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Influencing Factors of Real Estate Price based on Grey Relational Analysis

Lei Jiang and Yunli Gao*

School of Civil Engineering and Architecture, Dalian Nationalities University, Dalian, Liaoning, 116600, China

Abstract: This research answers the question of how to measure the impact of different factors on real estate price. It is well known that the real estate price is influenced by many factors, however, how to determine the factors and evaluate the influence degree is an important problem. Most of the previous research used multivariate statistical model, this paper proposed a different way—Grey Relational Analysis (GRA). This paper selected 11 influencing factors from economic area, market area, cost area and social area. Then the method to identify the influence degree of factors based on GRA was proposed. In addition, for explaining application of the influencing factors, the case of Dalian in China is studied. The result is that the key influencing factors are gross domestic product, average wage of employed persons in construction, annual per capita disposable income of urban households and per capita building space of urban household. The GRA is an effective way to assess the impact of different factors on real estate price and provides a good tool for designers, users, decision makers and researchers.

Keywords: Grey relational analysis (GRA), influencing factor, real estate price.

1. INTRODUCTION

Real estate is a key factor in national economics. The real estate price is influenced by many different factors, which is a well known and more studied subject in literature. Researchers has studied the influencing factors from different aspects, such as national and regional macroeconomic factors [1], real estate sub-markets [2], environment quality on residential location [3], policy actions [4] and population changes [5] Scholars often use multivariate statistical model to study the economic, which cannot explain the dynamic behaviors of economic [6].

Grey theory, which was proposed by J.L. Deng, is one of the new mathematical theories widely applied in various fields of science. Grey theory has advantages in the fields of uncertainty fields, and it is an effective method used to solve uncertainty problems with discrete data and incomplete information. Grey relational analysis [7] drived form grey systems theory is a measurement method to determine the relationship between sequences using limited amounts of data. Grey Relational Analysis (GRA) is suitable for solving problems with complicated interrelationships between multiple factors and variables [8], which has been widely applied to various field. For example, GRA was used to find out the relative importance of 4 different kinds energy consumption and economic growth [9]. A general sustainability indicator of renewable energy system is proposed to measure the sustainability of a renewable systems through GRA [10]. The "four elements and two hierarchies" model for advantages transformation are established and the methods to identify the key transformation factors are used by GRA [11]. A self-adaptation evaluation method in real time dynamics decision-making system is suggested based on grey close relationship [12]. About inter-enterprise cooperation and innovation in industrial clusters, a novel knowledge similarity degree based on GRA is proposed, and a dynamic evolution model of innovation net work is proposed [13].

This paper selected 11 different influencing factors of the real estate price, then a model based on GRA is established. After that, a case study of Dalian in China is applied, and the result and conclusion is summarized.

2. SLECTION OF FACTORS

This paper focuses on the real estate price and the influencing factors of it, by studying the literature and investigation, this paper has chosen 11 factors in 4 different areas, which are economic area, market area, cost area and social area, as shown in Table **1**.

3. INFLUENCING MODEL BASED ON GRA

To model the influencing factors of real estate, the first step is normalize all the factors and real estate price on the interval [0,1]. Then, the grey relational coefficients are calculated. After that, the grey relational grades are computed. The final procedure is to order the factors and analysis the evaluation results.

3.1. Normalization of the Original Values

The original sequences which have different dimensions and magnitudes couldn't be compared directly, so they should be converted to a comparable sequence which is generally dimensionless.

The algorithm of GRA is defined as follows.

Let the original reference sequence is

$$X_0 = (x_0(1), x_0(2), \cdots, x_0(n))$$

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Table 1. The criteria of influencing factors.

