Factors Affecting the Price of Cost-Equivalent Land: Application of Hierarchical Linear Modeling

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Abstract: This study examined 19 urban land consolidation areas in Kaohsiung City, Taiwan, as well as cost-equivalent lands auctioned off from 2013 to 2019. Hierarchical linear modeling was used for analysis, in which the Level 1b variables pertained to cost-equivalent land and the Level 2 variables pertained to land consolidation areas. According to the empirical results, in terms of the estimation results, there were significant differences between the mean price of each urban land consolidation area. Therefore, HLM is suitable for the subsequent analysis. A total of 76.7% of the differences in the mean land consolidation area price were contributed by the differences between the land consolidation areas. Therefore, it is important to consider the differences generated by the particular features of each area.

Keywords: urban land consolidation areas; land auction; cost-equivalent land prices; multilevel model

1. Introduction

Generally speaking, integrated land development methods in Taiwan consist of urban land consolidation, zone expropriation, urban renewal, etc. Even though the government has executed numerous political and economic construction projects over the years, many of these projects were obstructed due to land acquisition difficulties. Integrated land development through urban land consolidation not only saves significant expropriation and construction expenses for the government, if done so properly, it can also increase revenue for local governments and facilitate the acquisition of land for planned development, thereby safeguarding the property rights of citizens. This also demonstrates the salient role that urban land consolidation plays in urban planning. Urban land consolidation projects can be government-implemented or self-implemented. In the former, the competent authorities at all levels may apply for the rezoning of the selected area after the approval of the higher-level competent authority, or more than half of the landowners within a suitable land to be consolidated owning among themselves more than half the sum of all the area of the land within a consolidation area, may request the competent county/local government to perform a preferential consolidation upon approval of the application. In the latter, the landowners may form an urban land consolidation committee and, pursuant to approval by competent authority, perform the consolidation. This study focused on government-implemented urban land consolidation projects with readily accessible open data.

Urban land consolidation is not only an effective means for successfully acquiring the land needed for constructing public infrastructure outlined in urban planning, but landowners also themselves need to undertake the expenses for constructing roads, ditches, playgrounds, and neighborhood parks within the consolidation area, according to the proportion of the benefits that will accrue to them. Hence, landowners offer unconstructed lands to offset construction costs, land consolidation costs, and loan interests of a land...
consolidation project. Therefore, cost-equivalent land is the aforementioned unconstructed land that is used to offset a landowners’ joint contributions to the land consolidation project.

Following the completion of the land consolidation project, each plot of private land remaining within the consolidation area that is directly adjacent to a road and available for immediate construction projects shall be distributed to the original landowners according to the original distribution order. The unconstructed land previously owned by the landowners paid off to the government (the cost-equivalent land) would be tendered by the local government to serve as a major source of revenue for constructing public infrastructure within the jurisdiction. Consequently, the price of cost-equivalent land is equally important before and after a land consolidation project.

In the land market, land transactions can be completed either in private or through public auctions, such as auctions for state-owned land, cost-equivalent land, zone expropriation, and zone selling. Early studies on the prices of land parcels or land zones focused on factors such as the distance to the city center, land use zoning, and road access (see [1–3]). Recent studies have employed geographic information systems (GIS) in order to measure the distance from the land to a school park or MRT station, the frontage, and whether the land is a corner lot. Scholars have employed hedonic pricing models in order to examine the marked price of public land [4–8], or to examine the relationships between pricing strategies, the number of bids in land auctions, and premiums (see [9–14]). This study primarily examined the factors affecting the marked prices of public land (more specifically, cost-equivalent land).

The cost-equivalent land areas examined in this study were located or nested within urban land consolidation areas. The public infrastructure and construction projects within the area were all within the same range of a planned development area. The land areas had high similarity in terms of locational attributes, had spatial nesting relationships, and were suitable for hierarchical linear modeling. However, few studies on cost-equivalent land prices have employed hierarchical linear modeling for analysis, and most of them only examined either single or multiple land consolidation areas. In this study, the hierarchical linear modeling approach was used in order to analyze factors affecting cost-equivalent land prices. The variables were separated into two levels: Level 1 (individual level) pertaining to cost-equivalent land and Level 2 (macro level) pertaining to urban land consolidation areas. The sample consisted of 19 urban land consolidation areas in Kaohsiung City. The Level 1 variables included lot size, land shape, aspect ratio, corner lot, floor area ratio, frontage, distance from the cost-equivalent land area to a park, and distance from the cost-equivalent land area to an MRT station, etc. The Level 2 explanatory variables included the availability of large-scale public infrastructure, the size of the land consolidation area, and the mean cost of the urban land consolidation project. The main objectives of this study are as follows: (1) to check for significant differences in the mean price of cost-equivalent lands in urban land consolidation areas; (2) to examine the effects of the Level 1 independent variables on the price of cost-equivalent lands; and (3) to examine whether the Level 2 independent variables (the availability of large-scale public infrastructure, the size of the land consolidation area, and the mean cost of the urban land consolidation project) had cross-level effects on the price of cost-equivalent land areas.

HLM is an appropriate approach in this study because it is able to delineate the factors affecting cost-equivalent land prices in urban land consolidation areas. Significant differences were also found in the mean price of cost-equivalent land in urban land consolidation areas. In this study, 76.7% of the differences in the mean land consolidation area price were contributed by the differences between the land consolidation areas. Therefore, it is important to consider the differences generated by the particular features of each area. This also indicates that compared to an individual plot of cost-equivalent land, the mean price of a cost-equivalent land in a land consolidation area has a greater influence on land prices. The empirical results demonstrated that some Level 1 independent variables positively influenced cost-equivalent land prices according to the differences in the land price conditions, while some (such as frontage) resulted in usage differences, depending on
the benefits. Furthermore, regarding the Level 2 independent variables, the expected cost-equivalent land price is higher when the size of an urban land consolidation area is larger and the public infrastructure in the area is more developed. Therefore, the Level 2 independent variables had cross-level, direct, significant, and positive effects on cost-equivalent land prices.

2. The Current State of Urban Land Consolidation and the Principles of Tendering Cost-Equivalent Land

Urban land consolidation provides the local government with the land needed for constructing public infrastructure and buildings, saves land expropriation and compensation costs as well as construction expenses, promotes urban development, improves land use zoning control, and increases the quality of the living environment for residents. The first urban land consolidation pilot project in Taiwan was implemented in Kaohsiung City in 1958. Afterwards, Taichung City and Taipei City also began to develop their urban infrastructure and economies through urban land consolidation, which increases the comprehensiveness of public infrastructure, improves the quality of the living environment, and provide excellent residential areas. As of December 2020, a total of 1091 urban land consolidation projects have been completed in Taiwan, with a total area of over 17,777 hectares. The total area used for building roads and ditches was 6083 hectares while the total area available for building construction was 11,357 hectares. These projects saved the government a total of TWD 181.7 billion (As of 27 June 2021, 1$US is equal to 27.9$NT.) in construction costs 1. At present, there are 113 areas under consolidation, with a total area of 2423 hectares. These projects can effectively promote the economic use of urban land and increase the overall robustness of urban developments [15].

2.1. Principles of Tendering Cost-Equivalent Land

Regarding the tendering of cost-equivalent land in government-implemented urban land consolidation projects, Article 54 of the Regulations Governing the Implementation of Urban Land Consolidation states that the competent authority shall call for an open tender after the land distribution outcomes have been declared. The competent authority shall set the minimum starting price for a plot of cost-equivalent land within an urban land consolidation area, with the exception of lands used for public housing, public use, or Executive Yuan-approved projects, which have to be sold at their respective minimum price. Should no person win the tender, the competent authority shall call for another open tender at a lower starting price, a lease by tender, or a tender for the establishment of superficies, under the condition that the financial plans of the land consolidation project are unaffected.

