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ANALYSIS OF TAX ASSESSMENT BY ASSEMBLY AND PROPERTY DEVELOPMENT ACTIVITIES IN FRAGMENTED URBAN LANDS – GWANGJIN DISTRICT, SEOUL, SOUTH KOREA

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Abstract. Due to the land readjustment project in Gwangjin District, Seoul, Korea, in the 1970s, Gwangjin was characterized as a single-family residential area for individual households. Over the following 40 years, the land-use situation changed dramatically, and ironically, there is now a too-fragmented residential area and very insufficient commercial areas. We employed a balanced panel data analysis. The data for this study were 24,177 parcel tax assessments and land assembly, split, zoning change, and property development activities over nine years from 2011 to 2019. We found that de facto land assembly would affect the tax assessment by delaying it a year more than it is when the development is approved, while formal land assembly did not. Development activity itself increased the assessment for that year only. Finally, formal land assembly in the commercial zone increased the assessment only for the following year, while property development in the residential zone increased the assessment for that year only. We recommend that the government provide land-assembly-friendly policy incentives to allow for much larger property developments in both residential and commercial zones. The research on land and property development activities' impact on tax assessment can provide a reasonable basis for the government's tax assessment institution building.

Keywords: fragmentation, land assembly, property development, zoning, panel analysis, policy incentives.

Introduction

Due to the land readjustment (LR) project of the Seoul metropolitan government in the 1970s that aimed to accommodate rapid industrialization and the resultant urbanization, the massive district-wide land readjustment of Gwangjin District was completed as a single-family dwelling area for individual households, with an average parcel area of 100–160 m^2 (Lee, 2009). Figures 1 and 2 show the location of Gwangjin District and the results of the land readjustment project, respectively. Over the next 40 years, the land-use situation changed dramatically, and the scale of the commercially used area, which is now of a strip mall type, also expanded alongside the road under strict zoning regulations (Kim, 2013).

There are few studies in the literature on the impact of land assembly, split, and property development on the tax assessment of urban land parcels in an integrated manner. The tax assessment is the bottom line for both property tax and just compensation after eminent domain decisions, as well as the investment appraisal of land when investing in real estate property.

The data in this study were gathered by tracking tax assessments and land assembly, split, and property development activities of 24,177 parcels over 9 years beginning in 2011, using a balanced panel of a total of 217,593 (parcel * year) observations. Land activities refer to both land assembly and split activities; property development activities included only new construction, and thus, additions to existing buildings and the remodelling of existing buildings were excluded.

In this paper, we investigate the tax assessment via panel analysis, especially on the land activity-focused research questions: How is the tax assessment determined on the condition of formal land assembly, de facto land assembly, and property development approval? Do those activities increase the tax assessment in a statistically significant fashion? How long do these positive effects persist? What are the different effects if developers choose between formal land assembly and de facto land assembly when

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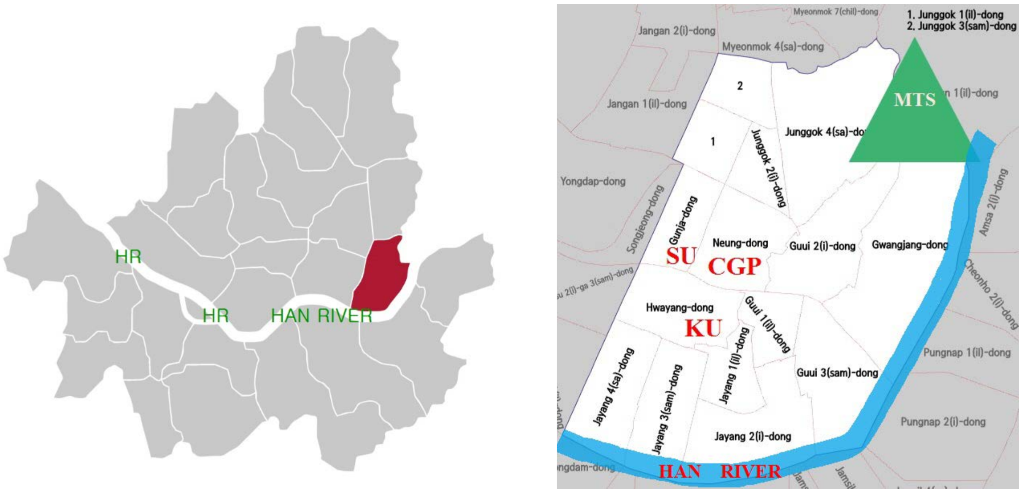

Figure 1. Gwangjin District, Seoul, Korea: (left) Kurykh and Anwoosuk; (right) Gwangjin District. MTS: mountains; SU: Sejong University; CGP: Children's Grand Park; KU: Konkuk University; HR: Han River

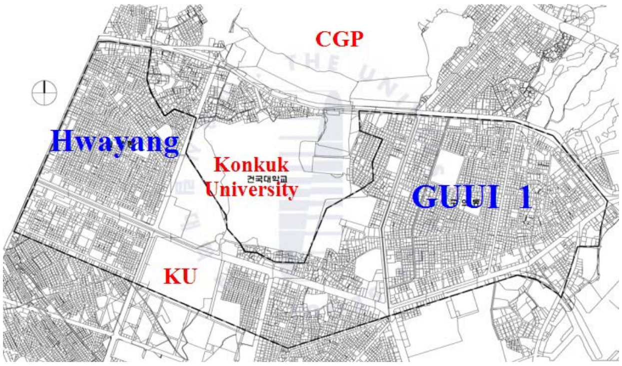

Figure 2. The land readjustment (LR) project in the early 1970s of Hwayang and Guui 1 towns (and surrounding areas), Gwangjin District. KU: Konkuk University; CGP: Children's Grand Park (source: Lee, 2009)

developing their property? How is the entire research area different from the nearby subway station? How can the local government provide helpful incentives to the local developers and also effectively capture the increasing value from the incentives?

We employed a panel data analysis, especially a fixed-effects model with a cluster-robust standard errors specification, as in Wooldridge (2009) and Petersen (2009).

We found that the de facto land assembly would affect the tax assessment by delaying it a year more than it is when the development is approved. Development approval itself increased the assessment for that particular year only. Finally, formal land assembly in the commercial zone increased the assessment of the assembled whole land only in the following year. We recommend that the government provide land-assembly-friendly policy incentives (e.g., a combination of upzonung and value capture) to allow for much larger property development in residential and commercial zones. Moreover, we need stricter regulations on de facto land assembly to establish a more transparent title ownership institution.

