Comprehensive Evaluation of Sustainable Development of Real Estate Industry Based on Information Entropy Weight Method

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Abstract. Under the conditions of market economy, the healthy development of the real estate market is of great significance to the normal operation of the real estate economy and the sustainable development of the real estate economy. Therefore, it is necessary to be able to accurately evaluate the development of the real estate industry and adopt appropriate macro-control measures in time. Taking Xiamen as an example, this paper adopts the way to combine objective information entropy weight method with subjective order relationship analysis method to determine the weight of group decision makers on program attributes and balance the importance of each index. According to the comprehensive attribute value of each scheme, the weight of decision makers is calculated by using entropy weight method for giving the evaluation result of the scheme. The results show that the overall situation of the development of real estate industry in Xiamen is more optimistic, and the weight of each index after the normalization of land transfer price is the highest. Based on the research conclusions, this paper proposes corresponding assessment commendations as a reference for relevant parties.

1. Introduction

Since China began the monetization reform of housing system, the sales volume and investment volume of the real estate industry have grown rapidly. As a new growth point of the national economy, the real estate industry has made important contributions to the rapid economic growth of China[1]. In order to achieve long-term development of the real estate industry, since 1998, the state has promulgated nearly 700 real estate macro-control policies to regulate and rectify the real estate industry. Especially in recent years, with the country's introduction of real estate purchase restriction policies, the excessive growth of real estate prices has made people to pay more and more attention to the development of the real estate industry environment. Therefore, strengthening macroeconomic regulation and control to promote the sustainable development of the real estate industry has already been a consensus of the society[2], and insisting on the sustainable development of the real estate industry is of great significance to promote the sustainable development of the national economy and urban economy and the optimization of industrial structure[3].

This paper takes Xiamen City as an example and uses the order relationship analysis method[4] to add preference information to the decision matrix, and then "rights" the data in the decision matrix; Then use the entropy weight method[5] to determine the weight of the index for the weighted data, and obtain a reasonable evaluation of each decision maker; finally, according to the results of the reference decision, the entropy method is used to empower the decision makers, and based on this, the comprehensive situation of real estate development in Xiamen is evaluated and provided to relevant parties making decisions.

2. The basic principle of attribute weight determination

2.1 The basic principle of determining the weight by entropy weight method

Multi-attribute decision making method based on information entropy is a method to determine index weights, which is based on the amount of information provided by observations of various indicators. The entropy value method for determining the weight of an index is given below by using the concept of entropy.

The main steps are as follows:

The items to be evaluated are Y=$(Y_1, Y_2, Y_3, Y_4, Y_5, \dots, Y_m)$, and the comprehensive evaluation system is Z=$(Z_1, Z_2, Z_3, Z_4, Z_5, \dots, Z_n)$, since the scales of the indicators in the indicator system are not the same, they cannot be used for direct comparison.Therefore, the index values are standardized before the comprehensive assignment, and the standardization formula is as follows:

$$r_{ij} = \left(x_{ij} - \min(x_{ij})\right) / (\max(x_{ij}) - \min(x_{ij})) \quad (1)$$

According to the above method, the survey data is converted to 0≤rij≤1, the worst value is 0, and the optimal value is 1. Entropy can be used to measure the amount of information. The more information transmitted by an indicator, the greater effect of the indicator on preferences. The entropy of the system $H = (p_1, p_2, p_3, p_4, p_5, \dots, p_m)$,and the entropy form of the system is as follows:

$$H = (p_1, p_2, p_3, p_4, p_5, \dots, p_m) = -k\sum_{i=1}^{m} p_i \ln p_i \quad (2)$$

In (4), $k = 1/\ln m$, m indicates the number of schemes of the system, p_i indicates the probability that a certain state of the system is present. Combined with the previously calculated standardized feature matrix (3), the entropy of the Jth indicator is:

$$H_j = -k\sum_{i=1}^{m} f_{ij} \ln f_{ij} \quad (j = 1,2,\cdots,n) \quad (3)$$

In (5), $f_{ij} = r_{ij}/\sum_{i=1}^{m} r_{ij}$,the entropy weight of the Jth indicator is:

$$W_j = (1 - H_j)/(\sum_{i=1}^{n} 1 - H_j) \quad (j = 1,2,\cdots,n) \quad (4)$$

Where: W_j——Normalized weight coefficient

The weight can reflect the function of the different indicators in the decision-making. When the entropy of an indicator is small and the entropy weight is large, it indicates that the indicator provides more useful information to the decision makers.