In Taiwan, cost-equivalent lands are tendered through the first-price sealed-bid method. This means that construction firms (the bidders) do not know who their competitors are, and therefore it is crucial to estimate bidding prices. The land may not be acquired if the bidding price is too low; while more cost is needed if the bidding price is too high, thereby reducing the profits of future developments or even incurring losses [13]. Cost-equivalent land tenders are called by the Land Administration Department of each County (Special Municipality) Government, in which the item to be tendered as well as the relevant information are announced. The bidders then mail their sealed bids to a specified address within the designated period by writing down their bid price on the form of tender, and the bid price must exceed the minimum price and cannot be amended afterwards. The government official presiding the opening of the tenders shall collect all the forms within a specified period and announce the time and location of the opening of tenders. However, the notices for land auctions or the regulations for state-owned land auctions are set by various agencies differently, for instance, the regulations for state-owned land auctions. All the sealed bids are then opened publicly, and the highest and second-highest bidders are subjected to an evaluation to determine whether their form and deposit are legitimate, and if so, the successful bidder shall be the one with the highest bid and is awarded the contract. The government official shall post the names (pseudonymized for privacy reasons) and
bid prices of the highest and second-highest bidders along with the results of the opening of tenders on the website of the National Property Administration. The successful bidder shall complete their payment within 30 days after being notified of their successful bid; those who failed to do so are regarded as to have withdrawn and their deposit shall be forfeited by the local Land Administration Department, and in this case, the second-highest bidder shall be notified to complete their payment within 30 days [12]. In this study, the winning bidder was supposed to pay the price with an installments plan of the notice. The payment was not made on time, so the deposit paid was confiscated to the treasury, with the right to purchase was deemed to have been waived, and there was no procedure for the second bid submission. Additionally, cost-equivalent lands were tendered by the Land Administration Department of the Kaohsiung City Government in accordance with the “333 Principle,” i.e., all openings of tender and awards of contract are performed on the third day (Wednesday) of every third week on the months divisible by three (March, June, September, and December). This approach gives appropriate time for investors to raise funds and prepare the required documents [16]. The proceeds of the tender are used to cover the development cost and to fund new development projects in the future. Any surplus shall be used to cover the cost of government-built infrastructure inside and outside the development area and also be used as government funds for subsequent developments that benefit citizens.

2.2. Cost-Equivalent Land Prices in Open Tenders

A government-implemented urban land consolidation is organized by the local government in accordance with Article 20 of the Regulations Governing the Implementation of Urban Land Consolidation, which states that pre-consolidation land prices are estimated based on the location, topography, transportation access, usage, and previous sales data of each plot of land, as well as the announced current land value. The street price or zone price of each consolidated road/street is estimated based on the location, topography, transportation access, road width, public infrastructure, land use zoning, and expected developments. Therefore, different factors affect land prices before and after consolidation are different, with the most significant difference being that the price of each plot of pre-consolidated land is estimated based on the characteristics of each plot of land within the consolidation area. The price of each plot of consolidated land is determined based on the differences in each block, and the street price or zone price is set accordingly.

The starting price for each plot of land for tender is set according to Article 54 of the Regulations Governing the Implementation of Urban Land Consolidation, which must not be lower than the appraised price of a plot of consolidated land (During the rezoning process, it is necessary to check the land price prior and after the rezoning, submit the land price, and standard land price appraisal committee for assessment, as the basis for land exchange allocation and calculation of costs.). The starting price is first evaluated based on the published current land price and actual registration data provided by the local land bureau, the land’s own conditions, surrounding environmental factors, etc., and an announcement is made after verification in accordance with the review procedures of the county (city) agencies.

3. Empirical Model

In general, cost-equivalent land prices are investigated by means of hedonic pricing models involving ordinary least squares (OLS) regression. When the data is clustered, and the OLS contains many explanatory variables, the characteristics or scenarios of explanatory variables embedded in each cluster may be omitted, and hence data independence is neglected in the results [17]. Jones and Bullen [18] claimed that hedonic pricing models place different levels of characteristic variables in a single level for estimation, which neglects the issue of levels. Thus, the spatial variations of housing prices between different levels cannot be presented, and the variations in the implicit values of housing structure attributes with locational characteristics cannot be correctly estimated. Giuliano, Gordon,
Pan, and Park [19] suggested that hierarchical linear modeling allows one to control the research data due to variances that arise from regional differences.

Antipova, Wang, and Wilmot [20] suggested that individuals nested with the same region are similar to each other, which explains their use of HLM. The first level consists of spatial attributes such as land use type and distance to higher education institutions nearby, as well as individual attributes such as income and gender. The second level consist of the neighborhood sociodemographic attributes. The authors demonstrated that land use type can be used to explain the length of the commuting time, while individual and neighborhood sociodemographic attributes have important effects on commuting time. Nickerson and Zhang [21] pointed out that land characteristic prices are considerably influenced by heterogeneity, and as a result, potential omitted-variable bias exist. Therefore, the factors affecting land price changes must be addressed to, and the potential omitted-variable bias must be reduced, so as to resolve the land price heterogeneity and spatial dependence that are likely omitted.

Arribas, García, Guíjarro, Oliver, and Tamošiūnienė [22] pointed out that the ordinary least squares (OLS) approach is the most common method for the mass appraisal of residential real estate assets. The OLS approach, however, does not take into account differences in the nested structure of the data, that is, intergroup relevance or interactions, and neighborhood attributes are also not accounted for. As a result, the data does not conform to the assumption of sample independence. In order to overcome this limitation, multilevel models or hierarchical linear models (HLM) can be used. The empirical results of the study showed that the HLM had a good fit, and all of the estimated variances of the parameters in the HLM were lower than the variances estimated through OLS.

Many factors affect the price of cost-equivalent land. Since each piece of cost-equivalent land was located in an urban land consolidation area, the public infrastructure, transportation and road access have similar neighborhood factors, that is, the data has a nested data structure. In order to distinguish ourselves from previous studies that have employed OLS, this study employed the hierarchical linear modeling approach to analyze the factors that affect the price of cost-equivalent land. The Level 1 variables pertained to cost-equivalent land, while the Level 2 variables pertained to land consolidation areas. Two models were developed by means of hierarchical linear modeling: a null model and an intercepts- and slopes-as-outcomes regression model. In this study, the winning bid price of a cost-equivalent land area served as a dependent variable. The Level 1 independent variables include the merger of Kaohsiung City, holding period, lot size, aspect ratio, corner lot, floor area ratio, frontage, distance from the cost-equivalent land area to a park, distance from the cost-equivalent land area to an MRT station, as well as the two dummy variables of a sluggish economy and a booming economy. The Level 2 characteristic variables include the availability of large-scale public infrastructure in the urban land consolidation area, the size of the urban land consolidation area, and the mean cost of the urban land consolidation project.

### 3.1. Null Model

A null model is also known as a one-way analysis of variance (ANOVA) with random effects model, which determines whether significant between-group differences exist between levels. When the between-group variance accounts for a certain proportion of the total variance, heterogeneity is said to exist between the data, which makes it suitable for assessing factors with different attributes through different levels. The settings of the null model are shown in Equations (1)–(3):

**Level 1:**

\[
\ln \text{Price}_{ij} = \beta_{0j} + \epsilon_{ij}, \epsilon_{ij} \sim N\left(0, \sigma^2\right)
\]

(1)

**Level 2:**

\[
\beta_{0j} = \gamma_{00} + \mu_{0j}, \mu_{0j} \sim N\left(0, \tau_{00}\right)
\]

(2)

Substituting Equation (2) into Equation (1) yields the mixed model Equation (3):
Mixed:
\[
\ln Price_{ij} = \gamma_{00} + \mu_{0j} + \epsilon_{ij}
\]  
(3)

where

- \(i\): Code of each winning bid price sample of a cost-equivalent land area in an urban land consolidation area, i.e., the marked price of each piece of cost-equivalent land.
- \(j\): Code of each urban land consolidation area.
- \(\ln Price_{ij}\): The logarithmic form of the \(i\)th winning bid price of a cost-equivalent land area in the \(j\)th urban land consolidation area.
- \(\beta_{0j}\): Mean winning bid price of cost-equivalent land area in the \(j\)th urban land consolidation area;
- \(\epsilon_{ij}\): Error term of the mean winning bid price of cost-equivalent land in the \(j\)th urban land consolidation area; assume that the mean is 0, the variance is \(\sigma^2\), and the error term is independently and identically distributed.
- \(\gamma_{00}\): is the grand mean winning bid price of cost-equivalent land in each urban land consolidation area.
- \(\mu_{0j}\): Difference between the mean winning bid price of cost-equivalent land in each urban land consolidation area and the grand mean winning bid price of cost-equivalent land in all urban land consolidation areas.
- \(\tau_{00}\): Variance of \(\mu_{0j}\) (between-group variance).