Our fully integrated study on the impact of land assembly, split, and property development activities on tax assessment can directly provide a reasonable basis for building the government's tax assessment institution in Korea. In addition, our findings can be used by urban planners for their urban planning endeavours. In practice, property developers and investors can improve their knowledge of urban land activities and make better land assembly or split decisions, especially in the context of both transaction timing decisions and land valuations.

The remainder of the paper is organized as follows. Section 1 consists of the theoretical analysis and resultant research hypotheses. We introduce our data and estimation method in Section 2. In Section 3, we present the empirical results and discuss our findings with policy implications. The last section concludes the study.

1. Theoretical analysis and research hypotheses

1.1. Theoretical analysis

Broadly speaking, one of the classical theoretical concepts regarding optimal land use is the tragedy of the commons and remedies for the problems it causes (Coase, 1960). On the other hand, what is currently being studied, more importantly, is severely fragmented land in both urban and rural regions, such as the tragedy of the anticommons or symmetric tragedies (Heller, 1998; Buchanan & Yoon, 2000; Poelmans & Van Rompaey, 2009), and remedies for such problems, e.g., either land consolidation, land rearrangement, or land readjustment on a large scale (Lin, 2005; Muchová & Jusková, 2017; Zhou et al., 2022) or land assembly on a small scale for extremely fragmented urban lands (Eckart, 1985; Fu et al., 2002; Menezes & Pitchford, 2004; Louw, 2008; Brooks & Lutz, 2016; Isaac et al., 2016). There are two prominent studies regarding the coexistence of symmetric tragedies (Zhu, 2012; Turk et al., 2020).

Land readjustment activities are globally prevailing phenomena, such as in Japan (Masser, 1984; Sorensen, 2000), South Korea (Lee, 1987), Thailand (Archer, 1992), Taiwan (Lin, 2005), Europe (Muchová & Jusková, 2017; Lindenthal et al., 2017), China (Zhou et al., 2022), and Vietnam (Tran et al., 2022).

Archer (1992) defined land readjustment as "consolidating a selected de facto land assembly of land parcels" Isaac et al. (2016) defined land assembly as the "consolidation of two or more contiguous parcels". Menezes and Pitchford (2004) considered only two adjacent parcels of land, while O'Flaherty (1994) considered several parcels of land. Although Louw (2008) defined land assembly as "a transfer of land ownership from passive to active owners (e.g., developers)", we prefer Isaac et al.'s (2016) definition, which is "consolidating two to several contiguous parcels".

Land assembly in this study is distinct from land consolidation (i.e., rearrangement and readjustment), which is a large-scale land assembly project, while our study focused on a small-scale project among contiguous lands that did not cause major changes to the characteristics of the overall assembled land (Brooks & Lutz, 2016; Isaac et al., 2016).

In the current urban renewal situation, especially in cities in advanced countries, land areas are too fragmented or extremely hard to assemble in principle (Grossman & Hart, 1980; Field, 1992; Strange, 1995; Miceli & Sirmans, 2007; Brooks & Lutz, 2016).

Strange (1995) simply stated that the holdup power of the last seller tends to increase the land price. In addition, when an assembly is in progress, this news is shared among neighbouring parcel owners, resulting in a holdup. For this reason, assembly occurs at a suboptimal frequency (Glaeser et al., 2005).

Many researchers, from academics to policymakers, studied the phenomenon of a holdup to solve the problem regarding the suboptimality of assemblage (Fu et al., 2002; Isaac et al., 2016; Menezes & Pitchford, 2004); in particular, Turk et al. (2020) narrowly defined the optimal use of urban land as densification via vertical and compact development with more open space. The Commission of the European Communities (1990), Shoup (2008), and Brooks and Lutz (2016) also followed this line of thought.

Others discussed the obstacles to the optimal use of fragmented urban lands, such as public regulation and insufficient incentives, in addition to holdup (O'Flaherty, 1994; Strange, 1995; Glaeser et al., 2005).

Two other studies explored the characteristics of developers who need to assemble land parcels (Neutze, 1987; Gabbe, 2018). Neutze (1987) emphasized that individual parcel owners who are not members of specialized property development companies cannot develop a property on their own and also do not have the financial power to assemble nearby land parcels. Gabbe (2018) found that there are many different types of property developers in the urban renewal scene. Lee and Shin (2021) recommended a specific matching incentive design for each developer.

The last line of research regarding the highest and best use of fragmented urban land concerns incentives, such as density bonuses, incentive zoning programs, deregulations, and conversion incentives (Amin & Capozza, 1993; Tang & Tang, 1999; Lum et al., 2004; Shoup, 2008; Ahlfeldt & McMillen, 2015; Wang et al., 2022). In return for these incentives, value capturing (van der Krabben & Needham, 2008; Kim, 2020; Potsiou et al., 2022) and development impact fees (Delaney & Smith, 1989) were also seriously studied to balance the private benefit and the public cost.

The other related but distinct classical land economics analysis focuses on plottage and plattage. This concerns whether the shape of the land price function is concave or convex with respect to the size of the land area. In terms of empirical analysis, this line of research considers the price of the land parcel as a dependent variable and the area of the lot as the primary independent variable. These studies recommended either a land split or an assembly of urban lands to achieve the optimal land size (Isakson, 2013).

According to the general view, there exists an optimal area size point that is suitable for each use of space. The left-side region of the optimal size is advantageous if assembled since the land area is narrow compared with the optimal area size, while the right-side region is a situation in which the area is wider than necessary; therefore, a split is advantageous (Colwell & Sirmans, 1978; Colwell & Munneke, 1999).

In the case of the United States, the cost of a split (i.e., subdivision) is relatively expensive due to land improvement costs, such as infrastructure and utility facility installation costs, and there is an argument that large land areas are cheaper. This is concerned with the notion of plattage (Colwell & Sirmans, 1978).

On the other hand, Lin and Evans (2000) argued for plottage. In cities that are already quite fragmented (e.g., Tokyo and Taipei), the assembly cost is more expensive and, as a result, the assembled land should be more expensive (Tabuchi, 1996; Lin, 2005).

Our research area was Gwangjin District, Seoul, Korea. The situation was quite similar in appearance to that in Zhu (2012) and Turk et al. (2020) and, therefore, densification was a necessity rather than an option (Zhu, 2012).

