The Unity Valuation Approach in Mass Appraisal of Real Properties:
 aCase Study for Shenzhen

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Key words: Real estate, Mass appraisal, Unity valuation, Model

SUMMARY

For the last two decades, China has achieved high economic growth, accompanied with rapid
development and a series of problems in real estate markets. In order to promote a healthy real
estate market, some cities in China began their studies and practice in mass appraisal of real
properties for transaction tax purposes. Mass appraisal (MA) has been used worldwide by
most assessment jurisdictions to provide estimates of market values for more than fifty years. However, different from the real estate markets in developed countries, traditional mass
appraisal techniques are hard to be implemented due to the varied characteristics in the real
estate markets of China. This paper investigates the characteristics of the real estate markets
of China and innovatively comes up with the Unity Valuation Approach based on the
traditional mass appraisal techniques. Then with an empirical analysis based on the practical
experiences in Shenzhen City of China, the results demonstrate that the Unity Valuation
Approach is acceptable and reliable. Our findings also suggest that this approach is also
applicable and helpful to countries or areas where transaction volumes are sufficient.
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1. INTRODUCTION
Over the last two decades, China has experienced rapid and stable economic growth. Although the financial crisis has substantial impact on the real estate markets of most countries in the world, it had little impact on the real estate markets in China. As a result of the rapid economic growth and urbanization, demands for new dwellings have increased rapidly, leading to the rapid growth of housing prices. In the context, along with the increasing transaction volume of real estate markets, “Yin and Yang” contracts have become a major mean to avoid paying transaction tax. In addition, the fluctuations in housing prices not only affect the fortunes of many corporations and households but also play an important role in the macroeconomic level. All of these issues would bring serious problems to the real estate markets in China. In order to promote a healthy environment and the tax reform, Chinese government has put forward the regulation that all municipal governments should adopt the assessed value as the tax base for transaction purposes. Therefore, some cities in China have started the studies and practice of mass appraisal for transaction tax purposes.

The mass appraisal technique was developed to enable assessors to accomplish the challenging task of estimating a value for each of the thousands of properties in their jurisdictions (IVSC, 2007). The International Association of Assessing Officers (IAAO) published “Standard on MA of Real Property”, defining MA as: the process of valuing a group of properties as of a given date using common data, standard methods, and statistical testing (IAAO, 2013; USPAP, 2006). In plain words, mass appraisal solves the problem of estimating a large number of properties at one time. However, because of the complexity involved in different types of properties and different basics in appraisal data, assessors tend to conduct different techniques. IAAO summarized five different calibration techniques for mass appraisal: Multiple Regression Analysis (MRA), Adaptive Estimation Procedure (AEP), Artificial Neural Networks (ANN), Time Series Analysis (TSA) and Tax Assessed Value Model (TAVM)(Kauko and D’Amato, 2008). Each calibration technique has its own advantages and disadvantages. Being a mature technique, MRA is considered to be very efficient which has been widely used and applied in US, Canada and Hong Kong (Woolery and Shea, 1985; Steven and Albert, 2009; Kauko and D’Amato, 2010). However, MRA may not be an ideal technique for anyone since it requires high accuracy and completeness of databases. To me more precise, there are a series of strict assumptions to comply with: 1) linear relationship between variables; 2) normally distributed error terms with consistent variance; 3) no multicollinearity; 4) random samplings and so on. In reality, however, most actual situations fail to meet all of these requirements and assumptions (Gloodemans, 1999). For example, historical trading data are representative (such as trading frequencies are not consistent in different areas). The factors affecting housing prices are quite complex which keep changing over time. In China, these kinds of situations are considered to be normal which might be very different from those in other countries. Furthermore, the types of real properties are complex and the accumulation of basic data of
real estate is relatively scarce. Therefore, it is almost impossible to meet all requirements where MRA is hard to be implemented in the cities of China.

Currently, most of the existing practical experiences in China just learn and imitate the advanced international experiences (Song and Chang, 2009). Very few refer to the study of mass appraisal methods based on different types of real properties (Ji and Fu, 2005; Zhou, 2005). In this context, it is important to conduct a further study of mass appraisal approach and model based on the characteristics of urban real properties, data and technical conditions in China. This paper proposes the Unity Valuation Approach (UVA) so as to solve the problems in China as well as to achieve a high precision and low-cost valuation target.

