Real Estate Appraised Model Based on GIS and VIKOR Method

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Abstract

The need for property mass appraised imposed by the information-based for the current property tax, property mass appraised model what is composed GIS and VIKOR method was proposed. Firstly, the factors affecting House prices were quantified by using GIS spatial analysis methods, secondly, combined with quantitative values, it calculated the price's influence factor of weight with Entropy method. Thirdly, real estate mass appraised model was built by VIKOR method. Fourth, appropriate real estate valuation system was developed who based on this real estate mass appraised model. By using this system, five appraised real estate of Ganzhou were estimated. And the calculated real estate prices are close with the actual trade prices. It can be showed that the model had high accuracy, so this model will has a wide range of applications' prospect in terms of rapid mass appraised real estate, and it can provide technical support for the levy of estate duty.

Keywords

Real estate valuation; VIKOR; GIS; model.

1. Introduction

Property tax policy in Shanghai and Chongqing has firstly tried for three years, pilot results were contested. Property taxes focused on the construction of long-term mechanism of the property market. Playing an important role in market regulation has been a growing number of people in the industry consensus [1]. Property tax policy having been implemented after nearly three years, to reform the real estate tax system has become an inevitable trend. At present, the promotion of the real estate registration regulations is formulated into a practical phase, which will prepare for expansion of the future property tax pilot. Nowadays, property tax of Shanghai and Chongqing collection means explicitly temporary price as the taxable value of real estate transactions, and when conditions are in accordance with the assessment value. Real estate tax assessment value is more scientific, but mass appraised on property value needs high technical requirements [2]. Therefore, to explore real estate mass appraised model of information has become serious problem [3]. Some scholars applied to real estate mass appraised with smart algorithm such as neural networks [4-5] and support vector machine [6], and achieved good results. However, as there are many variables involved in the real estate appraised, complex variables and price, these intelligent algorithms have a strong data dependent, and assess the accuracy of some volatility [7]. Multiple attribute decision method which is compromise and linear standard (VIKOR) was proposed by Opricovic and Tzeng, which group benefits can be maximized and opposition unfortunately minimized, also can improve the data-dependent problems [8-9]. Liu Hongyan [10] applied to a property price evaluation with the method and proved the validity of the method. But quantification of impact factor relies mainly on expert marking in real estate prices in this method. So

subjectivity remains affect the accuracy of the model. In recent years, some scholars had applied geographic information system (GIS) technology in extraction and quantification of factors affecting House prices [11-14]. This technology can greatly improve the accuracy of quantification factor. With the combination of GIS technology and theory of VIKOR, blending the advantages of both, a new real estate mass appraised model and its application is built, which will be able to provide technical support for the real estate tax system reform.

2. Build Assessment Model

2.1 Ideas of Building Model

Establishment of evaluation model is shown in Figure 1. Firstly, to set up a transaction case database and an appraised real estate library based on data from transaction case and estimated property. Combined with powerful GIS data management capabilities, application input and managed property information. Geospatial location of the trade cases was represented by a point on the map. So the transaction case database and appraised real estate library can be set up. Secondly, to be appraised real estate as a Center, application search around a range of trade cases. It can find N comparable transaction case by rules, which the type property and the property structure of search cases are the same as the real estate. If the screening result is less than n, or you need to expand your search radius to increase trade cases, until the transaction case number is over N. Comparable transaction case and appraised real estate case are quantified by the quantitative rule. The quantitative results are saved to the database. Thirdly, reading the quantitative impact factor values in the database, entropy weight method is used to calculate the price factor weights. While comparable trading case is corrected deal time, and comparable transaction cases price of time are modified as the same time of the current estimated property prices. Lastly, correlation coefficient of VIKOR method, such as Hamming distance weighted, weighted Chebyshev distance, and interest rates, are calculated. Based on sorting results which interest rates is sorted from smallest to largest by bubble sort method. So depending on the appraised property sorted result of interest rates, the estimated real estate prices can be calculated by linear interpolation. The critical points of the process are to quantify factors impact on housing prices, calculate weight and construct the VIKOR method of valuation model.