1.2. Research area

Gwangjin District was one of 25 districts on the northeastern side of Seoul, the capital city of South Korea (Figure 1). Gwangjin District occupied an area of 17 km^2 with approximately 33,307 land lots and a population of 366,939 (21,585 people/km^2) as of 2015. This district consisted of seven towns. Among them, the Guui-Gangbyeon (in short, Guui) Station area (447,749 m^2) and the KU Station area (214,509 m^2) were, respectively, the 24th and 37th largest active subcenter areas in Seoul, South Korea (Yim & Lee, 2016). Although the KU station area, at 37th place in terms of area size, was relatively small in size, it was the third most active retail area in the northern part of Seoul. In short, Gwangjin was a seriously small, fragmented, and dense area in a fully developed urban metropolitan city. The latter example is paradoxical for land readjustment as it is normally considered an efficient tool for land to cause serious fragmentation (Lin, 2005; Kim, 2013).

This study mainly modelled both land assembly and property development in an integrated fashion. Although assembly has significant benefits, as shown below, in reality, it is not conducted as frequently as seems to be optimal. Assembly has a significant economic benefit, at least in Gwangjin. Gwangjin is already considerably urbanized, and like the United States, except for the holdup cost, the legal cost incurred by land assembly is minimal and virtually zero (Brooks & Lutz, 2016). In Seoul, Korea, an individual can apply to a government agency for a land assembly permit and, subsequently, acquire permission from the government; then, they simply need to register the assemblage in the land registry. There is certainly no need to conduct any utility facility installation or land improvement work. It is simply a legal name change process.

Under current South Korean legislation, assembly does not provide any incentives for the floor area ratio (FAR) or building coverage ratio. That is, the floor area ratio or building coverage ratio is independent of the size of the area of a parcel in general, which is slightly different from the reduced setbacks benefit, as illustrated by Shoup (2008). Nevertheless, in the development of real estate properties, the assembly of multiple lots has a significant advantage compared with the development of a building for each lot (Figures 3 and 4). The first advantage is generic economies of scale. This reduces construction and financial costs during real estate development and increases the developer's bargaining power with construction companies and lenders. Second, in cases of the construction of apartment properties where a specific site size and parking lot installation are legal requirements, assembly is inevitable given the current situation of overly fragmented land ownership in Gwangjin. Third, an assembly can more appropriately change the shape of the land for both the architectural design and construction. In particular, an assembly with a lot adjacent to a main road increases the accessibility of the entire assembled lot. In addition, the assembly of parcels can accommodate various building usages by providing flexibility in the layout, location, and direction of the buildings (Hur, 2012). Fourth, in the case of large-scale developments through land assembly, compared with smaller individual parcel developments, the presale is slightly easier and better accepted by consumers. Common areas, such as parking lots, and landscaping can be sustainably managed at a lower cost after a development's completion (Brooks & Lutz, 2016). Lastly, and most importantly, based on Korean law, if developers provide certain areas of public open space, then governments allow a 20% greater FAR bonus (Hur, 2012).

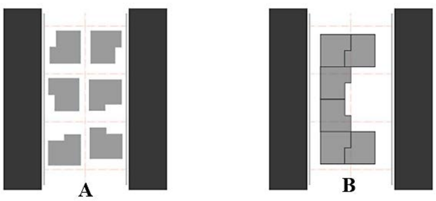

Figure 3. Flexibility of a site design (more feasible open space and parking space in (B)) (source: Hur, 2012)

While the benefits of assembly are tremendous, the reality is that there are more new constructions after the demolition of an existing property on a single parcel, and there are even fewer large assemblies among multiple parcels. From 2010 to 2020, there were 3618 property developments in Gwangjin, and only 175 cases (4.8%) involved land assembly (Lee & Shin, 2021).

1.3. Research hypotheses

Our three main empirical research hypotheses were as follows. Brooks and Lutz (2016) tested the hypothesis of an assembly premium using the difference-in-differences method with the pooled transaction price data of the to-be-assembled vacant parcels. They use the transaction price data before land assembly. We also tested the assembly premium of land parcels as our first hypothesis, when it occurs after the land assembly using an annual tax assessment balanced panel dataset. We extracted 24,177 land parcels that maintained their existence from 2011 to 2019. We tracked the land split and assembly by analysing both the tax assessment dataset and a cadastral map. By comparing the size of each parcel's area annually, we identified each assembly (if there was an increase in size) and split (if there was a decrease in size). We performed the same task via a GIS tool and identified the annual changes in each parcel's polygon. In addition to the efforts by Brooks and Lutz (2016), we also double-checked the reason why these land activities occurred by investigating the government's building registry books and land registry books in addition to the government's property development approval notices. We observed a three-year period from the assembly (year 0 dummy) to the following year (year 1 dummy) and two years from the assemblage (year 2 dummy). Differing from Brooks and Lutz (2016), it was slightly harder to test our hypothesis simply because, once assembled, the tax assessment of the assembled whole should be an average that is in

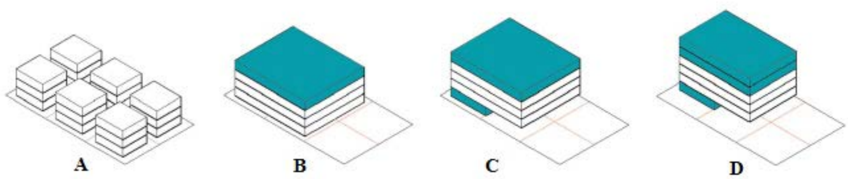

Figure 4. Flexibility of a building design (higher storied buildings) (source: Hur, 2012)

between the maximum and minimum of the involved parcels to maintain the total parcel value unchanged, as this is how it is conducted in the study area. Simple assemblage cannot change the tax assessment (tax burden), and taking an average guarantees the property. The tax assessment of a parcel is the average value per square meter, not a whole land value. If there is no significant change in terms of zoning, size, street accessibility, and so forth after the assemblage, the government maintains one parcel identification number among the involved ones. The surviving parcel with a parcel identification number used to be the parcel with the maximum tax assessment value in previous years in principle. Thus, the tax assessment (an average) after the assemblage should be smaller than the previous assessment (the maximum) if other things remain equal. If the coefficients of the three assembly dummies (years 0 to 2) are significant and positive, then we should admit that this is fairly rigorous evidence of an assembly premium.

Similar to Brooks and Lutz (2016), we also considered two types of assemblages: (1) formal and legal and (2) informal and de facto. In general, it is not required to build properties on only one parcel. Developers can build multiple buildings on multiple parcels and one large building on multiple parcels. The ownership of the land parcels does not matter here when developing a property in Seoul. We call them formal land assembly and de facto land assembly. The critical difference between the two is that de facto land assembly is characterized by simultaneous land assembly and property development, while formal land assembly can be development-oriented but not necessarily directly associated with property development.