3.2. Intercepts- and Slopes-as-Outcomes Regression Model

In this study, the winning bid price of a cost-equivalent land area served as a dependent variable. The Level 1 independent variables include the merger of Kaohsiung City (Time), holding period (Duration), lot size (Lotsize), aspect ratio (Aspect), corner lot (Corner 1–3), floor area ratio (Floor), frontage (Roadwidth), distance from a cost-equivalent land to a park (Park), and distance from the cost-equivalent land area to an MRT station (MRT), as well as the two dummy variables of a sluggish economy (Blue) and a booming economy (Red). The Level 2 characteristic variables include the availability of large-scale public infrastructure in the urban land consolidation area (Public), the size of the urban land consolidation area (Area), and the mean cost of the urban land consolidation project (Cost). The variables are detailed in Table 1. In an intercepts- and slopes-as-outcomes regression model, the Level 1 and Level 2 independent variables were consolidated into a model for analysis. In the multilevel analysis, the Level 1 and Level 2 residuals are independent and unrelated to one another. Between-group variances only occur in the Level 2 variables, while within-group variances only occur in the Level 1 variables. Snijders and Bosker [23] recommended that if each group of Level 2 samples have certain characteristics, then a fixed effects model in HLM should be used to construct the same model in each group. In the case of a random coefficient model, if the intercept \(\beta_{0j}\) of the Level 1 regression model is employed, then \(\mu_{0j}\) must be used in the Level 2 regression model to express the relation between groups. Level 1 explanatory variables were subjected to group-mean-centering (individual) in order to reflect the grand mean on the intercept \(\gamma_{00}\). Second-level explanatory variables were subjected to grand-mean-centering (aggregate), and \(\beta_{0j}\) can be transformed into the group mean of the dependent variables, while \(\mu_{0j}\) represents the difference between the group mean and the grand mean \(\gamma_{00}\). Here, \(\tau_{00}\) is the variance of the group mean, which has explanatory significance. [24] In this study, the coefficients of the Level 1 independent variables were modeled as fixed effects, while the intercepts were modeled as random effects, as shown in Equations (4)–(6):
Level 1:
\[
\text{InPrice}_{ij} = \beta_{0j} + \beta_{1j} \left( \text{Time}_{ij} - \text{Time}_{..} \right) + \beta_{2j} \left( \text{Duration}_{ij} - \text{Duration}_{..} \right) + \beta_{3j} \left( \text{Lotsize}_{ij} - \text{Lotsize}_{..} \right) + \beta_{4j} \left( \text{Aspect}_{ij} - \text{Aspect}_{..} \right) + \beta_{5j} \left( \text{Coner1}_{ij} - \text{Coner1}_{..} \right) + \beta_{6j} \left( \text{Coner2}_{ij} - \text{Coner2}_{..} \right) + \beta_{7j} \left( \text{Coner3}_{ij} - \text{Coner3}_{..} \right) + \beta_{8j} \left( \text{Floor}_{ij} - \text{Floor}_{..} \right) + \beta_{9j} \left( \text{Roadwidth}_{ij} - \text{Roadwidth}_{..} \right) + \beta_{10j} \left( \text{Park}_{ij} - \text{Park}_{..} \right) + \beta_{11j} \left( \text{MRT}_{ij} - \text{MRT}_{..} \right) + \beta_{12j} \left( \text{Blue}_{ij} - \text{Blue}_{..} \right) + \beta_{13j} \left( \text{Red}_{ij} - \text{Red}_{..} \right) + \epsilon_{ij}, \epsilon_{ij} \sim N(0, \sigma^2)
\]

Level 2:
\[
\beta_{0j} = \gamma_{00} + \gamma_{01} \left( \text{Public}_{ij} - \text{Public}_{..} \right) + \gamma_{02} \left( \text{Area}_{ij} - \text{Area}_{..} \right) + \gamma_{03} \left( \text{Cost}_{ij} - \text{Cost}_{..} \right) + \mu_{0j}, \mu_{0j} \sim N(0, \tau_{00})
\]

\[
\beta_{kj} = \gamma_{k0}, k = 1, \ldots, 13.
\]

where \( \beta_{0j} \) is a Level 1 intercept; \( \beta_{1j}, \ldots, \beta_{13j} \) is the coefficient of each Level 1 independent variable; \( \epsilon_{ij} \) is the within-group random error term, assuming that the mean is 0, the variance is \( \sigma^2 \), and the error term is independently and identically distributed. \( \gamma_{00} \) is the grand mean winning bid price of cost-equivalent land areas in all urban land consolidation areas; \( \gamma_{01}, \gamma_{02}, \gamma_{03} \) each represent the influence of the Level 2 variables of the availability of large-scale public infrastructure, the size of the urban land consolidation area, and the mean cost of the urban land consolidation project on the mean winning bid price of cost-equivalent land areas in each urban land consolidation area. \( \beta_{kj} \) is the coefficient of each Level 1 independent variable, modeled as fixed effects \( \gamma_{k0} \). Substituting Equations (5) and (6) into Equation (4) yields the mixed model of the intercepts- and slopes-as-outcomes regression, as shown in Equation (7):
\[
\text{InPrice}_{ij} = \gamma_{00} + \gamma_{01} \left( \text{Public}_{ij} - \text{Public}_{..} \right) + \gamma_{02} \left( \text{Area}_{ij} - \text{Area}_{..} \right) + \gamma_{03} \left( \text{Cost}_{ij} - \text{Cost}_{..} \right) + \gamma_{10} \left( \text{Time}_{ij} - \text{Time}_{..} \right) + \gamma_{12} \left( \text{Duration}_{ij} - \text{Duration}_{..} \right) + \gamma_{13} \left( \text{Lotsize}_{ij} - \text{Lotsize}_{..} \right) + \gamma_{20} \left( \text{Aspect}_{ij} - \text{Aspect}_{..} \right) + \gamma_{22} \left( \text{Coner1}_{ij} - \text{Coner1}_{..} \right) + \gamma_{23} \left( \text{Coner2}_{ij} - \text{Coner2}_{..} \right) + \gamma_{30} \left( \text{Coner3}_{ij} - \text{Coner3}_{..} \right) + \gamma_{32} \left( \text{Floor}_{ij} - \text{Floor}_{..} \right) + \gamma_{33} \left( \text{Roadwidth}_{ij} - \text{Roadwidth}_{..} \right) + \gamma_{40} \left( \text{Park}_{ij} - \text{Park}_{..} \right) + \gamma_{42} \left( \text{MRT}_{ij} - \text{MRT}_{..} \right) + \gamma_{43} \left( \text{Blue}_{ij} - \text{Blue}_{..} \right) + \gamma_{100} \left( \text{Red}_{ij} - \text{Red}_{..} \right) + \epsilon_{ij} + u_{0j}
\]

3.3. Description of Variable Settings
3.3.1. Dependent Variables

With regard to the estimation of land prices, most authors, such as Kostov [25] and Perry and Robison [26], have employed unit price as a dependent variable. In this study, the logarithmic form of the dependent variable of unit price was used for empirical analysis, and the settings and descriptions of the variables are presented in Table 1.
## Table 1. Description of variable settings.

<table>
<thead>
<tr>
<th>Level of Variable</th>
<th>Variable</th>
<th>Definition</th>
<th>Expected Sign of Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variables</td>
<td>Winning bid price</td>
<td>Logarithmic form of the winning unit price of each cost-equivalent land, measured in units of TWD10,000/m² (As of 27 June 2021, 1$US is equal to 27.9$NT.)</td>
<td></td>
</tr>
<tr>
<td>Level 1 Independent variables</td>
<td>The merger (Time)</td>
<td>Kaohsiung City and Kaohsiung County merged into Kaohsiung City on 25 December 2010. Cost-equivalent land transactions before 2011 are specified as pre-merge and assigned a value of 0; transactions after 2011 are specified as post-merge and assigned a value of 1.</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Holding period (Duration)</td>
<td>A continuous variable that represents the period from the allocation to the selling of a land area in an urban land consolidation area, measured in units of years. The sign of the coefficient is expected to be positive.</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Lot size (Lotsize)</td>
<td>A continuous variable that represents the registered lot size of a land area for auction, measured in units of m². The sign of the coefficient is expected to be positive.</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Aspect ratio (Aspect)</td>
<td>The ratio of land width adjacent to a road to the land depth not adjacent to a road, measured in units of percentage. A wider aspect ratio indicates that a lot has a larger area in contact with a road or street, and thus offers greater flexibility in terms of usage and planning. A larger aspect ratio represents better road access. The sign of the coefficient is expected to be positive.</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Corner lot (Corner 1–3)</td>
<td>A piece of land located at the intersection of two or more roads. Lots are divided into non-corner lots, corner lots along a road with a maximum width of 8 m and below, corner lots along a road with a maximum width of 10–25 m, and corner lots along a road with a maximum width of 26 m and above. Non-corner lots served as the basis of reference, and three dummy variables (Corner1, Corner2, and Corner3) were specified. For the Corner1 variable, corner lots along a road with a maximum width of 8 m and below were specified as 1, and 0 otherwise; for the Corner2 variable, corner lots along a road with a maximum width of 10–25 m were specified as 1, and 0 otherwise; and for the Corner3 variable, corner lots along a road with a maximum width of 26 m and above were specified as 1, and 0 otherwise. The sign of the coefficient is expected to be either positive or negative.</td>
<td>+ / −</td>
</tr>
<tr>
<td></td>
<td>Floor Area Ratio (Floor)</td>
<td>A continuous variable, measured in units of percentage. The sign of the coefficient is expected to be positive.</td>
<td>+</td>
</tr>
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<td></td>
<td>Frontage (Roadwidth)</td>
<td>A continuous variable that represents the width of the road in front of a cost-equivalent land area, measured in units of meters. If the land is adjacent to two or more roads, the largest road width is taken as the frontage. The sign of the coefficient is expected to be positive.</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Distance to a park (Park)</td>
<td>A continuous variable that represents the distance from a land area to a park, measured in units of meters. The sign of the coefficient is expected to be negative.</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>Distance to an MRT station (MRT)</td>
<td>A continuous variable that represents the distance from a land area to the entrance of an MRT station, measured in units of meters. The sign of the coefficient is expected to be negative.</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>Sluggish economy (Blue)</td>
<td>There are five indicators of the economic situation (the color of their corresponding signals, indicated in brackets), which include Sluggish (blue); Transitioning to Sluggish (yellow–blue); Stable (green); Booming (red); and Stable serving as the basis of reference, and two dummy variables are specified as well. For the Sluggish variable, an economy that is sluggish (blue) or is transitioning to sluggish (yellow–blue) is specified as 1, and 0 otherwise. The sign of the coefficient is expected to be negative.</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>Booming economy (Red)</td>
<td>For the Booming variable, an economy that is booming (red) or is transitioning to booming (yellow–red) was specified as 1, and 0 otherwise. The sign of the coefficient is expected to be positive.</td>
<td>+</td>
</tr>
</tbody>
</table>
### Table 1. Cont.