2. AN ANALYSIS OF THE REAL ESTATE MARKETS IN CHINA

Compared with the real estate markets in western developed countries, the real estate market in China differs which construction types are distinctively characterized as follows:

—*The development intensity is deeper and high-density real estate projects have become mainstreams.*

According to the official real estate statistics in Shenzhen, by the end of the year 2012, high-rise residences account for more than 85% of the registered properties while retail shops take up to 80% of the registered commercial properties in Shenzhen. This is quite different from the situation in western developed countries such as U.S. and Canada where detached houses are the majority type. However, although the homogeneity degree is lower in China, it’s quite reasonable that we can divide our market into several smaller ones such as we consider a residential community or commercial block as an appraisal division. Because the range is smaller, the discrepancy between real estate attributes are smaller. As a result, the precision of the predicted model is higher.

—*Mixed utilization of land is quite common.*

The clear and single-functional usage of land is quite common in many western countries while in China, the mixed utilization of land is quite common. Residential and commercial, commercial and office, office and residential are the most common cases. As the mixed usage of land is popular, the results of MRA are often difficult to pass a result test and the fitness of model is very low.

—*The real estate market is active while the land market is relatively inactive.*

As is known that the population of China is very huge, with the strong appetite of possessing their own houses, the transaction frequency of real properties is also high. Take Shenzhen for example, in the 11th-five plan, an average of 98.3 thousand second-hand residential properties are traded every year which takes about 9% of the total second-hand residential properties. For commercial properties, about 60% of commercial properties have been leased in Shenzhen every year. Due to the state-owned land policy, the transaction volume in land market is very small. Only about 0.1% of the total land has been traded annually. Taking all of these characteristics in into account, the mass appraisal approach to be conducted in China should mainly rely on the sales comparison approach.

—*The basic data of real properties are incomplete.*

Many cities in China started to build their real estate information systems several years ago. The accumulation of real estate data are insufficient and the databases are still incomplete. Information sharing mechanisms have not been established should be one of the reasons.

The Unity Valuation Approach in Mass Appraisal of Real Properties: a Case Study for Shenzhen, (6799) 3/12

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property data are the foundation of mass appraisal, the collection of data in some cities are very difficult and mainly rely on private assessment companies. In this way, the quality of data is usually difficult to guarantee.

Based on the property characteristics in China mentioned above, according to the appraisal principles, we introduce the UVA to implement the mass appraisal in China.

3. METHODOLOGY

Just as mentioned above, the appraisal approach should be based on the sales compare approach. The appraisal parameters should be flexible and the appraisal approach should not completely rely on the MRA. Instead, the approach should combine the qualitative analysis with the quantitative analysis. This is how UVA is conducted.

3.1 Model Specification

According to the basic principles of real estate valuation, all real estate units can be considered as a unity within a certain range. Although each unit is unique and heterogeneous, there is still an inter-connection in prices between real estate units which means that a price change of one real estate unit affects the prices of other real estate units. However, this kind of influence on the price is greater on the real estate units which are more similar with the price changing unit. By assuming that the inter-connection relationship remains unchanged in a certain period, when a new group of transaction prices have been obtained, all the real estate can be appraised through the inter-connection relationship and the level of influence on price.

3.2 The Definition of UVA

We define the adjustment coefficient $\alpha_{ij}$ to reflect the price relationship between real estate unit $i$ and $j$. Also, we use the weight value in the same appraisal set to reflect the influence degree of different real estate units. When a new group of transaction prices have been obtained, all the real estate units can be appraised by the UVA.

\[
\Phi \cdot P_{\text{transaction}} \cdot B = P_{\text{appraisal}}
\]

Where the $\Phi$ is the matrix of adjustment coefficients:

\[
\Phi = \begin{bmatrix}
\alpha_{11} & \cdots & \alpha_{1i} & \cdots & \alpha_{1n} \\
\vdots & \ddots & \vdots & \ddots & \vdots \\
\alpha_{ni} & \cdots & \alpha_{nj} & \cdots & \alpha_{nn}
\end{bmatrix}_{n \times n}
\]

\[a_{ij} = \frac{p_i}{p_j}\]

$P_{\text{transaction}}$ is the matrix of transaction prices:

\[
P_{\text{transaction}} = \begin{bmatrix}
p_1 \\
\vdots \\
p_n
\end{bmatrix}_{n \times n}
\]
Set the $P_i = 0$, if the price of property $i$ is none in the calculation period. $B$ is the influencedegree of price matrix:

$$B = \begin{bmatrix}
w_{11} & \cdots & w_{1l} & \cdots & w_{1n} \\
\vdots & \ddots & \vdots & \ddots & \vdots \\
w_{kl} & \cdots & w_{kl} & \cdots & w_{kn} \\
\vdots & \ddots & \vdots & \ddots & \vdots \\
w_{nl} & \cdots & w_{nl} & \cdots & w_{nn}
\end{bmatrix}_{n \times n}$$