The second hypothesis concerns development premiums, which were not tested by Brooks and Lutz (2016). From 2010 to 2020, there were 3618 new property developments. Among them, there were 3 split and development and 175 formal land assembly and development cases (4.8%). We considered property development in both residential and commercial zones.

The third hypothesis concerns the three de facto land assembly dummies (year 0 to 2 dummies), which was also not tested by Brooks and Lutz (2016). These three de facto land assembly dummy variables consider the assembly and simultaneous property development's interacting effect on tax assessments.

We control zoning and its annual change, the width of the adjoining road and its change, the slope of the land and its change, and so forth through the annual panel dataset. We also do sub-sample analyses, such as the land assembly premium near the subway station. In East Asian countries such as China, Japan, and Korea, the subway system virtually represents an urban transportation system and urban renewal planning via TOD.

Our originality is worth mentioning. We constructed a huge balanced panel dataset of tax assessments. We tracked all land activities and tax assessments annually, similar to the repeated sale or repeatedly assessed dataset. We also explicitly tracked all property development activities. This resembled same-store sales growth analyses in the retail literature, where researchers ignored both new store openings and closings during the observation period (Tuli et al., 2012).

2. Research design

2.1. Tax assessments

Now we briefly introduce the tax assessment system of South Korea. There are approximately 40 million land parcels in South Korea. Approximately 33 million land parcels have been assessed annually since 1990. The difference of 7 million land lots is due to these lots being mostly government-owned, non-taxed land. Every year around the end of May, the government announces the assessed value of 33 million land lots as of January 1 (lien date), which is assessed jointly by both appointed certified public property appraisers and government staff. First, the government categorizes all land as standard land (500,000) and individual (non-standard) land (32.5 million). Certified public appraisers appraise 500,000 pieces of standard land using the highest and best use method if vacant, and then they use the information from a site inspection to adjust a computer-assisted mass appraisal program, which is used for the assessment of the other 32.5 million individual land lots under the supervision of the same appraisers.

In Gwangjin District, two teams of certified property appraisers (two on each team for a total of four appraisers) were appointed as assessors. The two teams assessed 919 standard land lots that comprised approximately 2.95% of all land lots (31,150) assessed in Gwangjin District in 2012. Among them, 903 land lots (98.3%) were for either residential, commercial, or residential/commercial mixed use. Then, the government staff assessed the remaining individual land lots using a computer-assisted mass appraisal program.

The merit of our dataset is that it contained an extensive, nine-year time series of tax assessments. In addition, in the research area of this study, both residential and commercial areas are very close to each other. Therefore, it is easy to compare each land-use situation. Regarding the trajectory of the assembly and split activities of urban land over the past 9 years under study, we used six typical land activities, similar to Brooks and Lutz (2016):

- Case 1: one assembly-one (or multiple) parcel(s) is (are) combined and maintains only one site number (main parcel + assembled parcel(s));
- Case 2: split once and sold (main parcel + split parcel(s));
- Case 3: case 2 and then case 1-first split and assembled by adjacent parcel (two different main parcels + one split parcel);
- Case 4: case 1 and then case 2-one (or multiple) parcel(s) is (are) merged for medium-scale development and then sold in parts (one main parcel + split parcels);

– Case 5: case 3 and then case 2-first split and assembled for medium-scale development and then sold in parts (two main parcels + split parcels);
– Case 6: multiple parcels are assembled for very large-scale development (e.g., a condo) and then sold in strata titles (government assigns new parcel numbers).

In our dataset, only one "main" parcel was maintained for cases 1, 2, and 4; two "main" parcels for cases 3 and 5; and, finally, no parcels for case 6. Thus, although we maintained only the main parcels, we were able to track the land activities via assembly and split dummy variables over the nine years without discontinuity (Table 1).

Table 1. Land activities and balanced panel formation

Parcel/Year	2011	2015	2017	2019
Panel A. Land activities				
A	A^0	A^+	A^-	A^-
B	B			
C			C	C
Panel B. Area size change				
A	100	150	90	90
B	50			
C			60	60

Note: The super scripts (0, +, and –) of parcel A are hypothetical for the readability. The parcel A keeps its number all time. The assembly (A^0+B) in 2015 is coded as a Formal land assembly dummy variable in 2015 for the parcel A and the split (A^- and C) in 2017 is coded as a Split dummy variable in 2017 for the parcel A.

2.2. Model selection and control variables

The factors influencing the assessment value of land are categorized into the characteristics of the land parcel itself (area size, slope, and shape), neighbourhood characteristics (zoning, current usage, and surrounding usage), amenities (distance to shopping centre and access to street), land and development activities, and appraisers and appraisal method (Lai & Wang, 1998; Arnott, 2005; Chapman et al., 2009; Brooks & Lutz, 2016).

In this study, we want to focus on the impact of the valuation of land activities and development activities and also control relevant variables such as distance to subway stations, area size, the shape of a land parcel, zoning, and so forth. The basic model (Model 1) is given by Equation (1) below:

$$l(V_{i,t}) = \alpha + \sum_{m=1}^{M}\beta_m x_{i,t,m} + \sum_{r=1}^{R}\varphi_r D_{i,t,r} + \lambda_i + \mu_{i,t}, \quad (1)$$

where: λ_i is the entity – specific error term and $\mu_{i,t}$ is an I.I.D. random error; $x_{i,t,m}$ are continuous numeric variables such as distances to subway stations and a shopping centre and area size; $D_{i,t,r}$ are dummies such as the slope of land, the shape of land, zoning, and land and development activities. Please refer to the Table 2 for more details. $l()$ is a natural log transformation, following the general convention of the log hedonic model (Colwell & Munneke, 1999).

To carry out more robust model estimation and inference, we also introduce an alternative specification (Model 2) where we replace zoning (Commercial zone dummy) and land (Formal land assembly dummy) and development (Development dummy) activities with zoning-land activities interaction dummies (Commercial-Formal land assembly dummy) and zoning-development activities interaction dummies (e.g., Commercial-Development dummy).

Although we use tax assessment data which is different from the transaction price data used in previous literature, if we add one generic weak assumption to the relationship between the true land value and tax assessment, then we can generalize our findings to true land value and transaction price cases. Because tax assessment is carried out by both certified public appraisers (appraisal) and government staff (Mass appraisal) in a pegged order, it is generally accepted that the resulting numbers are biased to some degree (Lai & Wang, 1998; Yiu et al., 2006).

