Urban Residential Land Value Analysis: Case Danyang, China

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Abstract  The research attempts to find out how the location of the CBD (central business district), the distance to the main roads, the distribution of the public facilities, and the urban land-use pattern influence the urban residential land value variations. The study begins by identifying the influences into two categories: general circumstance and micro/neighboring circumstances. Benchmark price and market land value are tested to be the results influenced by general circumstance and both the influential range and the influential force of individual land-use are investigated and compared. At last explicit case comparisons are also taken for testing the result. The finding of the research is not only useful for understanding the spatial patterns of land values, but also beneficial for the policy-makers concerning land administration and urban planning.

Keywords  urban residential land value; land value evaluation; benchmark price; spatial analysis

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Introduction

Rapid urbanization has brought drastic changes to the cities both in spatial distribution and locational characteristics of urban land, and ultimately diversified the urban land-values from site to site[1]. As one of the most important cost factors for urban residence, residential land value plays a powerfully influential role in the social and political agenda of local government[2-4]. The analysis of the spatial variation of residential land-values has significant importance for land management and urban development.

In China, the open auction market has been put into operation in recent years. However, there was still not a basis for the measurement of land values (say, enough data of previous transactions for comparison)[1,2]. As a substitute, the physical homogenous circumstance is used for valuation of the urban land-use right transactions, from which local land administration bureaus work out a kind of assessment value-benchmark price (BP). Such physical homogenous circumstance is a kind of general mass appraisal according to the location to the city centre, transportation condition, public infrastructure condition, facilities supply, general eco-environment conditions, population density, and land quality[5-7]. Although the BP can outline the general physical circumstances of an area, it comes with its natural shortage of ignoring the micro circumstances, which can decide the difference of adjacent land-values[8,9]. That is the reason of why in actual land market the BP always bias from the actual market land value.

In this research, it is intended to provide a systematic analysis of the influence of the urban land-use pattern including location of the CBD, distance to the main roads, distribution of the public facilities and the surrounding land-uses on residential land value. The study will includes both general circumstances and micro circumstances. With the application of the
geographic information systems (GIS), which can handle and process large amounts of spatial data, it is possible to associate and process large number of the land value data and locational data, and take the analysis with multi-original data\cite{6,10,11}.

1 Study area

Danyang City is a “small city”\cite{12} in the Yangtze Delta Region, which is one of the most economic success areas of China. Since Danyang’s faster urbanization started at early 1980’s, a lot of industries were developed to have brought the city a better marketization circumstance\cite{13}. However, as the urban fringe has great extended, the former industries and surrounding low-quality housing used to be welcomed by industrial labours, were gradually enveloped inside the urban area, and finally become the most embarrassment for new residential land-use.

Though for the long-run viewpoint, all these “bad” land-uses inside the urban area will be transferred to other “good” land-uses, but for the current, the nearby industry and low-quality housings are still one of the major factors to be considered in local real-estate developing, which further decided the prices in local land market.

2 Benchmark price (BP) and market land value (MLV) of Danyang

2.1 Temporal characteristic of the data

All the land value data are selected of the year of 2002, in the same year the new benchmark price has just been worked out in Danyang.

Though in the long run, the land value fluctuates according to the monetary Inflation or depreciation, land supply, etc., but such influence to the land value can be ignored in a short term such as in the range of one year. It means that for this research, the job of the correction of the data according to the temporal change can be spared.

2.2 Residential BP (RBP) of Danyang

The most recent BP is made in 2002 by the Danyang Land Administration Bureau. The circumstance of the total urban area is classified as five grades (Table 1).

| Land class | RBP/yuan \( \text{m}^{-2} \) |
|------------|-------------------|
| Residential | 845 640 511 354 275 |

2.3 MLV of residential land (RMLV)

There are totally 33 plots of residential land transactions happened in Danyang in the year of 2002. To make it clearer and more comparable with the BP, The market land value is classified into five classed according to its natural breaks (Fig.1). These five classes are as follows (Table 2).

| Classification     | Value range/yuan | Mean/yuan |
|--------------------|------------------|-----------|
| Highest value      | 1 000-1 728      | 1 465     |
| High value         | 600-999          | 789       |
| Middle value       | 450-599          | 502       |
| Low middle value   | 300-449          | 371       |
| Low value          | 0-299            | 209       |

2.4 Spatial comparison of RBP and RMLV

The 2002 RBP of Danyang is digitised as Fig.3. The RBP is divided into five classes, their distribution works as five concentric circles from the city centre further to the fringe of the city. Obviously, in deciding
the physical homogeneous zones for RBP, the location to the CBD plays the most important weight. The main roads crossing the major centre also play an important role.