$w_{kl}$ is the influence degree of prices relationship between unit $k$ and $l$. And set $w_{kl}$ as follows:

$$\sum_{l=1}^{n} w_{kl} = 1$$

$P_{\text{appraisal}}$ is the final appraisal price matrix:

$$P_{\text{appraisal}} = \begin{bmatrix}
P_1 \\
\vdots \\
P_n
\end{bmatrix}_{n \times 1}$$

So the UVA can be expressed as the following matrix:

$$\begin{bmatrix}
\alpha_{11} & \cdots & \alpha_{1n} \\
\vdots & \ddots & \vdots \\
\alpha_{n1} & \cdots & \alpha_{nn}
\end{bmatrix}_{n \times n} \cdot \begin{bmatrix}
P_1 & \cdots & 0 \\
\vdots & \ddots & \vdots \\
0 & \cdots & P_n
\end{bmatrix}_{n \times n} \cdot \begin{bmatrix}
W_{11} & \cdots & W_{1n} \\
\vdots & \ddots & \vdots \\
W_{n1} & \cdots & W_{nn}
\end{bmatrix}_{n \times n}$$

$$= \begin{bmatrix}
\sum_{i=1}^{n} \alpha_{1i} P_i W_{i1} & \cdots & \sum_{i=1}^{n} \alpha_{1i} P_i W_{in} \\
\vdots & \ddots & \vdots \\
\sum_{i=1}^{n} \alpha_{ni} P_i W_{i1} & \cdots & \sum_{i=1}^{n} \alpha_{ni} P_i W_{in}
\end{bmatrix}_{n \times n}$$

Formula (1)

It should be noted that the $\sum_{i=1}^{n} \alpha_{ij} P_i w_{ij}$ means the prices of the appraisal objects are obtained by weighted prices of transaction objects. When the subscripts $i$ and $j$ of $a$ and $W$ are different from each other, it indicates that the adjustment coefficient is not correspondent with each other and this is meaningless. Therefore, only prices on the diagonal in the formula (1) have practical meanings. In order to have a more clear relationship between different properties, the formula (1) is changed as follows:

$$\begin{bmatrix}
\sum_{i=1}^{n} \alpha_{1i} P_i W_{i1} & \cdots & 0 \\
\vdots & \ddots & \vdots \\
0 & \cdots & \sum_{i=1}^{n} \alpha_{ni} P_i W_{in}
\end{bmatrix}_{n \times 1} = \begin{bmatrix}
\sum_{i=1}^{n} \alpha_{1i} P_i W_{i1} \\
\vdots \\
\sum_{i=1}^{n} \alpha_{ni} P_i W_{in}
\end{bmatrix}_{n \times 1} = \begin{bmatrix}
P_1^* \\
\vdots \\
P_n^*
\end{bmatrix}_{n \times n}$$

Formula (2)

For any real estate unit in the same appraisal set, the appraisal value is calculated by the following formula:

$$P_i^* = \sum_{j=1}^{n} \alpha_{ij} P_j w_{ij}$$

3.3 The Procedure of UVA
In order to implement the UVA, the following procedures are then introduced.

3.3.1 Identifying the appraisal sets
The appraisal set is the premise of unity valuation and it is also the scope to construct the system of adjustment coefficients. Properties in different appraisal sets must not participate in the calculation. It is noted that the properties in the same set are comparable which is considered to be a collection of similar real estate units. An appraisal set is made up of a group of similar properties which have similar characteristics on entity attributes, rights and interests, location and so on. Because the price influencing factors of different types of real estate are different, we set a series of different conditions for different types of real estate. In general, we can identify appraisal sets by type, location, right and quality of the real estate.

3.3.2 Establishing the system of adjustment coefficients
The adjustment coefficients are the core of UVA. The inter-connection of prices (rent or transaction price) can be obtained in the same appraisal set by adjustment coefficients.

3.3.3 Setting weight values
Generally speaking, rational consumers will have the same price expectations on similar properties. When we determine the weight values of different real estate units, we should follow the principle as “the higher the similarity between different real estate units, the higher the weight values”. Even for the same type of properties, because of the discrepancy on attributes which are reflected on prices, they can be considered as different products meeting the needs of different consumers. Therefore, we use the proximity to measure the degree of similarity between different real estate units. As the proximity is still a fuzzy concept, the quantification still needs the assumptions, simulation and techniques.

3.3.4 Acquiring transaction data
This is the most fundamental step of UVA. Data acquisition should be consistent and accurate. In order to ensure the accuracy of data, elimination of abnormal values, data processing and correlation are necessary.