We assume the relationship between unobservable true value (P) and tax assessment value (V) as follows:

$$V_{i,t} = P_{i,t} * exp(\varepsilon_{(i,t)}), \quad (2)$$

where measurement error $\varepsilon_{(i,t)} = K + \mu_{i,t}$, where K is the systematic error portion due to appraisers and appraisal methods. It is independent of both the individual parcel i and time t, while $\mu_{i,t}$ is an I.I.D. random disturbance, the same as that in Equation (1). This idea follows Geltner et al. (2003) who modelled appraisal smoothing process via the term of appraisers' confident factor. If appraisers are self-confident enough, then the required adjustment time can be a day. This research is based on a 9 years period which is a multiple of the 3 years used in this paper.

If we take the natural log of both sides of Equation (2),

$$l(V_{i,t}) = l(P_{i,t}) + K + \mu_{i,t}, \quad (3)$$

where: $V_{i,t}$ is the assessed value; $P_{i,t}$ is the unobservable true value of land lot i at time t, and $\mu_{i,t}$ is an error term, the same error in Equation (1).

We assume that $\mu_{i,t}$, $\mu_{j,t}$, and $\mu_{i,s}$ are I.I.D. random disturbances for individual lands i and j and times s and t. Here, we explain where the K, is derived from. Two same appraisers evaluate the same land parcels every year, and when necessary, only one appraiser is replaced to prevent an abrupt change in valuation. Fortunately, there has been no considerable change in appraisal methodologies during our research period; thus, the measurement error term $\varepsilon_{(i,t)}$ in Equation (2) preserves the same systematic error (K) for an extended period, if any.

Admitting that the true land value is also a function of the same variables in Table 2, then we have Equation (4).

$$l(P_{i,t}) = (\alpha - K) + \sum_{m=1}^{M}\beta_m x_{i,t,m} + \sum_{r=1}^{R}\varphi_r D_{i,t,r} - \mu_{i,t}. \quad (4)$$

Therefore, the K part has no impact on both model estimation or hypothesis testing (e.g., β_m and φ_r). Considering that we use a fixed effect model to get the within estimator, both constant and the entity-specific terms are fixed and estimable. The K has an impact only on the coefficient of the constant term. If it is the case, employing V instead of P does not harm both model estimation and inference especially on the relation between independent variables and a dependent variable. Again, we apply balanced panel data analysis, especially the fixed effect model with cluster robust standard errors specification as in Wooldridge (2009) and Petersen (2009). Finally, we use the annual growth rate of tax assessment as a dependent variable in order to incorporate the autoregressive process characteristics of tax assessment; it is an ar(1) process.

Among the input variables, both the distances to nearby subway stations and the largest shopping centre were time-invariant (Table 2). A split was categorized by dividing the property shares between the existing co-owners (non-development-oriented) and probable development-oriented ones. The latter included a split to sell (cases 2); a split for donating to local government for the right of way as a condition for new development approval; and, thirdly, a split for strata ownership sales after development completion (cases 4 and 5). In our sample of 24,177, there were only 3 development-oriented split cases out of

Table 2. Data and description

Name	Description	Dummy
Assessed value (real number)	Annual growth rate of tax assessment	No
Larger parcel	Larger than 3300 m^2	Yes
Area size (m^2)	Unit: m^2	No
Slope of land parcel	1, if no or little slope	Yes
Shape of land parcel	1, if in good shape for construction	Yes
Width of adjoining road	1, if broad enough	Yes
Subway station (meter)	Distance to a nearby subway station	No
Shopping centre (meter)	Distance to the largest shopping centre in Gwangjin	No
Residential zone	Residential zone	Yes
Commercial zone	Commercial zone	Yes
Formal land assembly 0	The duration of legal and formal land assembly	Yes
Formal land assembly 1	Year after formal land assembly	Yes
Formal land assembly 2	Two years after formal land assembly	Yes
Split 0	The duration of land split	Yes
Split 1	Year after land split	Yes
Split 2	Two years after land split	Yes
De facto land assembly 0	Informal land assembly+ property development approval	Yes
De facto land assembly 1	Year after land de facto land assemblying	Yes
De facto land assembly 2	Two years after land de facto land assemblying	Yes
Development 0	The date of development approval	Yes
Development 1	Year after development approval	Yes
Development 2	Two years after development approval	Yes
Residential & Formal land assembly 0	The date of legal land assembly in a residential zone	Yes
Residential & Formal land assembly 1	Year after legal land assembly in a residential zone	Yes
Residential & Formal land assembly 2	Two years after legal land assembly in residential zone	Yes
Commercial & Formal land assembly 0	The date of legal land assembly in commercial zone	Yes
Commercial & Formal land assembly 1	Year after legal land assembly in a commercial zone	Yes
Commercial & Formal land assembly 2	Two years after legal land assembly in commercial zone	Yes
Residential development 0	The date of property development approval in a residential zone	Yes
Residential development 1	Year after property development approval in a residential zone	Yes
Residential development 2	Two years after property development approval in residential zone	Yes
Commercial development 0	The date of property development approval in commercial zone	Yes
Commercial development 1	Year after property development approval in a commercial zone	Yes
Commercial development 2	Two years after property development approval in commercial zone	Yes
Year dummies	Year dummy variables	Yes

117 split cases in the research area. Most were split for donating to local government for the right of way as a condition for new development approval. This donation to the local government reduces the tax burden and maintenance responsibility of property owner. Although we input this split variable as a control, an in-depth investigation seemed inappropriate.

A dummy of area size larger than 3300 m^2 is worth noting. The government reduces tax assessments for larger parcels to decrease the tax burden. In contrast, parcels smaller than 10 m^2 were removed because their assessments tended to move in a very volatile fashion and behaved like an outlier, similar to penny stocks in the finance literature, as in Avramov et al. (2006).

The current usage dummies were removed due to serious multicollinearity with another set of variables, including zoning dummy variables. In our research area, 24% of the parcels (6704 parcels) in the residential zone were used for either mixed or commercial purposes, while 29% of parcels (173 parcels) in the commercial zone were used for either mixed or residential purposes in 2012. The photos are of typical mixed-use properties in Gwangjin (Figure 5).

Next, the year dummy variables may capture macroeconomic conditions. During the research period, no severe economic turmoil existed, such as a global financial crisis, COVID-19, or hyperinflation, in Korea. Thus, the year dummy variables were sufficient to control for the annual variation in the economic system.

Lastly, we considered a period of three years when making both the land and development activities dummies (e.g., Formal land assembly 0, 1, and 2 dummies). Based on Lee and Shin (2021), the average property development period from approval to the issuance of the occupancy permit is 202 days with a standard deviation of 108 days. Thus, a three-year observation period was sufficient.