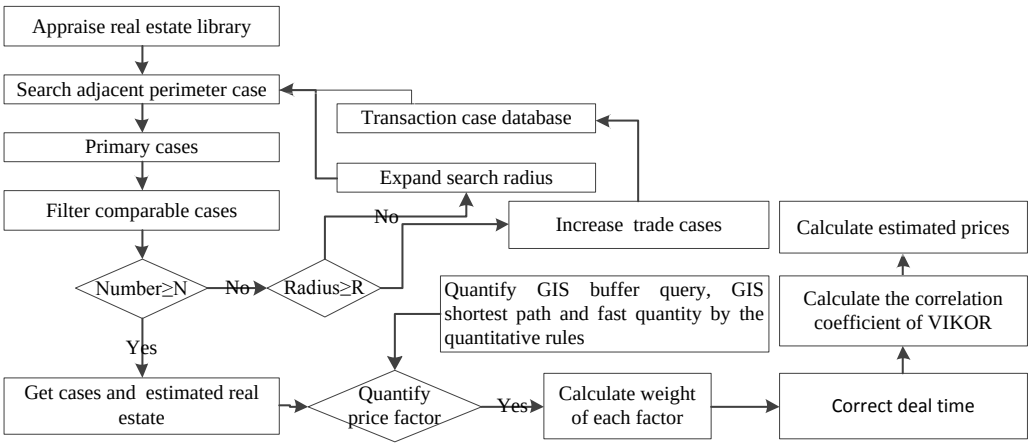

Figure.1 Logic diagram for Evaluation model

2.2 Confirm and Quantify Real Estate Price Impact Factor

According to the literature [12-14], real estate price impact factors and quantitative methods can be sure as table 1.In this table, from P1 to P6 stand impact of location on housing price in real estate area, from P7 to P15 stand impact of housing qualifications on housing price. Using GIS analysis to quantify the real estate, the same factors on different distances [13] have different effect on the housing price. So this model uses a hierarchical buffer query method to quantify. Depending on the degree of setting different values to quantify, quantifiable results can be more objective and reasonable.

Table.1 Real estate price impact factor and Quantitative methods

Housing Price Impact Factor	Quantitative Method of Housing Price Impact Factor
Distance To CBD(*P1*)	Shortest distances to the city center, 10 points for 0 to 5 km; 8 points for 5 to 10 km; 5 points for 10 kilometers away.
Transportation Convenience(*P2*)	Each with 1 point for bus stations within 500m ; Each with 0.5 point for bus route through the site; 2 points for near the main road; Each with 0.6 point for bus stations and bus routes through the site from 500m to 800m, top 10 points.
Supporting Education(*P3*)	3 points for kindergarten within 600m; 2 points for primary school and university; 1 point for kindergarten, primary school, university around the house from 600m to 1000m, top 10 points.
Sports Facility(*P4*)	Each with 1.5 points for playground, stadium, library and theatre within 600m; Each with 1 point for playground, stadium, library and theatre around the house from 600m to 1000m, top10 points.
Supporting Life(*P5*)	Each with 1.2 points for supermarket, bank, shopping mall, hospital, farm within 600m; Each with 0.8 point for supermarket, bank, shopping mall, hospital, farms around the house from 600m to 1000m,top 10 points.
Natural Environment(*P6*)	Each with 5 points for park and river within 1000m around the house; Reduce each with 1 point for highway, railway, urban main road within 500m, top 10 points.
Building Facilities(*P7*)	Each with 3 points for water and electricity; Each with 1 point for gas, broadband, TV, air-conditioning, parking, communications, anti-theft prevention, clean, top 10 points.
New Rate(*P8*)	With 8-10 points for good condition; With 6-8 point for basic good housing; With 4-6 point for general damage to the housing; Under 4 points for serious damage to the housing and dangerous rooms.
Apartment(*P9*)	With 10 points for more than 3 rooms 2 halls and 2 guards; With 8 points for 3 rooms 2 halls and a guard; With 6 points for 2 rooms 2 halls and a guard; With 4 points for 2 rooms a hall and a guard; With 2 points for others.
Towards(*P10*)	With 10 points for south; With 8 points for southeast, southwest, north and south; With 6 points for east; With 4 points for west, northeast; With 2 points for north.
Floor(*P11*)	No elevator: With 10 points for layer 3; With 8 points for layer 4; With 6 points for layers 2 and 5; With 4 points for layer 1; With 2 points for the top. Elevator: With 10 points for layers 25 above; With 8 points for layers 19 to 24; With 6 points for layers 13 to 18; With 4 points for layers 7 to 12; With 2 points for layers 1 to 6.
Community Environment(*P12*)	With 10 points for optimal: more than 30% green rate, very quiet; With 8 points for better: 20% - 30% green rate, quiet; With 6 points for general: 15% - 20% green rate, no noise; With 4 points for inferior: 10% - 15% green rate, big noise; With 2 points for bad: Less than 10% green rate, seriously noise..
Property Management(*P13*)	With 10 points for optimal: First-level management, all day security patrol, video monitoring. With 8 points for better: Second-level management, all day security patrol, and video monitoring. With 6 points for general: Second-level management, security patrol. With 4 points for inferior: Third-level management. With 2 points for bad: no management.
Ventilation and Lighting(*P14*)	With 10 points for optimal: Average 8 hours sunshine per day, window wall area above 1/3,air convection; With 8 points for better: Average 6 hours sunshine per day, window wall area above 1/4, air convection; With 6 points for general: Average 5 hours sunshine per day, window wall area above 1/5,no air convection; With 4 points for inferior: average 2 hours sunshine per day, window wall area above 1/7,no air convection; With 2 points for bad: Average below 2 hours sunshine per day or no window .
Repair Situation(*P15*)	With 8-10 points for luxury decoration; With 6-8 points for fully decoration; With 4-6 points for simple decoration; With 2-4 points for no decoration.