Areas	Factors	Mean of Factors	Unit
Economic	X1	gross domestic product	hundred million yuan
	X2	annual per capita disposable income of urban households	yuan
	X3	annual per capita consumption expenditure of urban households	yuan
Market	X4	real estate investment complete this year	thousand yuan
	X5	floor space of commercialized building sold	m^2
	X6	floor space complete	m^2
Cost	X7	average price of land purchased	yuan
	X8	purchasing price index for building materials	--
	X9	average wage of employed persons in construction	yuan
Social	X10	total population of a country or region	thousand people
	X11	per capita building space of urban household	m^2

Let the sequences for comparison are

$$X_1 = (x_1(1) \quad x_1(2) \cdots \quad x_1(n))$$

$$X_2 = (x_2(1) \quad x_2(2) \cdots \quad x_2(n))$$

… … … …

$$X_m = (x_m(1) \quad x_m(2) \cdots \quad x_m(n))$$

There are three different normalization methods for different situations:

for the greater the better situation, the normalization is:

$$x_i'(k) = \frac{x_i(k) - \min\limits_i x_i(k)}{\max\limits_i x_i(k) - \min\limits_i x_i(k)} \tag{1}$$

for the smaller the better situation, the normalization is:

$$x_i'(k) = \frac{\max\limits_i x_i(k) - x_i(k)}{\max\limits_i x_i(k) - \min\limits_i x_i(k)} \tag{2}$$

for the ideal value which is represented as x0 is the better situation, the normalization is:

$$x_i'(k) = 1 - \frac{\left| x_i(k) - x^0 \right|}{\max\limits_i \left| x_i(k) - x^0 \right|} \tag{3}$$

3.2. Calculation of the Grey Relational Coefficients

The grey relational coefficient between the normalized comparative sequence Xi and the reference sequence X0 is defined as:

$$\xi_{0i}(j) = \frac{\min\limits_i \min\limits_j z_{ij} + \rho \max\limits_i \max\limits_j z_{ij}}{z_{ij} + \max\limits_i \max\limits_j z_{ij}}, i \in m;\ j \in n \tag{4}$$

where is deviation between X0 and Xi:

$$z_{ij} = \left| x_{0j} - x_{ij} \right| \tag{5}$$

ρ is the distinguishing coefficient, $\rho \in (0,1)$, usually, ρ =0.5.

3.3. Calculation of the Comprehensive Coefficient

The grey relational grade for the sequence of Xi is calculated by averaging the grey relational coefficients as follows:

$$r_i = \frac{1}{n} \sum_{j=1}^{m} \xi_{0i}(j), i \in m \tag{6}$$

The grey relational grade γi defines the effect of comparative sequence to the tendency of reference sequence, and the comparative sequence are ordered by it.

4. CASE STYDY

In this study, we used GRA in order to find out the importance of influence factors on real estate price for Dalian in China. We defined that the average selling price of commercialized buildings as X0, and the unit of it is yuan/m^2. We used 2007-2012 data as shown in Table **2** for calculations to compute the GRA between real estate price and the influencing factors. By racking the factors, we try to show the influence degree of different factors and which are the important factors influencing real estate price for Dalian.

At first we normalized the original sequences and attained the values in the Table **3**. We used the greater the better for all the sequences.

Then we calculated the grey relational coefficients, in the last step of calculations we computed grey relational grades by averaging the grey relational coefficients for each comparative sequence. Grey relational coefficients and grey relational grades as well as rankings of them are shown in Table **4**.

Table 2. Values used in the analysis.

Values	2007	2008	2009	2010	2011	2012
X0	5567.76	5774.26	6249.04	7043.68	8052.00	8003.99
X1	3078.80	3803.30	4349.50	5158.20	6150.60	7002.80
X2	15108.60	17500.48	19014.37	21292.56	24276.16	27539.2
X3	12135.00	14101.38	15329.83	16579.70	18846.40	20417.46
X4	40357020	49581600	57894210	76802020	110746300	139652040
X5	8282375	8227065	11526834	12153259	9099105	10763024
X6	4283064	7555621	5496520	5709735	9428724	7499976
X7	1190.46	2288.23	2007.28	2020.71	1871.72	2540.97
X8	94.60	107.10	97.50	106.41	110.17	101.11
X9	25504.20	27333.27	35027.61	41601.58	43714.00	45099
X10	5782	5833	5848	5864	5885	5903
X11	24.64	24.07	25.04	25.67	27.04	27.3

Table 3. Normalized values.