Figure 5. Mixed-use properties in Gwangjin

As can be seen in Table 3, 98.2% of land and development activities were in the residential zone, while 1.5% were in the commercial zone. The rest were in either the greenbelt or mountain areas.

As can be seen from Table 4, the within variation of the subway station variable and the between variation of the year dummies were all zero. This implies that the subway station variable is time-invariant, while the year dummies are entity-invariant.

Table 3. Descriptive statistics

Variable	*N*	Min.	Max.	Mean	Std. Dev.
Assessed value (annual growth rate)	217,593	–0.90	6.80	0.05390	0.04378
Area size	217,593	10.60	87,244	260.23203	1226.83432
Slope of land parcel	217,593	0.00	1.00	0.93202	0.25170
Shape of land parcel	217,593	0.00	1.00	0.85955	0.34745
Width of adjoining road	217,593	0.00	1.00	0.07332	0.26067
Subway station	217,593	4.00	1100	423.52310	200.33256
Shopping centre	217,593	24.00	3810	1737.77330	945.60513
Residential zone	217,593	0.00	1.00	0.98237	0.13160
Commercial zone	217,593	0.00	1.00	0.01488	0.12106
Larger parcel	217,593	0.00	1.00	0.00506	0.07095
Formal land assembly 0	217,593	0.00	1.00	0.00120	0.03468
Formal land assembly 1	217,593	0.00	1.00	0.00108	0.03292
Formal land assembly 2	217,593	0.00	1.00	0.00097	0.03112
Split 0	217,593	0.00	1.00	0.00054	0.02318
Split 1	217,593	0.00	1.00	0.00047	0.02165
Split 2	217,593	0.00	1.00	0.00041	0.02033
De facto land assembly 0	217,593	0.00	1.00	0.00261	0.05098
De facto land assembly 1	217,593	0.00	1.00	0.00238	0.04873
De facto land assembly 2	217,593	0.00	1.00	0.00211	0.04593

End of Table 3

Variable	N	Min.	Max.	Mean	Std. Dev.
Development 0	217,593	0.00	1.00	0.01516	0.12219
Development 1	217,593	0.00	1.00	0.01382	0.11676
Development 2	217,593	0.00	1.00	0.01248	0.11102
Residential & Formal land assembly 0	217,593	0.00	1.00	0.00116	0.03408
Residential & Formal land assembly 1	217,593	0.00	1.00	0.00106	0.03249
Residential & Formal land assembly 2	217,593	0.00	1.00	0.00094	0.03068
Commercial & Formal land assembly 0	217,593	0.00	1.00	0.00004	0.00606
Commercial & Formal land assembly 1	217,593	0.00	1.00	0.00002	0.00479
Commercial & Formal land assembly 2	217,593	0.00	1.00	0.00002	0.00479
Residential development 0	217,593	0.00	1.00	0.01490	0.12115
Residential development 1	217,593	0.00	1.00	0.01363	0.11595
Residential development 2	217,593	0.00	1.00	0.01228	0.11013
Commercial development 0	217,593	0.00	1.00	0.00023	0.01500
Commercial development 1	217,593	0.00	1.00	0.00016	0.01250
Commercial development 2	217,593	0.00	1.00	0.00017	0.01304
Year dummies	217,593	0.00	1.00	0.11111	0.31427

Table 4. Between and within variations

Variable		Std. Dev.	Min	Max	Observations
Assessed value	Overall	0.04	−0.86	6.77	N = 217,593
	Between	0.02	−0.07	0.83	n = 24,177
	Within	0.04	−0.76	5.99	T = 9
Area size	Overall	1227	11	87,244	N = 217,593
	Between	1225	11	87,244	n = 24,177
	Within	66	−13,642	7211	T = 9
Slope of land parcel	Overall	0.25	0.00	1.00	N = 217,593
	Between	0.25	0.00	1.00	n = 24,177
	Within	0.01	0.27	1.71	T = 9
Shape of land parcel	Overall	0.35	0.00	1.00	N = 217,593
	Between	0.34	0.00	1.00	n = 24,177
	Within	0.05	−0.03	1.75	T = 9
Residential zone	Overall	0.13	0.00	1.00	N = 217,593
	Between	0.13	0.00	1.00	n = 24,177
	Within	0.03	0.09	1.43	T = 9
Commercial zone	Overall	0.12	0.00	1.00	N = 217,593
	Between	0.12	0.00	1.00	n = 24,177
	Within	0.03	−0.43	0.90	T = 9
Formal land assembly 0	Overall	0.03	0.00	1.00	N = 217,593
	Between	0.01	0.00	0.33	n = 24,177
	Within	0.03	−0.33	0.89	T = 9
Development 0	Overall	0.12	0.00	1.00	N = 217,593
	Between	0.04	0.00	0.33	n = 24,177
	Within	0.12	−0.32	0.90	T = 9
Subway station	Overall	200	4	1100	N = 217,593
	Between	200	4	1100	n = 24,177
	Within	0.00	424	424	T = 9
Year dummies	Overall	0.31	0.00	1.00	N = 217,593
	Between	0.00	0.11	0.11	n = 24,177
	Within	0.31	0.00	1.00	T = 9

Table 5. Descriptive statistics: land activities from 2011 to 2019

Year	Development approval 0	De facto land assembly 0	Formal land assembly 0	Split 0
2011	219	18	26	10
2012	399	35	31	10
2013	383	34	31	23
2014	304	42	29	16
2015	358	79	27	11
2016	563	160	30	9
2017	490	92	37	11
2018	292	58	25	12
2019	291	49	26	15
Total	3299	567	262	117

Table 6. Changes in residential and commercial zones from 2011 to 2019

Residential zone				Commercial zone			
Year	Mean area (m^2)	Total area (m^2)	Count	Year	Mean area (m^2)	Total area (m^2)	Count
2011	258	6,122,892	23,754	2011	408	142,277	349
2019	258	6,125,113	23,736	2019	393	148,697	378
Change	0	2221	−18	Change	−14	6420	29

Table 5 presents deficit descriptive statistics of land activities. As can be seen in Table 6, the number of parcels in the commercial zone increased, while the average parcel area size decreased. The average area size of 258 m^2 in residential areas increased compared with the 1980s (approximately 160 m^2), but it was still very small for necessary compact urban land use.

3. Empirical result and discussion

3.1. Estimation results

3.1.1. Whole-sample model

First, we checked the multicollinearity by considering that the urban land use situation may mostly stay the same. The VIF values greater than two were the residential zone (6.34) and commercial zone (6.40) variables. Thus, we concluded that multicollinearity did not matter.

