for development, and the remaining land is occupied by public facilities such as roads, a train station, and the famous Lungshan temple.

Registration of title and interest to land and any consequent changes is compulsory in Taiwan. Article 85 of Regulation of The Land Registration reads: "If there is any partition, consolidation, augmentation, diminution, or changes of land category and any other changes of descriptions after the general registration of land, the registration of the change in land descriptions shall be undertaken." The official records of title registration in land therefore provide a reliable source for us to trace the ownership transition over time. Despite this high-quality and reliable data, the digitalization of registration documents in 1988 instead resulted in the tracing of historical data difficult and time-consuming. Besides, data very early back might not be as accurate it may be today. After consultation with the staff of the local land office, we decided to focus on the ownership transition between 1970 and 1988.

Table 4 shows the changes in number and average size of plots over time in the study area. The noticeable fall in the number of plots and the rise in the average size of plots in 1977 are likely attributable to the resurveying of the cadastral map undertaken that year. Article 193 of the Regulation of Land Cadastre Surveying reads: "The owner of abutting plots with similar land use can apply to have them merged into a single plot under sole ownership." We actually found a number of title documents that record this type of site merger in accordance with this regulation. Over the course of the study, with the exception of the year immediately following the implementation of cadastral resurveying, the average plot size declined. Ownership in land seems to have been in a long-term process of fragmentation.

In order to understand the changes in the distribution of parcel sizes, we employ the concept of the Gini Coefficient, which is often used to measure the (in)equity of income distribution. Chao (2002, 2008) also employed the Gini Coefficient to examine the historical changes in China's farmland distribution among the population. How land is assembled or partitioned is a concern in an effort to understand how land is later developed. Values of the Gini Coefficient over time (Table 5) clearly indicate a long-term increase in the inequity of size distribution over land parcels. The values of the Gini Coefficient were on a rise, except in 1977 when cadastral resurveying took place. The increasing dispersion of plot sizes suggests frequent assemblage and partition of land.

It is now understood that distribution of parcel sizes is constantly changing, which implies land reconfiguration activity. We are primarily concerned with how the reconfiguration of land parcels relates to later land development. We further divide all parcels into two groups of developed and undeveloped parcels. In order to classify land parcels in terms of development status, we correlate registration record of land titles with building use permits both supplied by the Taipei City Government. All changes of land titles are required by law to register with the local land administration office. The title registration is mandatory so as for the land ownership to be legally protected. Besides, it is required by Article 28 of the Construction Law that all new buildings need to be registered with local governments, and subsequently granted use permits after inspection at the time of completion. Parcels that are listed in the building use permits are classified as developed parcels and others as undeveloped parcels. We are confident about the credibility of government provided data. We however run a risk of classifying developed parcels as undeveloped ones for buildings built prior to year 1948. Given that an average economic life of buildings in Taipei is approximately 35 years (Lin, 2014: 251), we expect errors thus possibly caused not to be significant. Another potential bias of misclassification comes from illegal buildings without use permit. We however lack such information to correct for possible bias.

Until 1988, the majority (57.54%) of developed parcels fell within the size range of 100 to 400 m^2. In contrast, as high as 84.56% of undeveloped parcels were smaller than 100 m^2 (Table 6). The size distribution of developed and undeveloped parcels appears to be different. Moreover, the size of developed parcels tends to be larger than that of undeveloped parcels. There are two possible explanations for the larger size of developed parcels. Developers may either purchase a larger parcel, or buy contiguous smaller parcels (land assembly). This finding corresponds with that of Lin (2005) but in a rather different context. Lin came to that conclusion in a case study of land readjustment project in the outskirts of Taipei. In contrast, this study observes a similar phenomenon but in a declined old part of Taipei. Put together, the activities of land assembly seem to exist everywhere of Taipei. No matter in outskirts or old part of the city, developers seem to avoid assembling parcels, particularly when many parcels are required, due to the heavy costs involved in negotiating with numerous land owners.

