



Research on Cost Approach for Real Estate Appraisal of Apartment Based on GIS

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Abstract

Real Estate Appraisal of apartment by traditional cost approach is heavy and the results tend to be affected by the appraisers' subjective opinions. To overcome these shortcomings, the study introduced GIS technologies into Cost approach for real estate appraisal of apartment. With separate estimation of land and building, the study assessed the replacement cost of land by Standard land price coefficient correction method. The replacement cost of building was estimated by Housing replacement compensation method. All appraisal was realized by GIS. The paper took 4 buildings with 266 apartments as appraisal objects, the result showed that the proposed method was rational and effective.

Keywords-Real estate appraisal; Cost approach; Separate estimation; GIS

1. INTRODUCTION

With continuous development of real estate industry, the business of real estate appraisal has become an important technical guarantee for the healthy development of real estate market. The valuation volume of sustained growth, valuation of more extensive, therefore it has become increasingly difficult [1]. Compared with the inefficient single real estate appraisal, how to carry out scientific and reasonable mass appraisal of real estate is the key work of future research. This trend has led a lot of information technology development in the field of real estate evaluation. In 2011, the International Association of assessing offices (IAAO) put forward the definition of Mass Appraisal in "Standard on Mass Appraisal of Real Property" [2]. Although mass appraisal technology has been established and used for decades abroad, domestic research is still immature. Domestic research mainly focuses on automated valuation model (AVM), and Computer- Assisted Mass Appraisal (CAMA). System was developed based on AVM [3,4]. However, mass appraisal in China mainly for taxation. The appraisal value of taxed is different from market value. Some research studied traditional appraisal method, introduced Geographic Information System (GIS) and Building

Information Modeling (BIM) technologies [5]. BIM has been widely adopted by the Architecture, Engineering, and Construction [6]. It precisely models the building in details. In practical of appraisal, it is necessary to accurately obtain the detailed information of buildings, which is often impossible for large number of apartments in stock [7,8]. Hence, this study want to improve former studies by different methods which are applied in real estate appraisal in apartment. The research want to put forward a new and convenient approach in real estate appraisal module by GIS.

2. METHODOLOGY

2.1. Land and building separation system in China

The ownership of real estate in China is different from that in other countries. In western countries, the house and the land have the same ownership. This is the real integration of real estate. In China, as development of history and difference of management system, the owners and value of land and house are independent systems. Due to a large number of population, people widely live in apartments in cities. Different apartment

owners in a building share the right to use the land in limit time. In practice of real estate appraisal, this is very important.

2.2. Cost structure

Cost approach is one of the four basic methods of real estate appraisal, which is suitable for schools, libraries, gymnasiums, administrative office buildings and other similar real estate with low transaction frequency and low profit. It requires to calculate the replacement (reconstruction) price of appraisal object at the appraisal time point, and deduct the depreciation, so as to obtain the objective and reasonable price of appraisal object. It has two ways, separate estimation of land and building, combined estimation of land and building [9]. In order to calculate the value automatically, this study adopts former one. According to the procedure, the value of land and building are estimated by different methods.

2.2.1. Land estimation by Standard land price coefficient correction method

This method is similar to Market method which is most popular in real estate appraisal, but different in purpose. It is used to estimate land value. The method need to select some comparable land cases as standard price, compare them with appraisal object, dispose the transaction prices of comparable cases appropriately, so to get the value of appraisal object [10].

2.2.2. Building estimation by Housing replacement compensation method

The compensation of replacement price refers to the price of rebuilding a building with the same functional utility as the appraisal object, which is in the same state of renovation according to price level by using the building materials and construction technology at appraisal time point. It is the compensation standard for government to levy owner's apartment, and the value is only for building [11]. Compared with precisely estimate of replacement cost and depreciation, this information is provided by local government as a guide price. In practice, final replacement compensation price of appraisal objects are determined by site investigation.

2.3. GIS technological approaches

With the help of GIS, real estate appraisers apply it to mass and automatic evaluation, obtain the location and attributes of the real estate, so as to evaluate the value of the real estate more accurately and conveniently. The powerful spatial analysis and data management functions are used to establish evaluated models. In practice, Standard land price are provided by grid price in region, which makes automatic estimation more feasible.