Calculate the formula of the comprehensive attribute value of each scheme:

$$Z_j(W) = \sum_{i=1}^{n} r_{ij} * w_i \ (i = 1,2,\cdots,n.\ j = 1,2,\cdots,m) \quad (5)$$

Finally, use $Z_j(w)$ to sort and optimize the scheme.

2.2 Order relationship analysis (G1 method)

The method is mainly divided into the following three steps:

2.2.1 Determining order relationship. If the importance of the evaluation index Xi with respect to an evaluation criterion is greater than (or not less than) Xj, then $Xi > Xj$.If the evaluation index $X_1, X_2, \dots, X_m$ has a relationship of $X^*{}_1, X^*{}_2, \dots, X^*$ with respect to an evaluation criterion, then the evaluation index $X_1, X_2, \dots, X_m$ is determined by ">". Here, $X^*{}_i$ denotes the i evaluation index (i=1,2, ⋯,m) after $\{X_i\}$ is sorted according to the order relationship ">". This uniquely determines a sequence relationship. For some problems, it is not enough to give the order relationship, but also to determine the weight coefficient of each evaluation index for an evaluation criterion. For the convenience of writing and without loss of generality, the following is still recorded as

$$X^*{}_1 > X^*{}_2 > X^*{}_3 > X^*{}_4 > X^*{}_5 \quad (6)$$

2.2.2 Give a comparative judgment of the relative importance between X^*k-1 and X^*k. Assuming that the decision maker's radio of importance to evaluation index X^*_{k-1} and X^*_k is $\frac{w_{k-1}}{w_k} = r_k$,the assignment of r_k can be referred to Table 1

Table 1 r_k assignment reference.

R_i	Description
1.0	Indicator X^*_{k-1} is as important as indicator X^*_k
1.2	Indicator X^*_{k-1} is slightly more important than indicator X^*_k
1.4	Indicator X^*_{k-1} is significantly more important than indicator X^*_k
1.6	Indicator X^*_{k-1} is more important than indicator X^*_k
1.8	Indicator X^*_{k-1} is extremely important than indicator X^*_{k-1}

2.2.3 Calculation of weight coefficient w_k. If the decision maker gives a rational assignment of r_k, then w_m is

$$w_m = \left(\sum_{k=2}^{m} \prod_{i=k}^{m} r_i + 1\right)^{-1} \tag{7}$$

$$w_{k-1} = w_k r_k,\ \ k = m, m-1, \cdots, 3,2 \tag{8}$$

2.3 Determination of decision makers' weights in multi-attribute group decision making method based on information entropy

In the decision-making process of modern large-scale systems, in order to reflect the democracy and rationality of decision-making, it is often necessary for multiple decision makers to participate together (ie, group decision making).

i For a multi-attribute decision problem, let X=$(X_1, X_2, \ldots, X_m)$ and U=$(U_1, U_2, \ldots, U_n)$ respectively be the program set and attribute set, and the attribute weights are completely unknown. D=$(D_1, D_2, \ldots, D_k)$ is the set of decision makers, and the weight of decision makers is completely unknown. Suppose the decision-maker $d_k \in D$ gives the comprehensive attribute value a_{ik} of scheme $x_i \in X$ under the attribute $u_j \in U$, and composes the comprehensive attribute values of decision-maker d_k for multi-attribute decisions of all schemes into an M-dimensional column vector, where A_k= $(a_{1k}, a_{2k}, a_{3k}, \ldots, a_{mk})^T$,then, the decision-making comprehensive attribute values of all decision makers are composed into a decision matrix A=$(a_{ik})_{m\times t}$

ii Calculate the characteristic weight of the decision maker d_k

$$P_{ik} = \frac{a_{ik}}{\sum_{i=1}^{n} a_{ik}} \tag{9}$$

Assume here a_{ik}>0, $\sum_{i=1}^{n} a_{ik}$>0.

iii Calculate the information entropy of the decision maker d k output

$$E_j = -1/\ln m \sum_{i=1}^{m} p_{ik} \ln p_{ik} \quad (i = 1,2,\cdots,m,) \quad (k = 1,2,\cdots,t) \tag{10}$$

iv Calculate the decision maker weight vector w =$(w_1, w_2, \cdots, w_t)$,where

$$W_t = (1 - E_k)/\sum_{t=1}^{t}(1 - E_k) \quad (k = 1,2,\cdots,t) \tag{11}$$

3. Empirical analysis

3.1 Establishment of indicator system

The indicator is the basis of determining the evaluation quality and the selection of the indicator factors directly affects the quality of the evaluation result. Therefore, the selection of indicators should be determined through carrying out field research and considering various factors.