Table 7 shows the project number, and the frequency of land assembly and land partition, respectively, over different size scales of residential development. Reconfiguration of land parcels prior to development was dominated by land assembly. For parcels developed during the study period, a total of 799 size changes occurred, including 627 land assembly changes and 172 land partition changes. More than half of the 267 development projects are under 300 m^2. New developments in this area are dominated by small-scale projects. Furthermore, for plots up to 600 m^2, the frequency of land assembly increases with plot size. More plots need to be assembled for a larger development project. To acquire a plot of 501 to 600 m^2 for development, 6.25 times of plot assemblage are required.

Table 4
Changes in Plot Distribution over Time in Study Area.

Year	Plot Number	Average Size (m^2)	Standard Deviation (m^2)	Year	Plot Number	Average Size (m^2)	Standard Deviation (m^2)
1970	2,838	80.36	187.73	**1980**	2,281	100.35	217.08
1971	2,839	80.38	187.70	**1981**	2,333	98.06	213.46
1972	2,840	80.35	187.67	**1982**	2,351	97.28	208.24
1973	2,841	80.37	187.64	**1983**	2,465	92.83	200.30
1974	2,867	79.49	185.86	**1984**	2,498	91.53	198.84
1975	2,916	78.04	182.47	**1985**	2,550	89.71	194.93
1976	2,959	76.93	173.45	**1986**	2,572	88.96	189.84
1977	2,247	101.78	217.57	**1987**	2,589	88.38	189.10
1978	2,267	100.94	216.30	**1988**	2,621	87.34	185.35
1979	2,280	100.29	215.76				

Table 5
Gini Coefficients of Distribution of Plot Size over Time.

Year	Gini	Year	Gini	Year	Gini
1970	0.5978	1977	0.5664	1984	0.6006
1971	0.5980	1978	0.5653	1985	0.6063
1972	0.5972	1979	0.5672	1986	0.6153
1973	0.5993	1980	0.5712	1987	0.6195
1974	0.5974	1981	0.5783	1988	0.6277
1975	0.5964	1982	0.5800		
1976	0.5989	1983	0.5970		

On average, every developed parcel went through an assemblage or partition of land 2.99 times. From the title registration records, we also find, that the average time between land size changes to be 6.35 years. Besides, a total of 51,506 m^2 of land was developed during the 19-year study period, and 153,939 m^2 remained to be developed. Given these figures, the whole Wanhua train station area will take 76 years to complete its development, far longer than the typical life span of a building in the city.

5. A dismal future?

Housing prices in Taipei have been soaring to an exceedingly unaffordable level. Most critics have placed blame on the demand-side for the oversupply of capital seeking investment opportunities. This is certainly true, but it also seems to be only a partial explanation. For the high price of a good or asset, demand and supply factors are both at play. In recent years, stringent land use regulations are argued to be responsible in some US cities for their unsustainably high housing prices. This is a supply-side explanation. We would like to add one more supply-side argument; that is small and fragmented land parcels partially account for a high housing price phenomenon, at least for a densely populated city such as Taipei.

With the macro- and micro-empirical evidence presented in this paper, we also hope that readers are convinced that the tragedy of anticommons in land likely exists in Taipei. It is found that both across the city, and in the Wanhua train station area, larger development sites tend to result from the assembly of smaller parcels. Also, in the Wanhua train station area, a representative case for old neighborhoods, the developed parcels tend to be larger than the undeveloped ones in size. Finally, the assembly activity tends to be time-consuming. The time needed for redevelopment by market forces far exceeds the time horizon that a typical urban plan can possibly foresee. The amalgamation of small parcels into a larger one is always taking place, however, at a fairly slow pace. The costs therefore incurred will feed into the high housing price together with other demand-side factors. It is expected that the slow adjustment of site size will eventually adversely affect the development and the economy of the city.

Table 7
Frequency of Land Assembly and Partition prior to Development.