<table>
<thead>
<tr>
<th>Level of Variable</th>
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<th>Expected Sign of Coefficient</th>
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<tr>
<td></td>
<td>Public infrastructure (Public)</td>
<td>Refers to the availability of large-scale public infrastructure, i.e., a literary institution, art museum, or a regional urban park near an urban land consolidation area. Areas with large-scale public infrastructure nearby are specified as 1, and 0 otherwise. The sign of the coefficient is expected to be positive.</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Size of urban land consolidation area (Area)</td>
<td>Total size of an urban land consolidation area. In this study, the size of an urban land consolidation area was calculated in units of hectares and was specified as a continuous variable. The sign of the coefficient is expected to be positive.</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Mean cost of an urban land consolidation project (Cost)</td>
<td>A continuous variable that represents the mean burden rate jointly contributed by all landowners involved in the project, measured in units of percentage. The monetary costs include the engineering costs, the land consolidation costs, and the loan interest. The sign of the coefficient is expected to be positive.</td>
<td>+</td>
</tr>
</tbody>
</table>
3.3.2. Level 1 Independent Variables

(1) Merger of Kaohsiung City

Tian, Ji, Chen, and Wu [27] indicated that the objectives of city-county mergers are to promote regional economic development and to strengthen the competitiveness of central cities. In that study, 19,211 pieces of secondhand housing data in Fuyang City and West Lake District from the years 2014, 2015, and 2019 were analyzed by means of the double differences model and the hedonic pricing model, so as to study the impacts of the city-county merger of Fuyang on housing prices. The empirical results showed that the city-county merger had temporal and spatial effects on housing prices. In terms of the temporal effects, the merger had positive and significant effects on housing prices in Fuyang City in the long term. Additionally, in terms of the spatial effects, in the long term, the effects on the merger on housing prices had weakened with the increasing distance from the West Lake District; in particular, the prices of houses located within 3–6 km of the West Lake District had the highest price increase. Kaohsiung City and Kaohsiung County merged into Kaohsiung City on 25 December 2010. In the short term, rural–urban disparities may exist, but in the long term, there are more opportunities for diverse development in transportation and resource sharing. In this study, we propose that the Kaohsiung city-county merger should have a positive effect on the price of cost-equivalent land, and that the coefficient is expected to have a positive value.

(2) Holding period

Levin and Pryce [28] established a theoretical model regarding housing market disequilibrium. The theoretical model revealed the process of the dynamic adjustment of price and quantity, in which sellers can adjust and reserve their holding period until the selling price is higher. The completion of a construction project in an urban land consolidation area refers to the period starting from the completion of infrastructure construction to the full development of the area through various development projects. Therefore, when the holding period is longer, a development area should be more well-developed. This should have a positive effect on the price of cost-equivalent land, and the coefficient is also expected to have a positive value.

(3) Lot size

Lin and Evans [29] pointed out that in Taiwan, the unit price of a lot increases alongside lot size. A primary reason for this is that many transaction costs are required during the process of land merging. Hu [30] claimed that a larger site area offers more diverse land use options, as well as higher flexibility for the planning and designing of residences. Therefore, lot size has a positive effect on land price. In general, a lot of a larger size is regarded as having the advantage in terms of greater economies of scale, and this should have a positive effect on the price of cost-equivalent land. The coefficient is expected to have a positive value.

(4) Aspect ratio

In a study by Chowdhury, Zhang, Tong, and Messac [31], the maximum farm capacity factor or farm output potential was represented as a function of the land aspect ratio and land orientation. A 25 MW wind farm was designed at a North Dakota site that experiences various dominant wind directions. At the wind farm, a 5% difference in the capacity factor was observed between the best and worst sample farmland shapes. The results demonstrated that among the 50 land shapes, farms with an aspect ratio greater than one and which were oriented longitudinally along the wind direction had higher production values.
The aspect ratio denotes the ratio of the lot width (adjacent to a road) to the lot depth (not adjacent to a road). A wider aspect ratio represents the fact that a lot has a larger area in contact with a road or street, and thus offers higher flexibility in terms of usage and planning. Wang [32] has suggested that when the frontage of the land up for auction increases, so would the winning unit price. In other words, the section of a lot that is adjacent to a road is priced higher than the sections that are not adjacent to a road. Nevertheless, a lot must have a certain ratio in order for it to be used easily, and it is difficult to compare the advantages and disadvantages of a lot merely through the frontage and the depth. In this study, the aspect ratio was specified as an independent variable in which a larger aspect ratio offers better land use. The aspect ratio should have a positive effect on the price of cost-equivalent land, and the coefficient is expected to have a positive value as well.

5) Corner lot

Chen [6] has demonstrated that the variables of lot size, corner lot, floor area ratio, and frontage had positive and significant (at a 1% level of significance) effects on the winning price. Lin [7] employed a hedonic pricing model and demonstrated that the frontage of a lot, whether a lot is a corner lot, and zoning each had positive and significant effects on the winning unit price. A corner lot is a piece of land located at the intersection of two or more roads, and it has the advantages of better ventilation, lighting, and entry. However, the functionality of a lot differs according to its frontage. According to existing building regulations, the width of roads adjacent to corner lots could result in different restrictions on the construction of buildings. In this study, corner lots were divided into non-corner lots, corner lots along a road with a maximum width of 8 m and below, corner lots along a road with a maximum width of 10–25 m, and corner lots along a road with a maximum width of 26 m and above. Non-corner lots served as the basis of reference, and three dummy variables (Corner1, Corner2, and Corner3) were specified (In general, road widths are planned in intervals of 8 m and 10 m. Similarly, the sampled roads in this study were specified as having a width of 8 m and below, 10 m to 25 m, etc.). For the Corner1 variable, corner lots along a road with a maximum width of 8 m and below were specified as 1, and 0 otherwise; for the Corner2 variable, corner lots along a road with a maximum width of 10–25 m were specified as 1, and 0 otherwise; finally, for the Corner3 variable, corner lots along a road with a maximum width of 26 m and above were specified as 1, and 0 otherwise. It is generally regarded that corner lots have more commercial benefits and also have greater ease of transportation and parking. Therefore, being on a corner lot should have a positive effect on the price of cost-equivalent land, but its benefits and usage differ according to the frontage. Moreover, corner lots adjacent to roads with different widths may be subjected to different restrictions on the construction of buildings. Hence, the coefficient is expected to have either a positive or negative value.

6) Floor area ratio

The statutory floor area ratio is a type of control measure for regulating the volume of a building; it is the ratio of the building’s total floor area to the lot size. Lin [33] used the floor area permitted for the construction of a building per unit lot size as an independent variable. The empirical results indicated that land prices increased alongside floor area ratio. In this present study, it is assumed that a higher floor area ratio allows for more floor spaces to be constructed and relatively larger floor areas to be planned. Therefore, floor area ratio should have a positive effect on the price of cost-equivalent land, and the coefficient is expected to have a positive value.