Impact factor of real estate prices in table 1 can be divided into three categories: a) Quantitative method based on image factor direct rate quantization, such factors include building facilities, ventilation and lighting, decoration situation, new rate and toward; b) Quantitative method based on GIS network

analysis techniques, Such as distance to the CBD, network analysis based on GIS shortest path analysis of estimating real estate to the city center, and calculates the shortest paths distances on income distance in accordance with quantitative method of scoring quantified; c) Quantitative method based on GIS buffer query, queried quantitative indicators related elements within the buffer number in buffer zone and rated according to the number of quantitative methods to quantify. Impact factors such as transportation convenience, supporting education, sports facilities, supporting life, and the natural environment. With above method, all price effect factors of real estate and trading case can be quantified one by one, but this was only from a number of angles to quantify the factors affecting property prices, and less about real estate price impact factor of scale and quality. For example, P3 of kindergartens, primary schools and colleges in size and quality also will have a certain impact on property prices, this requires valuation personnel through system provides query capabilities, check out enough information to judge. Therefore, assigning values to each factor, factor quantified value to fine-tune the permissions are given valuation personnel, so that the price factors in the process of quantifying would be more flexible, more reasonable, and it reflects the unity of science and art of real estate valuation. To avoid subjectivity in the process of fine-tune, according to the characteristics of various factors, it is set the scope to fine-tune the estimated personnel, and it must be given a detailed explanation of reasons for trimming. So it reflects the rigor of the assessment, and improve evaluation precision of the models.

2.3 Determining the Factor Weight

This model property influence factor of weight calculation is determined by entropy method, the method is not subjective, and it is an objective weighting method. In the course of use, according to the various factors influencing variation in real estate prices, the method use information entropy to calculate the entropy of impact factor of price. Then, it correct weight of impact factor effect on the property prices. Finally more objectively the impact of price factor weight can be obtained and it avoids obtaining a subjective and limit weight [15]. Specific steps of this method are as follow.

1) Construct matrix by 15 effect factors quantitative scores of N comparable trade case as (1). Where Y_i(i=1,2,……,N)stands i-th comparable trade case, and X_j(j=1,2,……,15)stands the j-th real estate price effect factor.

2) Calculate proportion P_{ij} with formula (2).

$$P_{i,j} = p_{i,j} \Big/ \sum_{i=1}^{N} p_{i,j} \tag{2}$$

Where p_{ij} stands the j-th real estate price effect factor value of the i-th comparable trade case.

$$\begin{array}{c|cccccc} & X_1 & X_2 & \cdots & X_j & \cdots & X_{15} \\ Y_1 & p_{1,1} & p_{1,2} & \cdots & p_{1,j} & \cdots & p_{1,15} \\ Y_2 & p_{2,1} & p_{2,2} & \cdots & p_{2,j} & \cdots & p_{2,15} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ Y_i & p_{i,1} & p_{i,2} & \cdots & p_{i,j} & \cdots & p_{i,15} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ Y_N & p_{N,1} & p_{N,2} & \cdots & p_{N,j} & \cdots & p_{N,15} \end{array} \tag{1}$$

3) Calculate entropy E_j with formula (3).

$$E_j = (-1/\ln N)\sum_{i=1}^{N} P_{i,j} \ln P_{i,j} \tag{3}$$

4) Calculate entropy weight W_j with formula (4).