After conducting several econometric specification tests, such as the Breusch–Pagan and Hausman tests, we decided to choose a fixed effect balanced panel estimation. In detail, we employed a within transformation method to account for the fixed effect, as in Wooldridge (2009). Regarding the robust error specification, we employed a cluster-robust standard errors specification that allowed for correlation within the tax assessment time series, as shown in Petersen (2009). Even the Hausman–Taylor estimation procedure failed to pass the Hausman test. Therefore, time-invariant variables, such as distances to subway stations and shopping centres, should be removed (Table 4).

To obtain more robust results, we fit two different models. Model 1 was a benchmark model with residential zone, commercial zone, and land and development activity variables without any interaction terms. Model 2 was an alternative model with interaction terms between the zones and activities, such as formal land assembly in a residential zone (Residential & Formal land assembly 0) and development in a commercial zone (Commercial development 0). The first hypothesis regarding the formal land assembly variable based on Model 1 (Table 7), there was no statistically significant positive impact. Considering that a tax assessment is an average value of the parcels assembled and admitting that we already controlled the macro-economic change through year dummies, we believe that a non-decreasing value can provide weak evidence of an assemblage benefit. Second, as expected, the development 0 variable showed a positive and statistically significant influence on the assessment. Third, de facto land assemblys 0 and 1 showed a positive and statistically significant influence on the assessment as hypothesized. Lastly, the area size variable also showed a positive and statistically significant influence on the dependent variable.

It was also worthwhile to compare the alternative model results, which showed that formal land assembly 1 in the commercial zone (Commercial & Formal land assembly 1) gained a statistically significant and positive sign. The area size variable showed a positive and significant impact on tax assessment in a statistical sense in both models. In short, assemblage and development activity guaranteed value increases in Gwangjin.

Table 7. Estimation results: whole sample (217,593 parcel * year)

Variable	Model 1	Model 2
Constant	−0.172*	−0.157*
Area size	0.000*	0.000*
Slope of land parcel	0.121	0.121
Shape of land parcel	0.022***	0.024***
Width of adjoining road	0.503***	0.554***
Residential zone	0.018***	(not included)
Commercial zone	0.191***	(not included)
Larger parcel	0.063	0.063
Formal land assembly 0	0.003	(not included)
Formal land assembly 1	0.000	(not included)
Formal land assembly 2	0.003	(not included)
Split 0	0.001	0.001
Split 1	−0.001	−0.001
Split 2	−0.000	0.000
De facto land assembly 0	0.049***	0.048***
De facto land assembly 1	0.010**	0.010**
De facto land assembly 2	−0.000	−0.000
Development 0	0.003***	(not included)
Development 1	−0.000	(not included)
Development 2	−0.000	(not included)
Year 2012	0.042***	0.043***
Year 2013	0.022***	0.022***
Year 2014	0.023***	0.023***
Year 2015	0.035***	0.035***
Year 2016	0.032***	0.032***
Year 2017	0.049***	0.049***
Year 2018	0.051***	0.051***
Year 2019	0.071***	0.071***
Residential & Formal land assembly 0	(not included)	0.003
Residential & Formal land assembly 1	(not included)	0.001
Residential & Formal land assembly 2	(not included)	0.002
Commercial & Formal land assembly 0	(not included)	−0.002
Commercial & Formal land assembly 1	(not included)	0.011***
Commercial & Formal land assembly 2	(not included)	0.017*
Residential development 0	(not included)	0.003***
Residential development 1	(not included)	−0.000
Residential development 2	(not included)	−0.000
Commercial development 0	(not included)	0.004
Commercial development 1	(not included)	0.000
Commercial development 2	(not included)	0.001

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

3.1.2. Subsample estimation result

To our surprise, the total population in Gwangjin decreased from 384,269 (year 2012) to 337,713 (year 2022) due to increasing housing costs and expanding commercial usage. Figure 5 depicts the gentrification via commercial use. This certainly caused an increasing commuting time and encroachment upon the greenbelt.

Currently, the South Korean government encourages property developers to develop more residential properties near transportation facilities, such as subway stations, based on the concept of a compact city and transportation-oriented development (TOD). For example, the government provides a denser FAR incentive if a developer develops a residential rental property connected to a broader main road and subway station, called “young adults apartment near subway station”. The admittable radius from the subway station is less than or equal to 250 m, as per the city regulations of Seoul. The regulation also defines the age range of young adults as being from 19 to 39. In Gwangjin, three subway lines operate with 11 stations. The longest distance from a parcel to a nearby station is 1100 m. Therefore, it is meaningful to further analyse the parcels within a 250 m radius of a nearby station (3 mins of walking distance). We called this subsample the near-subway subsample.

Except for the de facto land assembly 0 and development 0 variables, all of the other variable’s means were significantly different between subsamples in a statistical sense at the 1% level of significance (Table 8). Differing from the whole sample, in the near-subway subsample, the residential zone was smaller (98.2%: 94%), while the commercial zone was larger (1.5%: 6%). Thus, it was perfectly legitimate to perform a subsample analysis. To our surprise, there has been no zoning change at all in commercial zone for nine years. The commercial zone dummy is now a time-invariant same as the subway station variable. Thus, it is omitted during our fixed effect model estimation procedures (Table 9).

First, it was necessary to compare and contrast the subsample results with the whole-sample results (Tables 7 and 8). In the near-subway model, the larger parcel dummy gained a positive and statistically significant sign. In particular, when analysing the detailed interaction model (Subsample_Model 2), the development activity in the commercial zone showed a positive and statistically significant impact for two years (Table 9). In short, in the near-subway area, larger commercial property developments were much more preferred to residential ones.