7) Frontage

Uyar and Brown [34] utilized HLM in order to analyze the relationships between neighborhood affluence, school achievement scores, and housing prices. The results indicated that frontage had a positive and significant relationship with housing prices, because frontage represents the expanse of the view of a house, the ease of access to
main roads, as well as the potential for activities. Tsoodle, Golden, and Featherstone [1] investigated factors affecting farmland prices in Kansas by considering the accessibility of farmland to connecting roads, as well as the type and availability of roads (no road access, dirt road, gravel road, and paved road). The results showed that farmlands with paved road access and dirt road access were priced higher than those with gravel road access (Following land consolidation, the shape of a land area is mainly considered to be square. There are also more vacant lands as a result of the overall development of a land consolidation area, which leads to land division, land merging, and large-sized land developments. The planning and design of these development projects would modify the effects of land shape on land use. Therefore, land shape was not selected as an independent variable in this study.). A land area with a wider frontage not only enables buildings to have a better view and privacy, but also has greater potential for economic developments. Moreover, frontage is also one of the factors considered in building volume control measures. Therefore, frontage should have a positive effect on the price of cost-equivalent land, and the coefficient is expected to have a positive value as well.

(8) Distance to a park

Poudyal, Hodges, and Merrett [35] estimated the demand and benefits of parks and revealed that the presence of urban parks increased nearby property values. In this study, the distance from a land area to a park was calculated by means of plane coordinates. In other words, the longer the distance, the lower the accessibility. The distance to a park should have a negative effect on the price of cost-equivalent land, and the coefficient is expected to have a negative value.

(9) Distance to an MRT station

Goetz et al. [36] examined the economic and land use impacts of the Hiawatha Light Rail Line, and the authors developed a pricing model for residences within a half-mile radius of a station along the Hiawatha Line. Then, they analyzed trends in housing prices within the proximity of a station before and after the construction of the Hiawatha Line. The results suggested that the construction of the Line only affected the prices of houses located within station areas on the west side of the Line, while the prices of houses located on the east side of the Line were not significantly affected, due to the presence of a four-lane highway and a strip of industrial land. The results also suggested that relative to the control area, there was a high level of residential investment within areas close to the station. This study calculated the distance from a land area for auction to an MRT station. The longer the distance, the lower the accessibility, and thus the lower the price of the land. The distance to an MRT station should have a negative effect on the price of cost-equivalent land, and the coefficient is expected to have a negative value.

(10) Economic situation—sluggish and booming

Bourassa, Haurin, Haurin, Hoesli, and Sun [37], as well as Smith and Tesarek [38], concurred that the appreciation of initial housing values changes over time in response to economic changes. Tu [39] examined real estate data pertaining to repeated transactions in the six municipalities of Taiwan from 2012 to 2018. The hedonic pricing regression model showed that in terms of the changes in housing prices, the economic cycle and policy effects were salient factors affecting changes in housing prices. In this study, the economic situation during the month in which a cost-equivalent land transaction took place was specified as a dummy variable affecting the price of cost-equivalent land.

The economic situation during the month of the transaction refers to the five monitoring indicators developed by the National Development Council (National Development Council, Introduction to Monitoring Indicators https://www.ndc.gov.tw/News_Content.aspx?n=4BAAFB5D274162D4&sms=A9383740548FF94&ss=FBE6EFF9E8181156 Last accessed on 8 May 2020.). The indicators (the color of their corresponding signals, indicated in brackets) include Sluggish (blue); Transitioning to Sluggish (yellow–blue); Stable (green); Booming (red); and Transitioning to Booming (yellow–red). In this study, Sluggish and
Transitioning to Sluggish were combined as the single variable of Sluggish, and Booming and Transitioning to Booming were combined as the single variable of Booming, along with the Stable variable. Therefore, there were three economic situation indicators, with Stable serving as the basis of reference, and two dummy variables were specified as well. For the Sluggish variable, an economy that is sluggish (blue) or is transitioning to sluggish (yellow–blue) was specified as 1, and 0 otherwise. When the economy is sluggish, the demand for land may be gradually reduced, and therefore the coefficient is expected to have a negative value. For the Booming variable, an economy that is booming (red) or is transitioning to booming (yellow–red) was specified as 1, and 0 otherwise. When the economy is booming, the demand for land gradually increases, which elevates land prices. During this period, the coefficient is expected to have a positive value.

3.3.3. Level 2 Variables

(1) Public infrastructure

Yang, Wang, Zhou, and Wang [40] reported that the accessibility to public infrastructure affects housing prices, and different types of public infrastructure and services have varying effects on housing prices as well. Hu [41] performed a quantitative study on the externalities of land use by employing the contingent valuation method. The results demonstrated that urban parks had a positive effect on the prices of nearby housing properties, which increased by 17.5%; the degree of the influence decreased when distance increased, and becomes 0 when the distance was 7103 m or greater. In this study, the public infrastructure variable (Public) refers to the availability of large-scale public infrastructure, that is, a literary institution, art museum, or a regional urban park located within or nearby an urban land consolidation area. This variable was specified as a dummy variable. For the Public variable, areas with access to large-scale public infrastructure are specified as 1, and 0 otherwise. This is because areas located within or nearby large-scale public infrastructure have a better quality of service, and buyers are more willing to pay higher prices. The coefficient is expected to have a positive value.

(2) Size of urban land consolidation area

Guidry et al. [42] investigated the impacts of zoning control measures and natural restrictions on residential land prices in different cities, as well as the impact of the lot size of the residential land on residential land prices. The results demonstrated that lot size had a positive effect on land price, albeit not a statistically significant one. In this study, the size of an urban land consolidation area was calculated in units of hectares, and was specified as a continuous variable. Therefore, when the holding period is longer, a development area should be more well-developed. This should have a positive effect on the price of cost-equivalent land, and the coefficient is expected to have a positive value as well.

(3) Mean cost of an urban land consolidation project

Lee [43] examined the relevant factors affecting the completion of urban land consolidation projects. According to the results, a higher grand mean burden rate reflects a higher grand profit and a lower mean cost (According to existing regulations, there are two types of costs: 1. The cost of public infrastructure land: In an urban land consolidation area, the land used for ten types of public infrastructure—roads, ditches, children’s playgrounds, neighborhood parks, public squares, green fields, elementary schools, junior high schools, car parks, and retail markets—shall be covered by the original public land in the area used for public roads, ditches, rivers, and unregistered land. The costs of constructing public infrastructure in the parts of the land that remain uncovered for shall be contributed by the landowners involved in the projects in proportion to the benefits that will accrue to them. 2. Monetary costs: The monetary costs of an urban land consolidation project refer to the engineering costs, land consolidation costs, and the loan interests. The engineering costs include the design, planning, construction, grading, materials required, management costs, and taxation of public infrastructure such as roads, bridges, ditches, lampposts, signals, pipelines, utility tunnels, plants, neighborhood parks, public squares, green fields, etc. The
land consolidation costs include compensation for the demolition or relocation of buildings, agricultural crops, and graves, as well as compensation for loss of business, fees for cadastral management, and fees required for consolidation businesses. Loan interest is derived from the sum of the interest of all the aforementioned costs calculated based on the interest rate and loan period of the financial institution involved.). In this study, the engineering costs of a land consolidation project are associated with the overall construction plan of the area’s environment, critical infrastructure renewal, road widening, increased outdoor lighting, and other environmental health-related factors. Generally speaking, the higher the mean burden rate of a land consolidation project, the more improved the environment of the area becomes. This should have a positive effect on the price of cost-equivalent land, and the coefficient is expected to have a positive value as well.