The distribution map of RMLV (Fig.4) is developed by the thiessen polygon of the 33 traction samples. Differing from the regular concentric distribution of the RBP, it seems that there are no distinct rules of the distribution of RMLV can be observed if only investigate the value distribution itself. It can be found that in the city centre where are classified as the location with the highest value in RBP, there can be zones with the market land values range from the highest to the lowest value. At the same time, in the city fringe, although it is apart from the traditional city centre, the neighbouring circumvent may be more attractive for residential use.

The comparison indicates that the general circumstance itself cannot explain the exact land value. Plots were sold at the highest price in the market according to their direct circumvent. The individual characteristics of different locations play a more important role in deciding the RMLV.

### 3 General circumstance analysis model for residential land-use

#### 3.1 General circumstance analysis modeling

To settle the problems of potential non-linear relationship between dependent and independent variables in the model, the benchmark prices are transformed into common logarithms. Logarithms have the mathematical property that each doubling of the underlying data is associated with an equal increase in the logarithm[^11]. The model is of the form of the formula below:

$$\ln Y = a + \sum (b_i \times X_i)$$  \hspace{1cm} (1)

where $Y$ is the dependent variable; $a$ is the regression constant; $b_i$ is the value rating for the independent variables; $X_i$ represents the independent variables.

The following factors are used as independent variables.

- **RBP**: the benchmark price at location $i$;  
- **D_CBD**: distance to the CBD;  
- **D_MROAD**: distance to main road;  
- **D_RING**: distance to ring;  
- **D_P_SCH**: distance to nearest primary school;  
- **D_S_SCH**: distance to nearest secondary school;  
- **D_MARKE**: distance to nearest marketplace;  
- **D_RECRE**: distance to nearest recreational place;  
- **D_MEDIC**: distance to nearest hospital or clinic;  
- **D_H_IND**: distance to nearest high pollution industry;  
- **D_GREEN**: distance to nearest open green area.

To test whether the independent variables selected in this stage are suitable for explaining the generally
circumstance, four models are developed and four kinds of the variables are added step by step.  
Model 1: distance to the CBD ($D_{CBD}$).  
Model 2: $D_{CBD}$ and $D_{MROAD}$, $D_{RING}$.  
Model 3: $D_{CBD}$, $D_{MROAD}$, and distance to the public facilities ($D_{P\_SCH}$, $D_{S\_SCH}$, $D_{MARKE}$, $D_{RECRE}$, and $D_{MEDIC}$).  
Model 4: $D_{CBD}$, $D_{MROAD}$, distance to the facilities ($D_{P\_SCH}$, $D_{S\_SCH}$, $D_{MARKE}$, $D_{RECRE}$, and $D_{MEDIC}$) and $D_{H\_IND}$, $D_{GREEN}$.

3.2 Data measurement

As the measurement of general circumstance, the distance is measured as a straight-line distance interval at 400 m, about 1/5 of the radius of the urban area. While the distance to primary school, local shopping centre or marketplace, playfields are measured as the distance interval at 400 m according to the convenience standards of this facilities.

3.3 Result analysis

The Table 3 shows the result of the summary of the models.

| Model | $R^2$ | Adjusted $R^2$ | Std. error of the estimate |
|-------|-------|----------------|---------------------------|
| 1     | 0.527 | 0.511         | 0.108 3                   |
| 2     | 0.588 | 0.546         | 0.104 4                   |
| 3     | 0.885 | 0.847         | 6.064E-02                 |
| 4     | 0.887 | 0.835         | 6.286E-02                 |

Among the four models, the third model is adopted as the regression model for describing the influence of the general circumstance on the land value, since its $R^2$ is the highest and closest to 1 and it has the lowest standard error of the estimate.

It means that the variables account for 85% of the total RBP variations. There are other factors affecting general circumstance, such as the land quality and the population density mentioned in the chapter five, they can account for 15% of the RBP variations. Besides, the influence of the residential land-use is considered in the following analysis of the local circumstance, and be near to different residential land use can also means different population density in the local scale. So the variables adopted in the model can be adopted as the factors of the general circumstance.