$$W_j = (1 - E_j) \Big/ \sum_{j=1}^{15} (1 - E_j) \tag{4}$$

5) Normalize 15 factors affecting weight and get a weight vector as formula (5).

$$W = (W_1, W_2, \cdots\cdots, W_{15}) \tag{5}$$

2.4 Fix Trade Case Time

As the time factor effect on real estate prices, it need correct the trade cases transaction price to the current appraised real estate prices at the same time. By calculating the price correlation coefficient, namely from the product of the corresponding deal price, it can calculate and estimate property price comparable trading point in the same case. Among them, the sequential data is the price parameters over time, which data is authoritative. In this model, trade case time amendments to the housing price data per cent is according to the National Bureau of statistics, after amended to the comparable cases respectively, we obtain the i-th comparable deal revised price P_i'.

2.5 VIKOR Method of Real Estate Price Evaluation

Every comparable trade case and appraised real estate has 15 factors. VIKOR is a method making multiple attribute decision of selecting the best. According to the distance appraised properties with comparable trade cases as weights, estimating price is interpolated by revised price P_i' of comparable trade cases. The steps are as follows.

1) Construct matrix by appraised real estate and comparable trade cases as (6).

$$\begin{array}{c|cccccc} & X_1 & X_2 & \cdots & X_j & \cdots & X_{15} \\ Y_1 & p_{1,1} & p_{1,2} & \cdots & p_{1,j} & \cdots & p_{1,15} \\ Y_2 & p_{2,1} & p_{2,2} & \cdots & p_{2,j} & \cdots & p_{2,15} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ Y_i & p_{i,1} & p_{i,2} & \cdots & p_{i,j} & \cdots & p_{i,15} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ Y_N & p_{N,1} & p_{N,2} & \cdots & p_{N,j} & \cdots & p_{N,15} \\ Y_{N+1} & p_{N+1,1} & p_{N+1,2} & \cdots & p_{N+1,j} & \cdots & p_{N+1,15} \end{array} \tag{6}$$

Where Y_i(i=1,2,……,N)stands i-th comparable trade case, Y_{N+1} stands the appraised real estate, and X_j(j=1,2,……,15)stands the j-th real estate price effect factor.

2) Normalize matrix (6). According to the price factor quantification methods, the larger value means better, so all factors of the matrix (6) are positive indicators. And they are normalized by formula as (7).

$$f_{ij} = p_{i,j} \Big/ Max_i(p_{i,j}) \tag{7}$$

Where p_{ij} stands the j-th real estate price effect factor value of the i-th comparable trade case.

3) Calculate positive ideal solution and negative ideal solution of appraised and trading estate effect factors of new normalized matrix by formula as (8) and (9).

$$f_i^* = (Max_i f_{ij}) \tag{8}$$

$$f_i^- = (Min_i f_{ij}) \tag{9}$$

Where the f_i^* stands for positive ideal solution, and f_i^- stands negative ideal solution.

4) Calculate the hamming weighted distance S_i and the Chebyshev weighted distance R_i of all the appraised real estate and the trade cases with formula as (10) and (11).

$$S_i = \sum_j^{15} W_j (f_j^* - f_{ij}) \Big/ (f_j^* - f_j^-) \tag{10}$$

$$R_i = Max_j [W_j (f_j^* - f_{ij}) \Big/ (f_j^* - f_j^-)] \tag{11}$$

Where W_j stands the j-th weight of price impact factors, and the weight is calculated by entropy weight method.

5) Compute the value Q with formula (12).

$$Q_i = \frac{v(S_i - S^*)}{S^- - S^*} + (1 - v)\frac{(R_i - R^*)}{R^- - R^*} \tag{12}$$

Where $S^* = Min_j S$, it stands group the most effective solution, $S = Max_j S_j$, $R^* = Min_j R_j$, it stands opponent of personal regret minimization solution, $R = Max_j R_j$, v is maximize group effectiveness coefficient of decision mechanism. V is 0.5, it reflects the compromise idea of VIKOR model, taking between groups to maximize effectiveness and minimize regret are the result of a compromise.

6) Sort appraised real estate and comparable trade cases by Q value. Then interpolate the appraised real estate price by sorted Q value with formula (13).

$$P_k^{'} = [\frac{(P_{k+1}^{'} - P_{k-1}^{'})(Q_k - Q_{k-1})}{(Q_{k+1} - Q_{k-1})} + P_{k-1}^{'}] \tag{13}$$

where $P_k^{'}$ stands appraised real estate price, $P^{'}_{k+1}$,$P^{'}_{k-1}$ stand revised trade case price near this appraised real estate by sorting Q. Q_k belongs to the appraised real estate, Q_{k+1},Q_{k-1} belong to trade cases.