4. Data Sources and Description of Data

In this study, data was sourced from the website of the Kaohsiung City Government Land Administration Bureau (Kaohsiung City Government Land Administration Bureau, https://landp.kcg.gov.tw/ Last accessed on 15 February 2020). The open data pertaining to the results of urban land consolidation auctions were downloaded, and the land consolidation areas with high numbers of cost-equivalent lands for auction were selected. Nineteen urban land consolidation areas were sampled, which include the Phase 9, 29, 31, 33, 37, 42, 44, 47, 68, 77, and 84 areas, along with Fongqing, Neikeng, Kuopi 1, Hunei 1, Niaosong, Bade, Renwu, and Yucai. In terms of cost-equivalent land, the existing map area of each cost-equivalent land lot was compared in order to check whether or not it was consistent with the marked lot size. If the land was divided or merged (The researchers accessed the website of the Kaohsiung City Government Land Administration Bureau (Online Search-> Divided and Merged Land Lot Query System) in order to check the lot number of a land area both before and after its division or merge. Then, the website of the Bureau’s Land Information System (https://gisdawh.kcg.gov.tw/landeasy/) was accessed in order to check and compare the lot size.), the map area was compared with the existing cadastral volume and folio numbers. If the area remains inconsistent, or cannot be compared with, then the piece of transaction data was omitted. The total sample size consists of 380 samples, and the cost-equivalent land transactions spanned from 2003 to 2019. Most of the urban land consolidation areas were located in the administrative districts of Nanzih, Tsoying, Fongshan, Renwu, and Gushan. The locations of the cost-equivalent lands in the 19 urban land consolidation areas are shown in Figure 1 (Illustrated by means of Open source GIS (QGIS). The maps were obtained from the National Land Surveying and Mapping Center (https://wmnts.nlsc.gov.tw/wmnt) and the Kaohsiung City Government Land Information System (https://gisdawh.kcg.gov.tw/kcmap/). Last accessed on 15 May 2020. Due to the northerly location (longer distance) of the Hunei 1 consolidation area, it is shown in a single frame here, while the other 18 areas are shown in the same frame.)
5. Descriptive Statistics of Samples

This study examined cost-equivalent lands auctioned off in 19 urban land consolidation areas in Kaohsiung City. The sample size was 380. There were 380 Level 1 observations and 19 Level 2 observations. With regard to the descriptive statistics of the Level 1 independent variables, in the effective sample, the mean price per m$^2$ of a cost-equivalent land was TWD 70,700, while the minimum and maximum were TWD 9100 and TWD 926,300, respectively. The mean holding period was 10.07 years, and the minimum and maximum were 0.59 and 31.24 years, respectively. The mean lot size was 781.69 m$^2$, and the minimum and maximum were 46.9 m$^2$ and 8727.18 m$^2$, respectively. The mean aspect ratio was 0.75, while the minimum and maximum were 0.09 and 4.71, respectively. The mean floor area ratio was 291.21%, and the minimum and maximum were 120% and 840%, respectively. The mean frontage was 16.22 m, and the minimum and maximum were 4 m and 45 m, respectively. The mean distance to a park was 384.76 m, while the minimum and maximum were 19 m and 1898 m, respectively. The mean distance to an MRT station was 2628.72 m, and the minimum and maximum were 45 m and 16,569 m, respectively. Of the 380 samples, 241 transactions (63.4%) were completed pre-merge, while 139 (36.6%) transactions were completed post-merge. There were 272 transactions of non-corner lots, which accounted for 71.6% of the sample; there were 22 (5.8%), 52 (13.7%), and 34 (8.9%) transactions of corner lots along a road with a width of 8 m or less, 10–25 m, and 26 m and above, respectively. With regard to the economic situation during the month in which a transaction was completed, 116 (43.7%), 166, and 98 (25.8%) transactions were completed.
when the economy was stable, sluggish (or transitioning to sluggish), and booming (or transitioning to booming), respectively (see Table 2).

Table 2. Descriptive statistics of the Level 1 independent variables.

<table>
<thead>
<tr>
<th>Code Name</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price (TWD10,000/m²)</td>
<td>7.07</td>
<td>7.87</td>
<td>0.91</td>
<td>92.63</td>
</tr>
<tr>
<td>Independent variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration</td>
<td>10.07</td>
<td>6.82</td>
<td>0.59</td>
<td>31.24</td>
</tr>
<tr>
<td>Lotsize</td>
<td>781.69</td>
<td>1181.31</td>
<td>46.90</td>
<td>8727.18</td>
</tr>
<tr>
<td>Aspect ratio (%)</td>
<td>0.75</td>
<td>0.67</td>
<td>0.09</td>
<td>4.71</td>
</tr>
<tr>
<td>Floor Area Ratio (%)</td>
<td>291.21</td>
<td>108.57</td>
<td>120</td>
<td>840</td>
</tr>
<tr>
<td>Roadwidth (m)</td>
<td>16.22</td>
<td>9.55</td>
<td>4</td>
<td>45</td>
</tr>
<tr>
<td>Distance to a park (m)</td>
<td>384.76</td>
<td>369.05</td>
<td>19</td>
<td>1898</td>
</tr>
<tr>
<td>Distance to an MRT station (m)</td>
<td>2628.72</td>
<td>3229.69</td>
<td>45</td>
<td>16,569</td>
</tr>
</tbody>
</table>

Table 3. Descriptive statistics of the Level 2 independent variables.

<table>
<thead>
<tr>
<th>Attributes of variables</th>
<th>Frequency</th>
<th>Percentage</th>
<th>Cumulative percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>The merger</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-merge</td>
<td>241</td>
<td>63.4</td>
<td>63.4</td>
</tr>
<tr>
<td>Post-merge</td>
<td>139</td>
<td>36.6</td>
<td>100</td>
</tr>
<tr>
<td>Corner lot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-corner lot</td>
<td>272</td>
<td>71.6</td>
<td>71.6</td>
</tr>
<tr>
<td>Corner lot along a road with a width of 8 m and below</td>
<td>22</td>
<td>5.8</td>
<td>77.4</td>
</tr>
<tr>
<td>Corner lot along a road with a width of 10–25 m and below</td>
<td>52</td>
<td>13.7</td>
<td>91.1</td>
</tr>
<tr>
<td>Corner lot along a road with a width of 26 m and above</td>
<td>34</td>
<td>8.9</td>
<td>100</td>
</tr>
<tr>
<td>Economic situation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color of signal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td>116</td>
<td>30.5</td>
<td>30.5</td>
</tr>
<tr>
<td>Yellow–blue</td>
<td>166</td>
<td>43.7</td>
<td>74.2</td>
</tr>
<tr>
<td>Blue</td>
<td>98</td>
<td>25.8</td>
<td>100</td>
</tr>
<tr>
<td>Sluggish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Booming</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size of land consolidation area (Area)</td>
<td>79.62</td>
<td>68.32</td>
<td>4.65</td>
</tr>
<tr>
<td>Mean cost of an urban land consolidation project (Cost)</td>
<td>6.90</td>
<td>2.77</td>
<td>3.50</td>
</tr>
</tbody>
</table>

With regard to the descriptive statistics of the Level 2 independent variables, according to Table 3, the mean size of a land consolidation area was 79.62 hectares, with the largest and smallest sizes being 240.462 hectares and 4.65 hectares, respectively. The mean cost (burden rate) of an urban land consolidation project was 6.90%, while the maximum and minimum were 11.87% and 3.50%, respectively. Six (37.4%) urban land consolidation areas had large-scale public infrastructure nearby, while 13 (62.6%) lacked large-scale public infrastructure.

Table 4. Analysis of Empirical Results.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of land consolidation area (Area)</td>
<td>79.62</td>
<td>68.32</td>
<td>4.65</td>
<td>240.46</td>
</tr>
<tr>
<td>Mean cost of an urban land consolidation project (Cost)</td>
<td>6.90</td>
<td>2.77</td>
<td>3.50</td>
<td>11.87</td>
</tr>
<tr>
<td>Attributes of variables</td>
<td>Frequency</td>
<td>Percentage</td>
<td>Cumulative percentage</td>
<td></td>
</tr>
<tr>
<td>Public infrastructure (Public)</td>
<td>Yes</td>
<td>6</td>
<td>37.4</td>
<td>37.4</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>13</td>
<td>62.6</td>
<td>100</td>
</tr>
</tbody>
</table>

6. Analysis of Empirical Results

The estimation results of the null model are presented in Table 4. In terms of fixed effects, $\gamma_{00}$ was 1.61 and attained a 1% level of significance. This highlights the presence of significant differences in the mean price of the 19 urban land consolidation areas and the grand mean price of the land consolidation areas. $\tau_{00}$ was estimated to be 0.569 and attained a 1% level of significance. This elucidates the presence of significant differences
between the mean price of each urban land consolidation area. Therefore, HLM is suitable for the subsequent analysis. The variance \( \tau_{00} \) of the mean land consolidation area price \( \beta_{0j} \) and the Level 1 within-group variance \( \sigma^2 \) can be used to calculate the within-group correlation coefficient (\( \rho \) or ICC), which was 0.767 (\( 0.569 / (0.569 + 0.173) = 0.767 \)). According to Cohen’s [44] recommendations, the correlation was high. Therefore, 76.7% of the differences in the mean land consolidation area price were contributed by the differences between the land consolidation areas. Therefore, it is important to consider the differences generated by the particular features of each area. This finding highlights the importance of the influence of land consolidation areas on cost-equivalent land prices.