Factors	2007	2008	2009	2010	2011	2012
X0	0.0000	0.0831	0.2742	0.5941	1.0000	0.9807
X1	0.0000	0.1846	0.3238	0.5299	0.7828	1.0000
X2	0.0000	0.1924	0.3142	0.4975	0.7375	1.0000
X3	0.0000	0.2374	0.3857	0.5366	0.8103	1.0000
X4	0.0000	0.0929	0.1766	0.3670	0.7089	1.0000
X5	0.0141	0.0000	0.8404	1.0000	0.2221	0.6459
X6	0.0000	0.6360	0.2358	0.2773	1.0000	0.6252
X7	0.0000	0.8129	0.6048	0.6148	0.5044	1.0000
X8	0.0000	0.8028	0.1863	0.7585	1.0000	0.4181
X9	0.0000	0.0933	0.4860	0.8215	0.9293	1.0000
X10	0.0000	0.4215	0.5455	0.6777	0.8512	1.0000
X11	0.1765	0.0000	0.3003	0.4954	0.9195	1.0000

5. RESULTS

The grey relational coefficients quantify the relationship between the factors and real estate price. The value of the coefficients is higher, the relational degree of the factor with real estate price is higher. The calculated result are shown in Fig. (**1**).

5.1. Results of 11 Grey Relational Coefficients

The factors which are above 0.8 are selected as the key influential factors for real estate price. In this case, there are 6 factors are selected, they are X1 (gross domestic product), X9(average wage of employed persons in construction), X2(annual per capita disposable income of urban households), X11(per capita building space of urban household), X3(annual per capita consumption expenditure of urban households) and X4(real estate investment complete this year).

The grey relational coefficients of economic factors reflect the influencing degree of economic factors acting on real estate price. The higher the coefficients, the stronger is the impact. As can be seen in Table **4**, all the economic factors are in the top 5 factors, which means economic factors have a close relationship with real estate price. Two factors

Table 4. Grey relational coefficients and grey relational grades.

Factors	2007	2008	2009	2010	2011	2012	Mean	Rank	Mean for Areas
X1	1.0000	0.7930	0.8869	0.8583	0.6417	0.9527	0.8554	1	0.8422
X2	1.0000	0.7806	0.9068	0.8010	0.5970	0.9527	0.8397	3	
X3	1.0000	0.7160	0.7772	0.8713	0.6722	0.9527	0.8315	5	
X4	1.0000	0.9755	0.7994	0.6314	0.5719	0.9527	0.8218	6	0.7158
X5	0.9650	0.8239	0.4072	0.4893	0.3333	0.5374	0.5927	11	
X6	1.0000	0.4130	0.9101	0.5511	1.0000	0.5225	0.7328	8	
X7	1.0000	0.3477	0.5406	0.9496	0.4397	0.9527	0.7050	10	0.7533
X8	1.0000	0.3508	0.8155	0.7029	1.0000	0.4088	0.7130	9	
X9	1.0000	0.9744	0.6475	0.6311	0.8462	0.9527	0.8420	2	
X10	1.0000	0.5348	0.5892	0.8231	0.7233	0.9527	0.7705	7	0.8042
X11	0.6879	0.8239	0.9372	0.7975	0.8285	0.9527	0.8379	4	

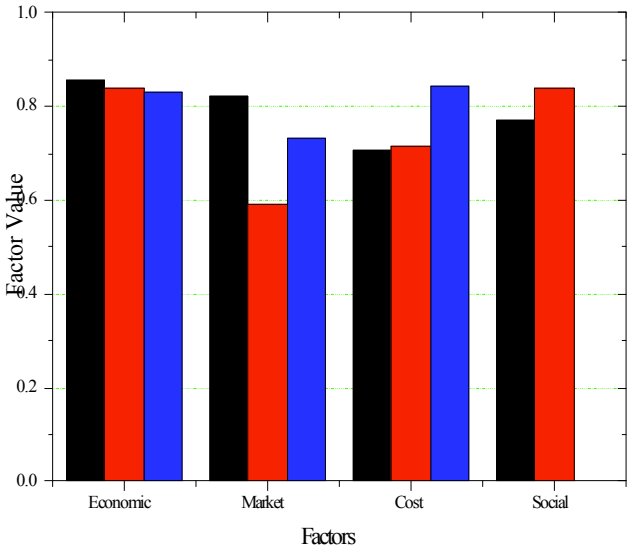

Fig. (1). Final results of factors of 11 factors.