3. Application

Based on above assessment model idea, application was developed by C# programming language with ArcEngine as GIS software platform. The system main interface is shown in Fig 2. By using this application, five appraised real estates of Ganzhou were estimated. The steps are as follows: Firstly, information was collected and trade case database and appraisal real estate database were established. While you record, a point was draw in the map that stands the actual location of trade case and appraised estate, and other basic property information was deposited in corresponding database. Secondly, impact factors of comparable trade case and appraisal estate was quantified as quantitative rule in table 1, and these quantitative results were deposited in database. Thirdly, appraisal real estate price was calculated by VIKOR model. Taking appraised real estate as center, around its 2km, 5 comparable trade cases that are the same estate type and structure and closed transaction time with appraisal estate. Then system quantified effect factors of 5 comparable trade case and appraisal real estate, calculated its weight, adjusted trade time, calculated related parameter of VIKOR, sorted by Q value, interpolated the appraisal real estate. Using the above method, application calculates prices of the other 4 appraised real estates, compares between prices by appraised real estate model and the corresponding actual trade case prices, counts the difference in price discrepancies, and calculates price error as a percentage of actual transaction prices, it is shown in table 2. The result present that 5 appraisal real estate prices are above 96% with the corresponding actual trade case price, and this model has a high accuracy can be proved.

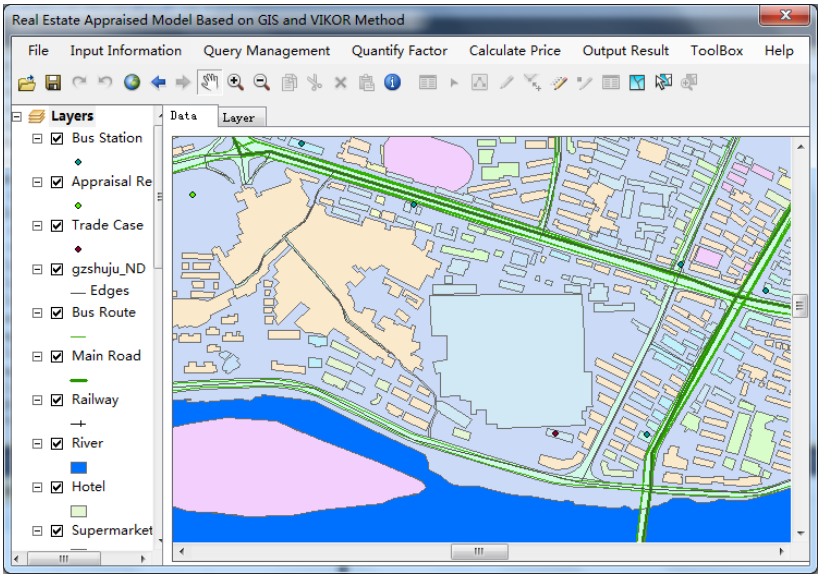

Figure.2 System main interface

Table.2 Statistics for appraised real estate prices by model and the actual trade price (Yuan/square meter)

ID	Model price	Actual trade price	Price errors	Percentage error (%)
1	7222	7180	42	0.58
2	9957	10112	-155	1.53
3	7429	7228	201	2.78
4	8308	8617	-309	3.59
5	4576	4494	82	1.84

4. Conclusion

Combined with advantages of GIS technology and VIKOR theory, this model has high accuracy and efficiency. Using GIS technology in collect data, manage and spatial analyze not only can solve subjective problem caused by experts giving estate price effect factors points, but also infinitely improve quantification accuracy and efficiency of effect factors. On the other hand, VIKOR method can make appraisal estate price more reliable because it solve problem of normal intellectual algorithm depending on large trade cases.so this model will has a wide range prospect in terms of rapid mass appraisal real estate, and it can provide technical support for the levy of estate duty.

The model uses GIS technology, improving the accuracy of the impact factors to quantify, but it still need be made use of GIS data collection and management, and collect more information about the impact factors to develop more detailed quantitative criteria; In addition, the buffer query method of quantitative impact factors only considers the linear distance of the property, without taking into account the topography and the traffic accessibility. It need to be further developed in the future to take into account topography and transportation accessibility of the property impact factors methods for quantitative GIS analysis to further improve the accuracy of quantitative, so it will improve the reliability of the model.

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