3. MATERIALS AND EXPERIMENTS

3.1. Materials

Appraisal Objects contain four buildings locate in Tiyuxi community, Tianhe District, Guangzhou, Guangdong, China. Take one apartment building as an example. Building 1# has three units, each with eight floors and four households on each floor. The total gross building area of each apartment is about 70-80 square meter, with South-North direction. The year of construction was 1979. However, the land usage term of apartment are different from 30-65 years (Not the design life of building). First floor serves as shops, second to eighth floors as apartment. The time point was supposed to be June 1, 2021.

The appraisal objects are in Tiyuxi community. The volume rate of this community is 2.3. The exterior wall is painted, the entrance doors of many apartments are hinged door with plastic steel window. The overall style of the appraisal object is Chinese style. The indoor stairs are marble tread and wooden handrail. Infrastructures like water supply, sewer, heating, electricity supply, gas etc. are completed. The maintenance condition of the appraisal object is good; the foundation is of strong bearing capacity with no settlement. According to the site investigation by the appraiser, the maintenance situation of the house at the point time is good and the comprehensive newness rate is normal.

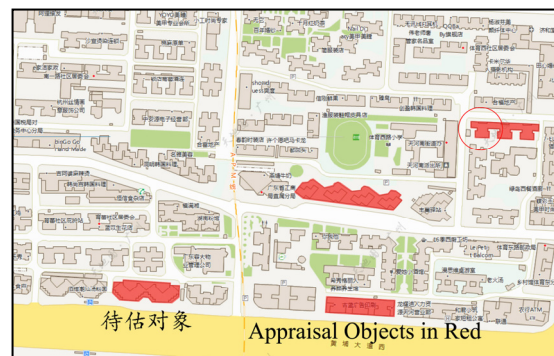


Figure 1. appraisal objects community

In addition, other materials are as follows.

- Plan design and parcel drawing of some apartments.

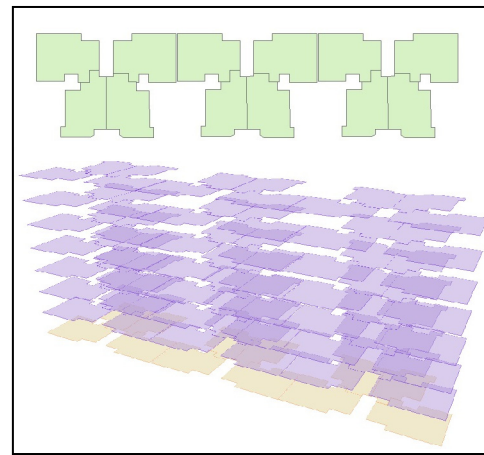
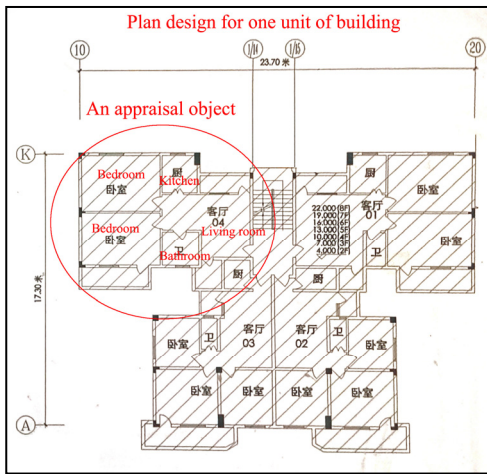


Figure3. Parcel database by ArcGIS

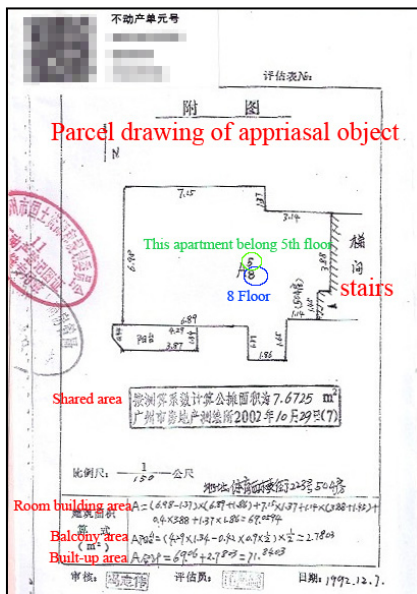


Figure2. Building information of an apartment sample

• Standard land price system (<http://jzdj.gzlp.gov.cn/>) and housing replacement compensation standard (see government website) are open online by local government.