### Table 4. Empirical estimation results of the null model.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-Value</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>1.610</td>
<td>0.170</td>
<td>9.450</td>
<td>0.001 ***</td>
</tr>
<tr>
<td>Random effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>( \tau_{00} )</td>
<td>0.569</td>
<td>18</td>
<td>897.726</td>
</tr>
<tr>
<td>Level 1 within-group ( \sigma^2 )</td>
<td>0.173</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deviance</td>
<td>487.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of estimated parameters</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** represents \( p < 0.01 \); ** represents \( p < 0.05 \); * represents \( p < 0.1 \); standard errors are calculated as robust standard errors.

The results estimated through the intercepts- and slopes-as-outcomes regression model are presented in Table 5. In terms of fixed effects, the estimated coefficient of the availability of public infrastructure (Public) was 0.543 and attained a level of significance of 5%. This suggests that the prices of cost-equivalent lands with large-scale public infrastructure nearby are 54.3% higher than those without. The empirical results of Hu’s [41] study highlighted the positive effect of urban parks on the prices of nearby housing properties, which increased by 17.5%; the degree of the influence decreased with increasing distance and become 0 when the distance was 7103 m. Yang, Wang, Zhou, and Wang [40] reported that accessibility to public infrastructure affects housing prices. For example, the shorter the walking distance to a commercial center, gymnasium, or cultural center, the higher the housing prices. The estimated coefficient of the size of a land consolidation area (Area) was 0.003 and attained a 10% level of significance. This shows that for every one-hectare increase in the size of an urban land consolidation area, the price of a cost-equivalent land area increases by 0.3%. Guidry et al. [42] pointed out that the size of an urban residential land area had a positive effect on land price, despite the fact that the empirical results were not statistically significant. This study suggests that the larger the size of an urban land consolidation area, the more developed the public infrastructure in the area, and hence, the higher the expected cost-equivalent land prices. The estimated coefficient of the mean cost of an urban land consolidation project (Cost) was 0.224 and attained a 1% level of significance. A high mean cost implies a better overall construction plan of the area’s environment, which includes critical infrastructure renewal, road widening, increased outdoor lighting, etc. In general, the higher the mean burden rate of an urban land consolidation project, the more improved the environment in the area, and hence, the higher the expected cost-equivalent land prices. The empirical results demonstrate that the Level 2 independent variables had cross-level, direct, significant, and positive effects on cost-equivalent land prices.
Table 5. Estimation results of the intercepts- and slopes-as-outcomes regression model.

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-Ratio</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean price (lnPrice)</td>
<td>1.611</td>
<td>0.082</td>
<td>19.681</td>
<td>0.001 ***</td>
</tr>
<tr>
<td>Public infrastructure (Public)</td>
<td>0.543</td>
<td>0.198</td>
<td>2.741</td>
<td>0.016 **</td>
</tr>
<tr>
<td>Size of land consolidation area (Area)</td>
<td>0.003</td>
<td>0.002</td>
<td>2.010</td>
<td>0.062 *</td>
</tr>
<tr>
<td>Mean cost (Cost)</td>
<td>0.224</td>
<td>0.031</td>
<td>7.285</td>
<td>0.001 ***</td>
</tr>
<tr>
<td>Merger (Time)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept γ10</td>
<td>0.275</td>
<td>0.101</td>
<td>2.723</td>
<td>0.007 ***</td>
</tr>
<tr>
<td>Holding period (Duration)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept γ20</td>
<td>0.042</td>
<td>0.015</td>
<td>2.731</td>
<td>0.007 ***</td>
</tr>
<tr>
<td>Lot size (Lotsize)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept γ30</td>
<td>0.001</td>
<td>0.001</td>
<td>4.277</td>
<td>0.001 ***</td>
</tr>
<tr>
<td>Aspect ratio (Aspect)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept γ40</td>
<td>0.046</td>
<td>0.024</td>
<td>1.899</td>
<td>0.058 *</td>
</tr>
<tr>
<td>Corner lot (Corner1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept γ50</td>
<td>−0.032</td>
<td>0.063</td>
<td>−0.508</td>
<td>0.611</td>
</tr>
<tr>
<td>Corner lot (Corner2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept γ60</td>
<td>0.108</td>
<td>0.043</td>
<td>2.518</td>
<td>0.013 **</td>
</tr>
<tr>
<td>Corner lot (Corner3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept γ70</td>
<td>−0.0144</td>
<td>0.088</td>
<td>−1.643</td>
<td>0.101</td>
</tr>
<tr>
<td>Floor area ratio (Floor)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept γ80</td>
<td>0.001</td>
<td>0.001</td>
<td>3.649</td>
<td>0.001 ***</td>
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<tr>
<td>Frontage (Roadwidth)</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Intercept γ90</td>
<td>0.011</td>
<td>0.003</td>
<td>3.977</td>
<td>0.001 ***</td>
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<tr>
<td>Distance to park (Park)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept γ100</td>
<td>−0.001</td>
<td>0.001</td>
<td>−2.626</td>
<td>0.009 ***</td>
</tr>
<tr>
<td>Distance to MRT station (MRT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept γ110</td>
<td>−0.001</td>
<td>0.001</td>
<td>−2.554</td>
<td>0.011 **</td>
</tr>
<tr>
<td>Sluggish economy (Blue)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept γ120</td>
<td>0.001</td>
<td>0.040</td>
<td>0.028</td>
<td>0.978</td>
</tr>
<tr>
<td>Booming economy (Red)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept γ130</td>
<td>0.047</td>
<td>0.037</td>
<td>1.287</td>
<td>0.199</td>
</tr>
</tbody>
</table>

Random effect

<table>
<thead>
<tr>
<th>Variance</th>
<th>df</th>
<th>Chi-square</th>
<th>p-value</th>
</tr>
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<tbody>
<tr>
<td>Intercept τ00</td>
<td>0.153</td>
<td>15</td>
<td>425.272</td>
</tr>
<tr>
<td>Level 1 within-group</td>
<td>0.092</td>
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</tr>
<tr>
<td>Deviance</td>
<td>354.417</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of estimated parameters</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** represents p < 0.01; ** represents p < 0.05; * represents p < 0.1; standard errors are calculated as robust standard errors.

In terms of the Level 1 independent variables, the estimated coefficient of the city-county merge of Kaohsiung was 0.275 and attained a 1% level of significance. This shows that the mean price of cost-equivalent lands was 27.5% higher post-merge than pre-merge. Tian, Ji, Chen, and Wu [27] indicated that the objectives of city-county mergers are to promote regional economic development and to strengthen the competitiveness of central cities. Kaohsiung City and Kaohsiung County merged into the new Kaohsiung City on 25 December 2010. In the short term, rural–urban disparities may exist; however, in the long term, there are more opportunities for diverse developments in transportation and resource-sharing. The empirical results indicated that cost-equivalent land prices were higher post-merge than pre-merge.

The estimated coefficient of the holding period was 0.042 and attained a 1% level of significance. The longer the holding period, the higher the expected price. Levin and Pryce [28] established a theoretical model on housing market disequilibrium, which revealed the process of the dynamic adjustment of price and quantity, in which sellers can adjust and reserve their holding periods until the selling price is higher. The completion of a construction project in an urban land consolidation area refers to the period starting from the completion of infrastructure construction up to the completed development of
the area through various development projects. The longer the holding period, the more well-developed a development area, and the more positive the impact on cost-equivalent land prices.

The estimated coefficient of lot size was 0.001 and attained a 1% level of significance. For every one square meter increase in lot size, the expected cost-equivalent land price increased by 0.1%. Lin and Evans [33] pointed out that in Taiwan, the unit price of a lot increases with increasing lot size. A primary reason for this is because many transaction costs are required during the process of land merging. Hu [30] claimed that a larger site area offers more diverse land use options, as well as higher flexibility for the planning and design of residences. Therefore, a large site area has a positive effect on land price.

In general, a larger lot size offers more economies of scale, which should have a positive effect on the price of cost-equivalent land. The estimated coefficient of the aspect ratio was 0.046 and attained a 10% level of significance. The greater the aspect ratio, the higher the expected cost-equivalent land area price. According to Wang [32], when the frontage of a land area up for auction increases, so would the winning unit price. Nevertheless, a lot must have a certain ratio in order for it to be used easily, and it is difficult to compare the advantages and disadvantages of a lot merely through the frontage and the depth. In this study, the aspect ratio was specified as an independent variable, in which a larger aspect ratio offers better land use. The aspect ratio should have a positive effect on the price of cost-equivalent land.