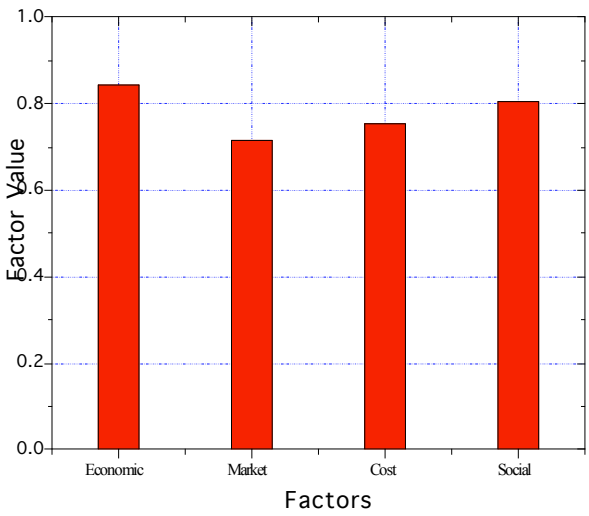

Fig. (2). Final results of four areas.

(X1 and X2) in economic area are key influential factors. The factor X1 (gross domestic product) is the highest in the 11 factors, which means the GDP plays an important role on real estate price. As we know that real estate becomes pillar industry of national economy, it is consistent with the current situation. The other factors X2 (annual per capita disposable income of urban households) and X3 (annual per capita consumption expenditure of urban households) which describes disposable income and consumption expenditure of urban households are ranked third and fifth.

Market factors reflect the real estate market volatility which act on the real estate price in a direct way. Factor X5(floor space of commercialized building sold) is the lowest in the 11 factors. Factor X4(real estate investment complete this year) is ranked sixth and factor 6(floor space complete) is ranked eighth.

The grey relational coefficients of cost factors reflect the direct cost of real estate. In the three factors, X9(average wage of employed persons in construction) is the highest and also the second highest in the 11 factors, so it is also key influential factors. It shows that average wage of employed persons in construction is the important element in the real estate cost, which is consistent with the current situation that high wage of employed persons promote the real estate price. The result of factor X8(purchasing price index for building materials) is close to factor X7(average price of land purchased), and they are relatively ranked ninth and tenth.

The grey relational coefficients of social factors reflect the regional social situation which will influence real estate price. Factor X11 (per capita building space of urban household) is racked forth, which means the basic living condition of urban household, and it is also key influential factors. It shows that basic living space of urban household has impor-

tant effects on real estate price. Factor 10(total population of a country or region) is racked seventh, which is a index reflecting the amount of people in a country or region.

5.2. Results of the Four Areas

The final results of economic factors, market factors, cost factors and social factors are summarized in Fig. (**2**). The economic factors is the highest (0.8422), the second is the social factors (0.8042), the third is the cost factors (0.7533), and the last is the market factors (0.7158). It is found that all the four areas factors have relatively high relational coefficients (over 0.7), while the economic factors and social factors are higher (over 0.8), which means that economic factors impact on the real estate price most, second is market factors, third is cost factors and at last is market factors. This is in accordance with the results of 11 grey relational coefficients.

CONCLUSION

This study develops the influencing factors of real estate price, which include four areas: economic factors, market factors, cost factors and social factors. Through normalizing the selected eleven factors and calculating the grey coefficients of the eleven factors in the above four areas, the key influential factors are X1 (gross domestic product), X9 (average wage of employed persons in construction), X2 (annual per capita disposable income of urban households) and X11(per capita building space of urban household). In the four key influential factors, two are in economic areas, cost and social area has one separately. In the four areas, economic factors is the highest (0.8422), the second is social factors (0.8042), the third is cost factors (0.7533), and the last is market factors (0.7158).

However, this indicator is only proper for Dalian in China and current situations, with the economic development and the change of market, cost and social environment, the real estate price would also change, and the selected factors would also change. As a result, the final result of the research would be different to the description as discussed above.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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