Size of Development Sites (m^2)	No. of Projects	Average Experienced Assembly Frequency (times)	Average Experienced Partition Frequency (times)
Below 100	61	0.51	0.31
101-200	88	1.25	0.35
201-300	38	3.39	0.66
301-400	22	4.05	0.86
401-500	12	4.42	1.17
501-600	12	6.25	1.25
601-1000	17	4.65	1.59
1001-2000	12	4.17	1.08
Above 2001	5	2.20	1.80

Heller (1998) was convinced that once anticommons property is created, it is difficult to find a way out. Neither markets nor governments may be able to rebundle anticommons into usable private property. He proposed that one path to well-functioning private property is to convey a core bundle of rights to a single owner. Even if fragmentation of rights is allowed, numerous safeguard mechanisms shall be in place to ensure that rights can be rebundled and the property can be put to use within a reasonable period. Housing price is susceptible to how land is supplied. For a city where land parcels are small and land ownership is fragmented, its supply of land is almost bound to be inelastic and slow in adjustment. Difficult as it may be, demand-side problems of housing prices might be overcome through monetary or fiscal policies. However, what makes this supply-side ownership issue a concern for policy is that any coercive measure to force owners to sell their parcels or to merge them with others is fairly impractical. The tension between the tragedy of anticommons and the respect of private land rights seems to be difficult, if not impossible, to resolve. Sensible policies are therefore urgently called for.

One reviewer regards our conclusion fairly pessimistic and suggested we offer some possible solutions. In principle, three policy measures are available to redevelop an area; they are, respectively, compulsory purchase, land readjustment and urban regeneration. In most countries and Taiwan is no exception, the requirement for the use of compulsory purchase is rather strict. This power is primarily

Table 6
Size Distribution of Developed and Undeveloped Parcels.

Size (in m^2)	Under 100	101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-1000	1001-2000	Above 2001
Developed (%)	23.41	35.71	12.7	9.13	4.76	3.57	2.78	0.79	1.19	1.19	3.57	1.19
Undeveloped (%)	84.56	11.45	1.65	0.6	0.14	0.37	0.27	0.14	0.14	0.23	0.37	0.09

exercised to acquire sites for public use, such as schools, hospitals, roads and etc. Wanhua even though is an old area and demands further investment, its public infrastructure is not significantly lagging behind other parts of the city. Largely because it was developed early, substantial amount of public money was invested there. What Wanhua needs is the upgrading of existing infrastructure. Moreover, the problem of fragmented ownership in land identified in this paper cannot be solved through compulsory purchase.

In regards of consolidating fragmented ownership and irregular shape of land parcels, a high hope is placed on land readjustment. (Hong and Needham, 2007). The difficulties with land development are largely solved in that the location and shape of land parcels are readjusted to fit the plan of future development. Land readjustment in Taiwan was successful in the era of rapid urbanization in accommodating the massive flow of industry and population into the cities. However, both of the number and scale of land readjustment projects in Taipei have declined in recent years. The city has passed its time of rapid growth. Also, the new projects mainly occur in the city outskirts. One feature of land readjustment is the contribution of part of private land to the government to provide public infrastructure. The possibility of contributing land hinges on the expected rise in land value after readjustment. (Lin and Ding, 2018: 176) In Taiwan, land readjustment often went hand in hand with upzoing and the readjustment area saw a significant rise in land value. Nevertheless, Wanhua is already a highly urbanized area that leaves very little room for rezoning for an even higher dense land use.

Finally, a better way of putting Wanhua in perspective might be through urban regeneration. In his study of urban growth of Taipei, Lin (2014) came to a somewhat dismal conclusion. Lin found that the developers are not in favor of the regeneration areas designated by the government, even though some incentives are offered. The city government wishes to see more urban regeneration occur in the old part of Taipei in which Wanhua is part of them. Despite of the policy incentive such as floor bonuses, developers are instead most interested in expensive central districts. They are areas where urban regeneration would likely take place even if without policy incentive. In conclusion, urban regeneration policy in Taipei has to a large extent reinforced the market trajectory, not altered it.