The estimated coefficient of corner lots along a road with a width of 10–25 m (Corner2) was 0.108 and attained a 5% level of significance. This shows that the mean price of corner lots along a road with a width of 10–25 m was 10.8% higher than that of non-corner lots. The estimated coefficient of corner lots along a road with a width of 8 m and below (Corner1) and 26 m and above (Corner3) were -0.032 and -0.144, respectively. Neither coefficient attained a level of significance. Chen’s [6] study demonstrated the significant and positive effects of corner lots on the winning bid price. In a similar vein, Lin [7] also showed that corner lots had significant and positive effects on the winning bid price. It is generally regarded that corner lots have more commercial benefits, and that they have the ease of transportation and parking as well. Therefore, a corner lot should have a positive effect on the price of cost-equivalent land, but its benefits and usage differ according to the frontage. Moreover, corner lots adjacent to roads with different widths may be subjected to different restrictions on the construction of buildings on the lot.

The estimated coefficient of floor area ratio (Floor) was 0.001 and attained a 1% level of significance. This shows that the higher the floor area ratio, the higher the price of a cost-equivalent land area. Lin [33] also demonstrated that the land prices increase with an increasing floor area ratio. In general, a higher floor area ratio signifies that more floor spaces can be constructed, as well as relatively higher floor areas that can be planned. Therefore, floor area ratio has a positive effect on the price of cost-equivalent land. The estimated coefficient of frontage (Roadwidth) was 0.011 and attained a 1% level of significance. This shows that the wider the frontage, the higher the price of a cost-equivalent land area. Tsoodle, Golden, and Featherstone [1] investigated the accessibility of farmland to connecting roads, as well as the type and availability of roads (no road access, dirt road, gravel road, and paved road). The results showed that farmland with paved road access and dirt road access were priced higher than those with only gravel road access. A land area with a wider frontage not only enables buildings to have a better expanse of view and privacy, but also has greater potential for economic development. Moreover, frontage is also one of the factors considered in building volume control measures. The empirical results suggest that the wider the frontage, the higher the price of a cost-equivalent land area. The estimated coefficient of the distance from the land to a park (Park) was -0.001 and attained a 1% level of significance. This shows that the closer a land is to a park, the higher its price will be. The estimated coefficient of the distance from a land to an MRT station (MRT) was -0.001 and attained a 5% level of significance. This shows that the closer
a land is to an MRT station, the higher its price will be. The results of both aforementioned
variables are consistent with those in the existing literature.

The estimated coefficients of a sluggish economy and a booming economy were 0.001
and 0.047, respectively; both coefficients had positive values and did not attain any level
of significance. Bourassa, Haurin, Haurin, Hoesli, and Sun [37], as well as Smith and
Tesarek [38], consolidated the results of various studies and showed that the appreciation
of initial housing values changes with time, according to the economic situation. Tu [39]
examined real estate data pertaining to repeated transactions in the six municipalities of
Taiwan from 2012 to 2018 and showed that both the economic cycle and policy effects
were salient factors affecting changes in housing prices. The empirical results of this study
suggest that the economic situation had no significant effects on cost-equivalent land prices.

In terms of random effects, the estimated between-group variance of the intercepts τ₀₀
was 0.153 and attained a 1% level of significance. This shows that the mean price
of cost-equivalent land in an urban land consolidation area remains random after being
tested against the three Level 2 independent variables. Moreover, some of the Level 2
independent variables were not included in the model.

7. Conclusions and Recommendations

This study examined 19 urban land consolidation areas in Kaohsiung City, as well as
cost-equivalent lands auctioned off from 2013 to 2019. Hierarchical linear modeling was
used for analysis, in which the Level 1 variables pertained to cost-equivalent land and the
Level 2 variables pertained to land consolidation areas. According to the empirical results,
in terms of the estimation results of the null model, there were significant differences be-
tween the mean price of each urban land consolidation area. Therefore, HLM is suitable for
the subsequent analysis. A total of 76.7% of the differences in the mean land consolidation
area price were contributed by the differences between the land consolidation areas. There-
fore, it is important to consider the differences generated by the particular features of each
area. In terms of the estimation results of the intercepts- and slopes-as-outcomes regression
model, with regard to the Level 1 independent variables, the mean price of cost-equivalent
land had increased by 27.5% following the city-county merge of Kaohsiung. For every
one-year increase in holding period, the price of cost-equivalent land increased by 4.2%.
For every one square meter increase in lot size, the price of cost-equivalent land increased
by 0.1%. For every 1% increase in aspect ratio, the price of cost-equivalent land increased
by 4.6%. The mean price of corner lots along a road with a width of 10–25 m was 10.8%
higher than that of non-corner lots. For every 1% increase in floor corner ratio, the price of
cost-equivalent land increased by 0.001%. For every 1 m increase in frontage, the price of
cost-equivalent land increased by 1.1%. For every 1 m increase in the distance from the land
area to a park, the price of cost-equivalent land decreased by 0.1%. For every 1 m increase
in the distance from the land to an MRT station, the price of cost-equivalent land decreased
by 0.1%. With regard to the Level 2 independent variables, the mean price of urban land
consolidation areas located within the vicinity of large-scale public infrastructure were
54.3% higher than those not in the vicinity of such infrastructure. For every one-hectare
increase in the lot size of an urban land consolidation area, the mean price increased by
0.3%. For every 1% increase in the mean cost of an urban land consolidation project, the
mean price increased by 0.224%.

The ordinary least squares (OLS) approach is the most common method for the
estimation of land prices, and discussions regarding cost-equivalent land prices may only be
restricted to single or multiple land consolidation areas. The OLS approach, however, does
not consider the differences in the nested structure of the data, i.e., intergroup relevance or
interactions, and neighborhood attributes are not accounted for either; as a result, the data
does not conform to the assumption of sample independence [22]. The cost-equivalent
land areas examined in this study were located or nested within urban land consolidation
areas. The public infrastructure and construction projects within the area were all within
the same range of a planned development area, and the land areas had high similarity.
in terms of locational attributes, had spatial nesting relationships, and were suitable for hierarchical linear modeling. Previous studies were limited by the restriction to either individual or group analysis in conventional multivariate analyses. By analyzing multiple urban land consolidation areas through HLM, the characteristics of spatial organizations can be measured in a more objective and direct manner. The Level 2 (aggregate level) variables all had significant and positive effects on the winning bid price.

This study contributes to the existing literature pertaining to urban land consolidation in Taiwan. The data consisted of directly measured Level 2 characteristics of urban land consolidation projects. The results indicated that the mean cost of an urban land consolidation project positively affected the price of cost-equivalent land. This subverts the previous concepts in the assessment stage of development plans, to which the feasibility of developments that were previously not pursued due to a higher average cost should be reassessed from an objective perspective. The empirical results indicated that 76.7% of the differences in the mean land consolidation area price were contributed by the differences between the urban land consolidation areas. This highlights the significant influence of urban land consolidation areas, as the number of bids may be associated with the characteristics of the consolidation areas as well as the profitability of the bid. Therefore, the appraisal, assessment, and implementation of urban land consolidation is important for the future developments of a city.

With regard to trading strategies within the holding period of a plot of land, the empirical results of this study support Levin and Pryce’s [28] proposed process of dynamic price and quantity adjustment whereby sellers can adjust the holding period until there is a higher selling price. In general, most government departments prefer to tender off developed lands in a single go until attaining financial equilibrium. The empirical results can serve as a reference for land banking and supply–demand regulation strategies. By adopting the process of dynamic price and quantity adjustment, when financial plans attain equilibrium even if the number of new construction projects sold is gradual or the developments are yet complete, the cost-equivalent land within the area must be banked. When the market demand is greater than the supply (i.e., there is less land available on the market), the aforementioned cost-equivalent land can be made available to regulate the land supply and demand.

The reserve price is the list price of the seller, who can employ a variety of different pricing strategies. Harding, Knight, and Sirmans [45] pointed out that negotiated transactional prices are affected by the bargaining power between the buyer and the seller, as well as the particular characteristics of properties themselves. However, in public land bidding systems, there is no room for buyer–seller negotiation on the bid price. Moreover, the difference between the winning bid price and the reserve price (the premium) is associated with the pricing strategies adopted, as well as the characteristics of the bid (the profitability). In other words, the price of cost-equivalent land and the winning bid price could be associated with the strategies adopted by both the seller and the buyer (reserve pricing strategies and bidding strategies). The seller may also adopt different pricing strategies according to the economic situation when a land area was sold, the locational characteristics, and other individual-level conditions. Subsequent studies can focus on issues pertaining to the relationships between pricing strategies and land prices. According to the random effects model, the mean price of cost-equivalent land in an urban land consolidation area remains random after being explained by the three Level 2 independent variables. Moreover, some of the Level 2 independent variables were not included in the model. Future studies can include other Level 2 characteristic variables in the model for further estimation.

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