Here, the multi-attribute decision-making based on applying information entropy weight and quadratic weighting method is used to evaluate the sustainable development of the real estate market. Taking the development of the real estate market in Xiamen as the research object, we evaluate the sustainable development situation of the real estate in Xiamen in 2014 to 2017. The selected indicators affecting the sustainable development of the real estate market mainly include 7 items u_1, u_2, u_3, u_4, u_5, u_6, u_7:

u_1: Average selling price of commercial housing
u_2: Average price of house transactions
u_3: The proportion of real estate investment completion occupying total social fixed assets investment
u_4: Land transfer price
u_5: Vacant housing ratio
u_6: The quality of commercial housing
u_7: Acceptability of commercial housing prices

The first five items are quantitative indicators, and the last two items are qualitative indicators. The expert group consists of three decision makers to score u_6 and u_7. The attribute values of the annual real estate sustainable development evaluation indicators are shown in Table 2 to Table 4.

Table 2 d_1 gives the decision matrix A.

	u_1	u_2	u_3	u_4	u_5	u_6	u_7
2014	13625	18568	40	16425	32	70	60
2015	15378	19868	45	16252	20	70	55
2016	16122	25862	41	36464	26	75	50
2017	20021	31805	35	26662	23	75	50

Table 3 d_2 gives the decision matrix B.

	u_1	u_2	u_3	u_4	u_5	u_6	u_7
2014	13625	18568	40	16425	32	70	80
2015	15378	19868	45	16252	20	68	75
2016	16122	25862	41	36464	26	65	65
2017	20021	31805	35	26662	23	65	60

Table 4 d_3 gives the decision matrix C.

	u_1	u_2	u_3	u_4	u_5	u_6	u_7
2014	13625	18568	40	16425	32	78	60
2015	15378	19868	45	16252	20	80	63
2016	16122	25862	41	36464	26	81	62
2017	20021	31805	35	26662	23	82	60

Source: National Bureau of Statistics(u_1—u_5)

3.2 Evaluation of sample entry

The first is to evaluate the choice of samples, the samples should be representative and comprehensive; then the initialization of the sample data is processed to meet the needs of the application. Use the following formula to regulate

$$r_{ij} = \frac{a_{ij}}{max(a_{ij})}, \ i \in N, j \in I \quad (12)$$

The standardized table is shown in Tables 5 to 7

Table 5 d_1 gives the decision matrix A^*.

	u_1	u_2	u_3	u_4	u_5	u_6	u_7
2014	0.6805	0.5838	0.8889	0.4504	1	0.9333	1
2015	0.7681	0.6247	1	0.4457	0.625	0.9333	0.9167
2016	0.8053	0.8131	0.9111	1	0.8125	1	0.8333
2017	1	1	0.7778	0.7312	0.7188	1	0.8333

Table 6 d_2 gives the decision matrix B^*.

	u_1	u_2	u_3	u_4	u_5	u_6	u_7
2014	0.6805	0.5838	0.8889	0.4504	1	1	1
2015	0.7681	0.6247	1	0.4457	0.625	0.9714	0.9375
2016	0.8053	0.8131	0.9111	1	0.8125	0.9286	0.8125
2017	1	1	0.7778	0.7312	0.7188	0.9286	0.750

Table 7 d_3 gives the decision matrix C^*.

	u_1	u_2	u_3	u_4	u_5	u_6	u_7
2014	0.605	0.5838	0.8889	0.4504	1	0.963	0.9524
2015	0.7681	0.6247	1	0.4457	0.625	0.9877	1
2016	0.8053	0.8131	0.9111	1	0.8125	1	0.9841
2017	1	1	0.7778	0.7312	0.7188	0.9877	0.9524

3.3 Comprehensive

Evaluation Based on Entropy Weight Method and Order Relation Analysis. According to the individual's point of view, the three decision makers obtain the subjective weight B_{kl} (l=1,2,…,n) of each attribute value according to formula (9)

$$T_1=(0.0520,0.1223,0.0524,0.1468,0.0627,0.2055,0.3288)$$
$$T_2=(0.2312,0.1605,0.1115,0.1338,0.0774,0.0929,0.1927)$$
$$T_3=(0.1935,0.1935,0.0933,0.1613,0.0933,0.1120,0.1344)$$