Besides, the third model’s $F$-value is 23.112, far above the critical $F_{0.05}(8, 24)$, which means that the model is significant at 95%.

4 Micro locational characteristics and residential land value

4.1 Micro circumstance analysis modeling

Here the variable of market land values is also transformed into common logarithms. Logarithms have the mathematical property the each doubling of the underlying data is associated with an equal increase in the logarithm. Eight models are developed with different measurement of the independent variables. The model is of the form of Eq.(1)

According to the each measurement of the independent variables, individual models are developed. Altogether 10 variables are considered in as the local circumstance.

$D_{H\_IND}$: distance to high-pollution industry; $D_{L\_IND}$: distance to low-pollution industry; $D_{N\_IND}$: distance to no-pollution industry; $D_{L\_RES}$: distance to single-story residential area; $D_{M\_RES}$: distance to multi-story residential area; $D_{LQRES}$: distance to low quality residential area; $D_{COMMO}$: distance to commerce and services; $D_{GREEN}$: distance to open green area; $D_{OFFIC}$: distance to office place; $D_{TRANS}$: distance to bus/railway station.

Other independent variables analysed in the previous paragraph keep the same measurement in each models.

Totally 8 models are developed with different measurement mentioned above. The following analysis will find out which model can match the data best.

4.2 Data measurement

The measurement of the micro circumstance is evaluated by the nearest distance to different land uses. Differing from the measurement of the general circumstance, the scale is selected at small interval (the basic interval is at 50 m, which is almost the smallest length to contain a multiple-family sector, normally whose width is 12 to 16 m in China [12]). To analysis what distance does the different land-use have the most influence on the residential land value,
the first scale of each land-use has been selected as 50 metres, 100 m, 150 m, 200 m, 250 m, 300 m, 350 m and 400 m to build different models. The first scale is given the smallest value of 1 m (the influence will be immeasurable if given the value 0), which means that in this range, all the influences are directly; the distance more than 500 m is supposed to have little influence on the land value, which is given the largest value of 3 000, which is a value bigger than the radius of the city to represent the smallest influence. The tables below show the measurement of the distance to different land uses.

4.3 Model summary

Table 4 and Table 5 show the summary of the regression analysis.

| Model | First interval | $R^2$ | Std. error of the estimate |
|-------|----------------|-------|---------------------------|
| 1     | 50 m           | 0.864 | 0.169 14                 |
| 2     | 100 m          | 0.867 | 0.167 27                 |
| 3     | 150 m          | 0.836 | 0.186 13                 |
| 4     | 200 m          | 0.866 | 0.167 89                 |
| 5     | 250 m          | 0.871 | 0.165 02                 |
| 6     | 300 m          | 0.861 | 0.171 34                 |
| 7     | 350 m          | 0.891 | 0.151 86                 |
| 8     | 400 m          | 0.846 | 0.179 94                 |

The range of $R^2$ of the 8 models is very small. The result means that the all these variables can account for at least 84% of the total land value variations and at most 89% of the total land values. The remained land value variations should be explained by other factors, which is not included in the content of this research.

Table 5 Results of the analysis of variance

| Model | F-value | Sig. |
|-------|---------|------|
| 1     | 4.358   | 0.005|
| 2     | 4.471   | 0.004|
| 3     | 3.480   | 0.013|
| 4     | 4.433   | 0.004|
| 5     | 4.613   | 0.004|
| 6     | 4.299   | 0.005|
| 7     | 5.571   | 0.001|
| 8     | 3.771   | 0.009|

Also the result shows that in all eight models, the total regression works well, as the $F$-statistic is greater than the critical $F$-value and the significance value of the $F$-statistic is also very confident (the largest Sig. value is 0.013).

4.4 $B$-coefficient analysis of the influences of different neighboring land-uses

The parameter estimates of proximity to different land-uses by using distance intervals are shown in Fig.5. The $B$-coefficients represent how much importance each independent variable contributes to the dependent value. With different measurements, variables appear different behaves in different models, which represent the different importance of these variables in deciding the neighboring residential land values in different distance scope. The $t$-value measures the significance, or importance of the variable is measured by $t$-value.

![Fig.5 $B$-coefficient analysis of different land-use](image-url)

Then, for each individual independent variable, the variation of the $B$-coefficient in different models is shown in linear figures, which indicates the different influential force of the same land use when given the most importance to different distance range. The positive $B$-coefficient value means the influence of the land use is negative, that is, with the distance increasing, the surrounding residential land value also increases. The high coefficient value indicates that such negative influential force is high.