3.2. Experiments1: Parcel database

After vectorizing the plan or parcel of apartment in ArcGIS software, we get some parcel and all plan map of apartments. These are the basic layer of real estate appraisal. Due to vertical distribution of apartments, the apartment patch will be overlap on the two-dimensional plan, so it is necessary to set the elevation field for zoning.

The experiment set up attribute table of parcel layer. Field of parcel attribute included building information, like address, floor, build-up area, owner etc. Fields about appraisal were also included. Parcel layer in 2D and 3D display, see Figure3. First floor are shops, appraisal in different way.

3.3. Experiments2: Standard land price Feature layer

Standard land price were obtained by grid points from government website. In ArcGIS software, this experiment created point feather layer, which field includes the Standard land price. Each point needs to be on one parcel. The standard land price passed down to parcel layer by spatial connection. It is not the final price, the land price need to be modified according to appraisal objects by site investigation. The modified land price were evaluated is obtained by coefficient correction according to local government policy document [10]. The modified land price calculate according to equation (1). The attribute field of modified land price was calculated automatically in ArcGIS software.

$$Pm = Ps * a1 * a2 * a3 * a4 * a5 \quad (1)$$

- Pm: modified land price.
- Ps: standard land price.
- a1: correction factor of volume rate. According to computing formula, volume rate of community is 2.3, then $a1 = (2.7/2.3)^{0.3} = 1.04927$ [10].
- a2: correction factor of floor (elevator or none). Refer to multi-storey building coefficient table [10].
- a3: correction factor of location (whether near sea or river). No river nearby, get 1.
- a4: correction factor of land usage term. Refer to land usage term coefficient table.
- a5: correction factor of trade time. Base date was 2019, right now is 2021, coefficient adjustment for two year. The average growth rate of real estate industry is 15% (different from 10% to 20% in 2013 to 2018, <http://www.landvalue.com.cn/>).

3.4. Experiments3: Building replacement price

Building value was estimated by attribute of

apartment replacement price. According to local government, apartment replacement price can be determined by details of apartment, which include building structure, exterior wall, interior wall, floor, doors and windows [11]. Buildings are divided into different grades according to the building structure, which is partly shown in following Tab.1. The unit of replacement price is yuan per square meter. The appraisal need to grand each apartment after site investigation according to housing replacement compensation

standard.

The appraisal objects was divided into the fourth category. The replacement price of each apartment can be adjusted by detailed scoring. In this experiment, each factor is divided into four grades: excellent(+100), good(+50), medium(0) and poor(-50). The difference between each grade is 50 yuan per square meter. The results automatically obtain by VB script programming in ArcGIS.

Table 1. Housing replacement compensation table(excerpt).

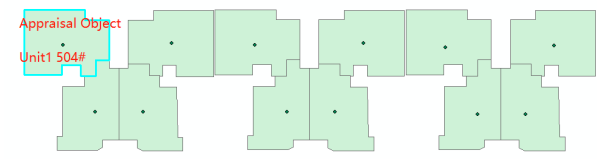
Item	Grade	Exterior wall	Interior wall	Floor	Doors and windows	Replacement price
Frame structure	1	pasted with high-grade glazed tile or paper stone	decorated with high-grade level and suspended ceiling	paved with stone or wood floor	aluminum alloy doors and windows,panels	2115
	2	pasted with glazed tile or paper stone	decoration and suspended ceiling	colored glazed ceramic tile	aluminum alloy doors and windows,panels	1725
	3	glass or mosaic	whitewashing plastering of ceiling	colored glazed ceramic tile	steel door, wooden door,panels	1660
	4	granitic plaster	Whitewashing plastering of ceiling	colored glazed ceramic tile	steel door, wooden door,panels	1605

3.5. Experiments4: Modeling of Cost approach

The final result by cost approach will be calculated using the following formula:

Real estate value = (modified land price + replacement building price) * built-up area.