Table 8. Difference in the mean *t*-tests for the near-subway subsample (44,352 parcel * year) and remote subsample (173,241 parcel * year)

Variables	Assumptions	Levene’s variance test		*t*-test		
		F	*p*-value	*t*	*p*-value	Mean difference
Assessed value	Homoscedasticity			–3.80***	0.000	–0.001
	Heteroscedasticity			–3.10***	0.002	–0.001
Area size	Homoscedasticity			5.43***	0.000	35.465
	Heteroscedasticity			5.35***	0.000	35.465
Subway station	Homoscedasticity			–420***	0.000	–332.926
	Heteroscedasticity			–672***	0.000	–332.926
Shopping centre	Homoscedasticity			–12.81***	0.000	–64.481
	Heteroscedasticity			–12.34***	0.000	–64.481
Slope of land parcel		11362***	0.000			0.066
Shape of land parcel		11.86***	0.001			–0.003
width of adjoining road		4840***	0.000			0.049
Residential zone		27649***	0.000			–0.056
Commercial zone		37946***	0.000			0.059
Larger parcel		102.59***	0.000			0.002
Formal land assembly 0		12.25***	0.000			0.000
Split 0		24.81***	0.000			0.000
De facto land assembly 0		5.83**	0.016			0.000
Development 0		3.48*	0.062			–0.001

*Note:** $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 9. Estimation results: near subway sub-sample (44,352 parcel * year)

Variable	Subsample_Model 1	Subsample_Model 2
Constant	–0.002	–0.125***
Area size	0.000	0.000
Slope of land parcel	–0.002***	–0.002***
Shape of land parcel	0.032**	0.037**
Width of adjoining road	0.941***	1.003***
Subway station	(omitted)	(omitted)
Shopping centre	(omitted)	(omitted)
Residential zone	–0.119***	(not included)

End of Table 9

Variable	Subsample_Model 1	Subsample_Model 2
Commercial zone	(omitted)	(not included)
Larger parcel	0.020***	0.020***
Formal land assembly 0	0.008	(not included)
Formal land assembly 1	–0.007	(not included)
Formal land assembly 2	0.007	(not included)
Split 0	0.002	0.002
Split 1	0.002	0.003
Split 2	0.012***	0.012***
De facto land assembly 0	0.015	0.014
De facto land assembly 1	0.002	0.001
De facto land assembly 2	–0.002	–0.002
Development 0	0.003	(not included)
Development 1	–0.002	(not included)
Development 2	0.000	(not included)
2012	0.043***	0.045***
2013	0.023***	0.023***
2014	0.023***	0.023***
2015	0.037***	0.037***
2016	0.029***	0.029***
2017	0.047***	0.046***
2018	0.049***	0.050***
2019	0.066***	0.067***
Residential & Formal land assembly 0	(not included)	0.006
Residential & Formal land assembly 1	(not included)	–0.004
Residential & Formal land assembly 2	(not included)	0.006
Commercial & Formal land assembly 0	(not included)	(omitted)
Commercial & Formal land assembly 1	(not included)	(omitted)
Commercial & Formal land assembly 2	(not included)	(omitted)
Residential development 0	(not included)	0.003
Residential development 1	(not included)	–0.003
Residential development 2	(not included)	0.000
Commercial development 0	(not included)	0.009***
Commercial development 1	(not included)	0.005**
Commercial development 2	(not included)	0.001

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

3.2. Discussion

In Gwangjin, the areas near subway stations have already turned into very low-density commercial use areas. These buildings are commercially used single-family detached homes after slight conversion and remodelling. Please refer to Figure 6.

There are many low-density small retail buildings at the front of streets, initially developed as single-family houses, and, peculiarly, high-density residential buildings stand behind them, which is extremely contrary to the TOD policy of the government. The owners of the front low-density buildings are holding a waiting option or waiting for the opportunity to be the last to sell their properties (Strange, 1995; Grossman & Hart, 1980).

This issue is common, and the government tries to deal with it with different policy tools. Firstly, the government provides incentives to develop mixed-use buildings right behind commercial zones, which are cheaper than front commercial ones. Secondly, it also provides incentives for front-line commercial building owners to assemble behind residential parcels, which are undervalued due to their inferior accessibility, simply because it is virtually impossible for commercial building owners to assemble commercial buildings next to their properties. To make this assemblage attempt feasible, the government also recommends that developers collaborate with neighbouring landowners as limited partner investors in a joint venture. Nevertheless, in Seoul, there is still no standard contract regarding a waterfall structure aimed at balanced profit

Figure 6. Low-density small retail buildings near subway stations

and risk sharing between the general partner and limited partners in a joint venture. A profit- and risk-sharing norm is necessary for a joint venture to feasibly pursue property development (Geltner et al., 2001). Despite the efforts above, Gwangjin District still needs to overcome fragmentation problems.

Conclusions

Due to the land readjustment project in Gwangjin District, Seoul, Korea, in the 1970s, Gwangjin was characterized as a single-family residential area for individual households. Over the following 40 years, the land-use situation changed dramatically and, ironically, it now has a too fragmented residential area and very insufficient commercial areas.

We employed a balanced panel data analysis. The data for this study were 24,177 parcel tax assessments and the land assembly, split, zoning change, and property development activities over nine years from 2011 to 2019.

We found that de facto land assembly accompanied by a property development increased the assessment by up to two years, while formal land assembly did not. Development activity itself increased the assessment for that particular year only. Lastly, legal and formal land assembly in the commercial zone increased the assessment only for the following year, while property development in the residential zone increased the assessment for that year only.

When using a subsample in the areas near subway stations, we found that the larger parcel dummy gained a statistically significant and positive sign. In particular, when analysing the detailed model, development activity only in the commercial zone showed a positive and statistically significant impact for two years.

We recommend that the government provide land-assembly-friendly policy incentives to allow for much larger property developments in both residential and commercial zones. The research on the impact of land and property development activities on tax assessments can directly provide a reasonable basis for the government's tax assessment institution building. Moreover, we need stricter regulations for de facto land assembly to establish a much more transparent title ownership institution.

Gwangjin district was developed as a single-family residential district for individual households; thus, land assembly with graduated density bonus (Shoup, 2008) and a combination of upzoning and value capture (Kim, 2020) can be a solution for large-scale property development in Gwangjin. For sustainable urban renewal in Gwangjin District, we recommend a balanced approach between developers, landowners, and public planners concerning profit and risk sharing. The planning-led quasi-market model in Louw (2008) would be a good choice. To prevent the greenbelt from leapfrogging encroachment, Gwangjin needs denser and much more compact property development. Following Lee and Shin (2021), we also suggest supporting local fee developers who have competitive local knowledge, especially in small-to-mid-scale property developments. Small-to-mid-scale property development may adjust itself quickly to the ever-changing situation. Lastly, we also recommend legal and formal land assembly incentives. Based on the research findings of Lee and Shin (2021), property developments on legally assembled sites show significantly faster development periods in a very strict statistical manner. In addition, this improves the transparency in ownership title institutions.

Our study had some limitations, especially regarding the data. Our research area was a district of Seoul. Our findings might not be generalizable to other cities, such as London, Los Angeles, or Beijing. In addition, in-depth analyses regarding the structural influencing factors of land and property development activities still need to be included. Thus, our subsequent research journey will be heading in these directions.

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