The following table (Table 6) is the summary of the figure analysis above.

4.5 Main roads and rings in the analysis of local circumstance

Though the distance to the main road and rings can still be regarded as the general circumstance as mentioned in the former analysis, in the micro scale, the influence of the main roads and rings can be figured out. In the local sense/micro scale, both of the rings
Table 6  Influence of different land uses

| Variable | Most influential range | B-coefficient | Measurement of the influence |
|----------|------------------------|---------------|------------------------------|
| D_L_IND  | 300 m                  | 0.396         | ♦ ♦                         |
| D_N_IND  | 350 m                  | -0.411        | ★★                         |
| D_L_RES  | 250 m                  | -0.644        | ★★★                         |
| D_M_RES  | 100 m                  | 0.157         | ♦                           |
| D_LQRES  | 100 m                  | 1.452         | ♦ ♦ ♦ ♦ ♦ ♦                  |
| D_COMME  | 250 m                  | -1.124        | ★★★★                       |
| D_GREEN  | 300 m                  | -0.692        | ★★★★                       |
| D_OFFIC  | 250 m                  | -0.934        | ★★★★                       |
| D_TRANS  | 100 m                  | -0.160        | ♦                           |

and main roads are the direct and main measurement of the accessibility. The influence of rings and main roads should be included in when analysis the residential land value in local scale.

In the analysis of the residential land value in local scale, the influence of the nearby main road and rings will be used as a complement other than the influences of different surrounding land-uses. Considering most of the samples are nearby the main road or rings, to simplify the following analysis, here only the range of 51-200 m to the main road and rings is investigated. Inside this range, the distance is classified into four grades interval at 50 m, the same measurement as analysis in the general circumstance. The distance outside the range is given less emphasis (Table 7).

Table 7  Grading of the influence of main road in local sense

| Distance/m | 1-50 | 51-100 | 101-150 | 151-200 |
|------------|------|--------|---------|---------|
| Grade      | ★★★★ | ★★★★  | ★★★★  | ★★★★  |

Generally, when it has easy accessibility to more than one main road, it may mean more convenience. As a non-normalized criterion in the road design in China, every 200 m there should be an access to the main road. That means the distance less than 200 m can be regarded as a willing distance for the walking, especially in Danyang automobile is not the prevailing method for private transport. That’s why the range of 200 m is counted in this research.

5 Case study

5.1 Case selection

The land value of the 33 samples(Fig.2) of this research is shown in Fig.6. In this figure, the 33 samples are classified into five classes according to their RBP. As mentioned in the previous analysis, the RBP is an average value of certain zones that are regarded to have the same general circumstance. So it appears as intervals (horizontal lines). The market land values of the samples are represented as points.

In the general sense, the land prices should be similar in the same territory (e.g. 3-5-6-8-10, 4-7, and 30-31-32-25, etc.). But there are still some cases with the similar/nearby location but have distinctly different land values (e.g. 1-12, 21-22, and 26-29, etc.). The following analysis select typical cases and analysis their local/neighbouring circumstance to answer the difference.

Fig.6  Value distribution of 33 samples

For each zone, one pair of cases is selected for the comparison. They are: ① 1-12 in the zone 1; ② 11-2 in the zone 2; ③ 21-20 in the zone 3; ④ 29-26 in the zone 4.

5.2 Case comparison

The result of the spatial analysis and tabular comparison of four selected cases shows that the micro circumstance or the surrounding different land-uses and nearby main roads/rings provide important contribution to residential land-values.

All the four comparisons show that location with better marks in both the influence of the surrounding land uses and location to the main road/ring have the prevailing high land value. The good match between land-values and total-marks in all case studies proves that the measurement of the influence of the different land-uses is correct.
6 Conclusions

Through regression statistic analysis and spatial analysis in GIS, the study has confirmed and measured out the influences of the main variables on the spatial characteristic of the urban residential landvalues in Danyang.

1) The spatial variation of urban residential land value is influenced by the spatial land-use pattern

2) The influence of the spatial land-use pattern can be divided into general circumstance and micro/neighbouring circumstance for the urban residential land value

3) Different land uses have different influential range on the surrounding residential land value

4) The influential forces of different land uses are also different

The study will be helpful for improving the land valuation thus make the land market more efficient, which should bring faster market correction and reducing the state’s risks in the urban land-use right transactions.

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