The results were automatically obtain by programming in attribute table in ArcGIS software.



Struct	Repl	Inter	Ext	Flo	Doc	Modifl	Standa	a1	a2	a3	art	a5	Modified land	Built-up area	Appraisal value	Unit Price
框架	1725	中	优	中	1825	32938	1.04927	1.038	1	0.9739	1.3225	49295	310515	79.5129	3619239.362733	45330.31
框架	1725	中	优	中	1875	32938	1.04927	1.029	1	0.9443	1.3225	44412	534091	79.5129	3680456.129902	46287.54
框架	1725	优	中	中	1925	32938	1.04927	1.029	1	0.9245	1.3225	43504	812816	83.5413	3795265.526584	45429.81
框架	1725	优	中	中	1875	32938	1.04927	1.029	1	0.9194	1.3225	43241	430676	83.5413	3795955.176267	45114.43
框架	1725	中	优	中	1825	32938	1.04927	1.029	1	0.9245	1.3225	43504	812816	79.5129	3604304.932673	45329.81
框架	1725	优	中	中	1875	32938	1.04927	0.993	1	0.9739	1.3225	44202	189628	79.5129	3663731.031317	46077.19
框架	1725	优	中	中	1925	32938	1.04927	0.993	1	0.925	1.3225	41822	79529	83.5413	3688112.656138	43907.78
框架	1725	优	中	中	1875	32938	1.04927	0.993	1	0.9739	1.3225	44202	189628	83.5413	3849348.225647	46077.19
框架	1725	优	中	中	1825	32938	1.04927	0.993	1	0.9696	1.3225	43961	637631	79.5129	3640628.399055	45786.64
框架	1725	优	中	中	1875	32938	1.04927	0.973	1	0.9194	1.3225	40888	153373	79.5129	3400222.393704	42763.15
框架	1725	优	中	中	1925	32938	1.04927	0.973	1	0.9485	1.3225	42182	307526	83.5413	3684781.716179	44107.31

Figure4. Appraisal results by modeling in ArcGIS

4.CONCLUSIONS AND DISCUSSIONS

4.1. Conclusions

The experiment compared with the appraisal price of similar real estate in the same community for judicial sale price. All details about the judicial sale can be checked on the website (<https://sf.taobao.com/>). Table 2 shows the main comparison result.

Table 2. Comparison result.

No.	Address	Area (M ²)	Appraisal value (RMB)	Unit Price (yuan/M ²)
1	Room 805, No.23, liuyunqi street, Tianhe south 2nd Road, Tianhe District, Guangzhou	72.28	3,115,479	43,103
2	No. 402, 83 Guangli Road, Tianhe District, Guangzhou City, Guangdong Province	85.79	3,800,500	44,300
3	Room 1804, No.40, south 2nd Tianhe Road, Tianhe District, Guangzhou	78.11	4,414,426	56,516
4	Appraisal objects sample (Unit 1, 504#)	79.51	3,604,305	45,331

The experiment did not compare to listing price by the real estate agency, as the price was not the final trade. From the Tab.2, it showed that the appraisal results are similar to estimation value, equivalent, though for auction purpose. The study showed that this method was rational and effective.

4.2. Discussions

In the whole experiment, there are some details can be discussed.

4.2.1. Appraisal method

Appraisal objects can get different value according to different purpose or different method. It is generally believed that the result would be lower by cost approach then by market approach. However, research aimed to mass appraisal for region, so that much more effective and feasible way would be considered in the first place. If cost approach carries out in precise way, it will be not feasible in practice. According to the statistics of real estate in 2018 in Guangzhou, there are more than 223000 apartment. Most of them are stock or second-hand apartment. This problem requires a better choice of methods. The research provided a rational and effective way for mass appraisal of apartment in city.

4.2.2. Basic database

Mass appraisal carries out automatically need apartment detail information. By GIS software, apartment information can be well organized in spatial graph and attribute table. Appraisal method can be modeled in attribute field by programming.