The weighting formula is as follows:

$$r^* = B_{kl} r_{ij} \tag{13}$$

Use the formula (15) to weight each of the indicators of the matrix A, B, and C separately, and obtain the weighting matrix as follows

$$A^{\#} = \begin{pmatrix} 0.0354 & 0.0714 & 0.0466 & 0.0661 & 0.0627 & 0.1918 & 0.3288 \\ 0.0399 & 0.0764 & 0.0524 & 0.0654 & 0.0392 & 0.1918 & 0.3014 \\ 0.0419 & 0.0994 & 0.0477 & 0.1468 & 0.0509 & 0.2055 & 0.2740 \\ 0.0520 & 0.1223 & 0.0408 & 0.1073 & 0.0451 & 0.2055 & 0.2740 \end{pmatrix}$$

$$B^{\#} = \begin{pmatrix} 0.1573 & 0.0937 & 0.0991 & 0.0603 & 0.0774 & 0.0929 & 0.1297 \\ 0.1776 & 0.1003 & 0.1115 & 0.0596 & 0.0484 & 0.0902 & 0.1807 \\ 0.1862 & 0.1305 & 0.1016 & 0.1338 & 0.0629 & 0.0863 & 0.1566 \\ 0.2312 & 0.1605 & 0.0867 & 0.0978 & 0.0556 & 0.0863 & 0.1445 \end{pmatrix}$$

$$C^{\#} = \begin{pmatrix} 0.1317 & 0.1130 & 0.0829 & 0.0726 & 0.0933 & 0.1079 & 0.1280 \\ 0.1486 & 0.1209 & 0.0933 & 0.0719 & 0.0583 & 0.1106 & 0.1344 \\ 0.1558 & 0.1573 & 0.0850 & 0.1613 & 0.0758 & 0.1120 & 0.1323 \\ 0.1935 & 0.1935 & 0.0726 & 0.1179 & 0.0671 & 0.1106 & 0.1280 \end{pmatrix}$$

After normalizing the above matrices, the weighting coefficient vector W^t of the decision maker d_k for each attribute of the scheme X_i is calculated by using equation (6) as follows

$$W^1= \{0.0873 \quad 0.2035 \quad 0.0347 \quad 0.5113 \quad 0.1313 \quad 0.0059 \quad 0.0261\}$$
$$W^2= \{0.0849 \quad 0.1978 \quad 0.0338 \quad 0.4971 \quad 0.1277 \quad 0.0049 \quad 0.0542\}$$
$$W^3= \{0.0898 \quad 0.2092 \quad 0.0357 \quad 0.5257 \quad 0.1350 \quad 0.0016 \quad 0.0028\}$$

Calculating the comprehensive attribute value of the scheme X_i for the decision maker D_k using equation (7)

$$Z_{11}(W^1)=0.0710,Z_{21}(W^1)=0.0684,Z_{31}(W^1)=0.1157,Z_{41}(W^1)=0.1000$$
$$Z_{12}(W^2)=0.0860,Z_{23}(W^2)=0.0847,Z_{32}(W^2)=0.1285,Z_{42}(W^2)=0.1183$$
$$Z_{13}(W^3)=0.0897,Z_{23}(W^3)=0.0882,Z_{33}(W^3)=0.1455,Z_{43}(W^3)=0.1320$$

Calculate the weight vector of the decision maker using equation (13)

$$W=(0.3715 \quad 0.2574 \quad 0.3710)$$

Use the formula $U_i(w)=\sum_{k=1}^{t} z_{ik}(w^k)\, w_k$ to calculate the final attribute value of each scheme

$$U_1(w)=0.2002,\ U_2(w)=0.1958,\ U_3(w)=0.3185,\ U_4(w)=0.2854$$

3.4 Analysis of evaluation results

According to the evaluation results, the overall development situation of the real estate industry in Xiamen in 2014-2017 is on the rise, and the property value of the real estate industry has grown significantly in 2015-2016, and the industry development has been further improved.

4. Conclusion

In summary, the development of the real estate industry in Xiamen is more optimistic, but the development in 2017 is slightly worse than the development in 2016. From the analysis of the normalized weight coefficients of each index, the three decision makers gave the highest weight values for the land transfer price, which were 0.5113, 0.4971, and 0.5257 respectively. Land transfer must be carried out by the state as the land owner, which indicates whether the real estate industry can continue to develop healthily and closely related to the country's macro-control policies. Therefore, the timely adjustment of land transfer prices by the government and the adoption of appropriate regulatory measures to control the excessive growth of real estate prices are of great significance to the sustainable development of the real estate industry in Xiamen. From this point of view, this paper believes that the first is to prevent the government from pursuing excessive fiscal land sales prices; Second, the government departments should play a leading role in macroeconomic regulation and control to form an orderly land transfer price mechanism and market, and get rid of the rigid model of government “estimate” traditionally to promote the sound development of the real estate industry.

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