In light of the importance and complexity of adjustment coefficients, this paper further elaborates on them as follows.

4. THE CONSTRUCTION OF ADJUSTMENT COEFFICIENTS
Adjustment coefficients are the core and basis of the UVA. Only through the adjustment coefficients, the price relationship between real estate units is reflected. Based on adjustment coefficients, the city's real estate units are no longer isolated, but interconnected and have formed a network of price relationship. By identifying appraisal sets, each appraisal set is consistent and has a certain degree of substitutability. Therefore, we can use the microscopic differences between the attributes of real estate units to reflect their different effects on real estate prices. As a result, the adjustment coefficients have formed.

Therefore, the construction of adjustment coefficients requires an in-depth study on each appraisal set with similar properties in the early stage. Next, we need to find out the main factors affecting prices and the degree of impact on prices. Then, the adjustment coefficients are identified by comparing the attribute differences of real estate units with those of standard property.
The range of constructing the adjustment coefficients is internal. As the process of identifying an appraisal set has already taken the location factors into account, the construction of adjustment coefficients mainly considers the individual factors. For residential properties, we should include floor no, orientation, layout. For street shops, floor no and width of facing street should be considered. For each attribute, there is a corresponding adjustment coefficient which is shown as follows:

\[ S = 1 + \sum_{i=1}^{m} J_i X_i \]

\( S \) represents the adjustment coefficient while \( J \) represents the attribute difference between the estimated real estate unit and the standard real estate unit. \( X \) is the \( i \)th unit factor affecting the price. For example, for the factor of floor no, within a certain appraisal set, the floor no increases by one floor, the price is raised by 1%. If a real estate unit is on the 12th floor, the standard unit is on the 10th floor, with other properties remain the same, the adjustment coefficient of estimated real estate unit is \( 1 + (12 - 10) \times 1\% = 1.02 \).

The attribute values can be obtained from either a hedonic price model or appraisers’ experiences depending on the sufficiency of data within an appraisal set. When there are sufficient amount of data in an appraisal set satisfying the basic requirements of multiple regression analysis, quantitative analysis along with qualitative analysis are more proper. However, in the absence of enough data in an appraisal set, qualitative analysis will be the major method to be used.

Therefore, if there is an appraisal set \( A \) which has \( n \) real estate units \( A_1, A_2 \ldots A_n \). There are \( m \) factors affecting the price respectively. We define the matrix

\[
J = \begin{bmatrix}
j_{11} & j_{12} & \ldots & j_{1m} \\
j_{21} & j_{22} & \ldots & j_{2m} \\
\vdots & \vdots & \ddots & \vdots \\
j_{n1} & j_{n2} & \ldots & j_{nm}
\end{bmatrix},
\]

\[
X = \begin{bmatrix}
x_1 \\
x_2 \\
\vdots \\
x_m
\end{bmatrix},
\]

\[
I = \begin{bmatrix}
1 \\
1 \\
\vdots \\
1
\end{bmatrix}
\]

Matrix \( J \) is \( m \times n \) which is the attribute differences between one real estate unit and the standard unit. Matrix \( X \) is an \( m \times 1 \) attribute coefficient matrix. Matrix \( I \) is an \( n \times 1 \) constant column vector. Thus, the adjustment coefficient matrix \( S \) is

\[ S = JX + I, \]
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Yan Li and Mengting Wang (China, PR)

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From the formula above, $S_1$ is the adjustment coefficient of the subject real estate unit referring the standard real estate unit. Similarly, $S_n$ is the adjustment coefficient of the $n^{th}$ real estate unit.

5. CASE ANALYSIS

The housing transaction data of the Central District of Shenzhen will be used to employ a unity valuation analysis in order to test the validity and practicability of the approach.

First of all, according to the principles of identifying the appraisal sets of similar real estate units, the residential ordinary properties in the Central District which building age is less than 10 years are considered to be in the same appraisal set. For ordinary units, we construct the system of adjustment coefficients from building, community and set gradually. Taking a community area within an appraisal set as an example. The community is consisted of four buildings. For each building, there are 28 floors and 6 households on each floor. Firstly is to establish the adjustment coefficients within a building. Table 1 shows the transaction prices and some attribute information of some of the apartments in building No 1. In order to ensure the price information to be comparable, all prices in Table 1 have been adjusted to the December, 2011 level.