4.2.3. Appraisal result

From all appraisal apartment, we can see that land value is much more than building value, averagely speaking, land value make up about 90% of whole real estate value. This is due to the specific national conditions of Chinese cities, mainly because the price of land is very high when it is sold.

4.2.4. Cost approach

This method is popular when mass appraisal for region. In experiment, some parameters need to be discussed in further way as following.

4.2.4.1. Standard land price

The data provided by local government, and periodically update and open online. In the experiment, appraisal objects are complex buildings. First floor is shops, so that they can not estimated value in residential way. Appraisal objects are classified by their usage.

4.2.4.2. Area

Built-up area is different from graph area in modeling. Built-up area includes inside building area and the shared area. So parcel drawing is not necessary. In experiment, built-up area can be a field in attribute.

4.2.4.3. Building value estimation

Different from tradition cost approach, building value is estimated by housing replacement compensation method which can save much more construction information and depreciation calculation. However, it is determined still need site investigation.

4.2.4.4. Appraisal models

According to Real Estate Appraisal Code(GB/T 50291-2015)[9], each appraisal object value need two approach to determined final value. It points out the direction for further research, which can make the appraisal result more precisely.

4.2.4.5. Limit samples

As appraisal objects involve owners' privacy, the research took four buildings to experiment. Some information can be supplemented by symmetry of buildings. Research mainly want to solve the problems of evaluation methods and approaches, so that limit samples were enough.

We hope more and more information technology are used into traditional industry of real estate appraisal, make it more and more intelligent and automated.

ACKNOWLEDGMENT

This paper is supported by Guangdong Provincial Department of Education Key field of natural science (Grant No. 2020ZDZX3107). The authors are very grateful to ArcGIS software provided by 2021 GIS development competition for Chinese College Students by GeoScene Information Technology Co. Ltd. The company provided trial software during competition. The authors are also grateful to Guangdong Polytechnic of Industry & Commerce with supported project (No. 2021SCPY025). The authors would like to thank Dongying Liu et al. as apartment households to provide apartment parcel data to do some experiments.

REFERENCES

- [1] H. Zhang, Y. Li, B. Liu, C. Liu. The Application of GIS 3D Modeling and Analysis Technology in Real Estate Mass Appraisal – Taking landscape and sunlight factors as the example[J]. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,2014,XL-4(1).
- [2] The Technical Standards Committee. Standard on Mass Appraisal of Real Property[M]. International Association of Assessing Officers, Chicago, 2011:1-22.
- [3] Minghua Cheng, Zelu Jia, Hanming Xu, Yaolin

- Liu. Research on Intelligent Mass Appraisal Public System of Real Estate Based on Automated Valuation Models[J]. China real estate,2013(18):67-72.
- [4] Stojanka Brankovic. Real Estate Mass Appraisal in the Real Estate Cadastre and GIS Environment[J]. Geodetski list,2013,67(2).
- [5] Wei Xiong, Qingsheng MENG. Research on Cost Approach for Real Estate Appraisal Based on GIS and BIM[J]. Construction economy,2016,37(10):71-75.
- [6] Jingming Li, Kereshmeh Afsari, Nianping Li, Jinqing Peng, Zhibin Wu, Haijiao Cui. A review for presenting building information modeling education and research in China[J]. Journal of Cleaner Production, 2020,259.
- [7] Jian Ping Yang, Qing Bai. Research of Real Estate Appraisal Based on GIS Technology[J]. Advanced Materials Research,2014,2920.
- [8] Weiyi Wang. Application potential of GIS based on big data in real estate evaluation in China. Appraisal Journal of China[J]. 2020(10): 51-56.
- [9] GB/T 50291-2015, Real Estate Appraisal Code[S]. Ministry of Housing and Urban Rural Development of People's Republic of China, 2005
- [10] Guangzhou Bureau of planning and natural resources. Announcement on the results of updating the benchmark land price of state owned construction land use right in Guangzhou in (2020-00045) [EB/OL]. 2020,2.
- [11] General Office of Guangzhou Municipal People's Government. Announcement on printing and distributing the Trial Measures of compensation for expropriation of land collectively owned by farmers in Guangzhou (No. [2017]10) [EB/OL]. 2017, 8

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