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References

Brooks, L., Lutz, B.F., 2016. From today's city to tomorrow's city: an empirical investigation of urban land assembly. Am. Econ. J.: Econ. Policy 8 (3), 69–105.
Buchanan, J.M., Yoon, Y.J., 2000. Symmetric tragedies: commons and anticommons. J. Law Econ. 43 (1), 1–14.
Chao, K., 2002. Farmland distribution in traditional China. Chin. Stud. 20 (1), 441–452.
Chao, K., 2008. Land distribution in traditional China. Chin. Stud. 26 (4), 311–320.
Chiang, Ying-Hui, Chuang, Yu-Ting, Chang, Chin-Oh, 2017. The impact of public bike station on residential housing price in Taipei City. Transp. Plan. J. 46 (4), 399–428 (in Chinese).
Cohen, L., 1991. Holdouts and free riders. J. Leg. Stud. 20 (2), 351–362.
Colwell, P., Munneke, H., 1999. Land prices and land assembly in the CBD. J. Real Estate Finance Econ. 18 (2), 163–180.
Colwell, P.F., Scheu, T., 1989. Optimal lot size and configuration. J. Urban Econ. 26 (1), 90–109.
Cunningham, C., 2013. Estimating the Holdout Problem in Land Assembly. Federal Reserve Bank Atlanta Working Paper No. 2013-19.
Evans, A.W., 1986. The supply of land: a pedagogic comment. Urban Stud. 23 (6), 527–530.
Evans, A.W., 1991. Rabbit hutches on postage stamps': planning, development and political economy. Urban Stud. 28 (6), 853–870.
Glaeser, E., Gyourko, J., 2005. Why Is Manhattan so expensive? regulations and the rise in housing prices. J. Law Econ. 48 (2), 331–369.
Glaeser, E., Ward, B., 2009. The causes and consequences of land use regulation: evidence from Greater Boston. J. Urban Econ. 65, 265–278.
Gujarati, D., 2003. Basic Econometrics. McGraw-Hill, Singapore.
Heller, M., 1998. The tragedy of the anticommons: property in the transition from Marx to markets. Harv. Law Rev. 111, 621–688.
Hong, Yu-Hung, Needham, Barrie (Eds.), 2007. Analyzing Land Readjustment: Economics, Law, and Collective Action. Lincoln Institute of Land Policy, Cambridge.
LaSalle, Jones Lang, 2016. Global Real Estate Transparency Index- Taking Real Estate Transparency to the Next Level.
Lin, T.C., 2005. Land assembly in a fragmented land market through land readjustment. Land Use Policy 22 (2), 95–102.
Lin, T.C., 2014. Land development and urban growth in a booming property market: the Taipei experience. In: Aveline-Dubach, Natacha, Jou, Sue-Ching, Hsiao, Hsin-Huang Michael (Eds.), Globalization and New Intra-Urban Dynamics in Asian Cities. National Taiwan University Press.
Lin, Tzu-Chin, Ding, Hsiu-Yin, 2018. Urban land redjustment. In: De, Souza, Francisco, Felipe, Ochi, Takeo, Hosono, Akio (Eds.), 2018. Land Readjustment- Solving Urban Problems Through Innovative Approach. Japan International Cooperation Agency Research Institute, Tokyo, pp. 175–179.
Lin, T.C., Evans, A., 2000. The relationship between the price of land and size of plot when plots are small. Land Econ. 76 (3), 386–394.
Lin, Tzu-Chin, Jhen, Min-Hua, 2009. Inequity of land valuation in the highly developed City of Taipei, Taiwan. Land Use Policy 26 (3), 662–668.
Lindenthal, T., Eichholtz, P., Geltner, D., 2017. Land assembly in Amsterdam, 1832-2015. Reg. Sci. Urban Econ. 64 (May), 57–67.
Oliver, Shyr, Andersson, David, Emanuel, Wang, Jamie, Huang, Taiwei, Liu, Olivia, 2013. Where do home buyers pay most for relative transit accessibility? Hong Kong, Taipei and Kaohsiung compared. Urban Stud. 50 (12), 2553–2568.
Shoup, D., 2008. Graduated density zoning. J. Plan. Educ. Res. 28 (2), 161–179.
Sim, L.L., Lum, S.K., Malone-Lee, L.C., 2002. Property rights, collective sales and government intervention: averting a tragedy of the anticommons. Habitat Int. 26 (4), 457–470.
Tabuchi, T., 1996. Quantity premia in real property markets. Land Economics 72 (2), 206–217.
Zhu, J., 2012. Development of sustainable urban forms for high-density low-income Asian countries: the case of Vietnam: the institutional hindrance of the commons and anticommons. Cities 29 (2), 77–87.