<table>
<thead>
<tr>
<th>Room No</th>
<th>Floor</th>
<th>Layout</th>
<th>Time-adjusted Price (Yuan/m²)</th>
<th>Gross Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>16E</td>
<td>16</td>
<td>E</td>
<td>37671</td>
<td>123.67</td>
</tr>
<tr>
<td>25B</td>
<td>25</td>
<td>B</td>
<td>37486</td>
<td>123.66</td>
</tr>
<tr>
<td>6E</td>
<td>6</td>
<td>E</td>
<td>35929</td>
<td>123.67</td>
</tr>
<tr>
<td>7F</td>
<td>7</td>
<td>F</td>
<td>35139</td>
<td>177.44</td>
</tr>
<tr>
<td>10A</td>
<td>10</td>
<td>A</td>
<td>35968</td>
<td>168.78</td>
</tr>
<tr>
<td>13C</td>
<td>13</td>
<td>C</td>
<td>36058</td>
<td>86.97</td>
</tr>
<tr>
<td>9F</td>
<td>9</td>
<td>F</td>
<td>35953</td>
<td>177.44</td>
</tr>
</tbody>
</table>

Since there are sufficient trading data and comprehensive attributes in this building, we can apply a hedonic price model to determine the adjustment coefficients of the building. According to our research results, the building is a high-rise residential building with ordinary real estate units. The layout distributions on each floor are consistent and each apartment layout has a fixed position, size and orientation. Therefore, the layout variable can replace those three variables. By setting the time revised price as independent variable and the floor, layout variables to be dependent variables for multiple regression analysis, the regression results of linear model are listed in Table 2.
The regression results show that the price difference on floor variable is 192 Yuan. Apartment layouts A, B, F are at similar price levels. Compared with the layouts A, B and F on the same floor, layout C is 1492 Yuan higher, layout D is 1802 Yuan higher and layout E is 1640 Yuan higher. Thus, it is reasonable to choose the layout C on the 14th floor as the standard unit. Then the prices of each unit can be calculated by the regression results and the adjustment coefficients between each unit and the standard unit are determined. Some of the adjustment coefficients are indicated in Table 3.

Similarly, we apply the same approach to establish the adjustment coefficients between buildings in a community and between communities within the appraisal set which are shown in Figure 1. Based on these adjustment coefficients, as the real estate units within an appraisal set are similar real estate units, the weight values should be set equal to 1. Then, it is accessible to employ the mass appraisal approach to assess the 11206 real estate units in this appraisal sub-division.
In order to test the validity of the model, IAAO Standards (2010) are used to test the appraisal results. The total number of testing sample is 1579 and the results are shown in Table 4.

From Table 4, we can see that the results of ratio studies meet the IAAO standards. The difference between the appraisal results and the market prices are less than 2%. The dispersion of results is also low. Moreover, PRD result shows that each type of appraisal results is consistent.

<table>
<thead>
<tr>
<th>Type</th>
<th>Central Tendency</th>
<th>COD</th>
<th>PRD</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAAO Standards (2010)</td>
<td>0.90-1.10</td>
<td>5-10</td>
<td>0.98-1.03</td>
</tr>
<tr>
<td>Results</td>
<td>0.982</td>
<td>6.0</td>
<td>1.008</td>
</tr>
<tr>
<td>Conclusion</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4: Ratio Analysis**

**6. CONCLUSION**

Based on the characteristics of the real estate markets in China, this paper puts forward to an applicable mass appraisal technique to the real estate markets in China. Meanwhile, the transaction data of Central District of Shenzhen were used to carry out a case study and a ratio analysis. The results prove that the unity valuation model in this study is accessible. At present, the results of the model which are the assessed values of the real estate in Shenzhen have been applied to the real estate transaction tax collection and management. Overall, the social effect is satisfactory which dispute rate is below 1%.

Although the application results have confirmed the validity of the model, it is still necessary to pay attention to the premise and hypothesis. As is mentioned above, this model assumes that the prices of similar real estate units within an appraisal set are interconnected. If there is a large fluctuation occurred in the real estate markets, it may break the current relationships.
between the real estate prices. At this stage, the system of adjustment coefficients needs to be revised and even reconstructed. In addition, if there is a substantial change taking place at housing attributes, such as the landscape of a unit disappears due to the occlusions. At this point, adjustments need to be made as well.

Although this model is built based on the characteristics of the real estate market in China, it does not mean that the application of the model is only effective in the real estate markets in China. For real estate markets where sales comparison approach is applicable and sale data are sufficient, the unity valuation model is also accessible and rapid with a prosperous application.

REFERENCES


BIOGRAPHICAL NOTES

Dr. Yan Li is a senior researcher and the chief administration of Tax Assessment Department in the Center for Assessment and Development of Real Estate, Shenzhen. She received her PH.D degree in engineering administration from Harbin Institute of Technology in China. Her research work focuses on real estate market analysis and mass appraisal of real properties.

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