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RESEARCH PAPER

Quantitative Evaluation of Real Estate's Risk based on AHP and Simulation

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Abstract: New quantitative model of evaluating the economic risk of a real estate project has been proposed in this article and the weight of each risk factor influencing the outcome of a real estate project in the model has been objectively calculated by using AHP. On the basis of simulation, the quantified evaluation and analysis of economic risk of example has been done; the sensitivity analysis of the influence of one factor or more factors combined on the real estate project has been made by using new model proposed in this article.
Key Words: analytical hierarchy process (AHP); real estate; risk analysis; sensitivity analysis

Real estate development has been regarded as a kind of economic issue of high investment, high profit, and high risk. The variables such as investment, profit, and construction cost and construction duration are affected by all kinds of risk factors related to real estate development during the development and management process of a real estate project. The change of every risk factor is likely to bring about great influence on investment, profit, construction cost, and construction duration of real estate project. Thus, it is impossible to gain a higher return from the real estate investment if the risks during the process of the real estate development are neglected and a comprehensive and correct analysis of them not made. There are many methods or models to evaluate and analyze the economic risk of real estate project, such as NPV, IRR, and multi-objective decision-making method etc. and the economic risk of a real estate project can be dynamically evaluated by using some methods among them based on simulation[1−8]. However, on the one hand, these methods can only consider all risk factors' comprehensive influence on the expected outcome of real estate investment (such as NPV), but cannot consider one risk factor's or more combined risk factors' influence on the expected outcome of a real estate project, which the investor cares for. On the other hand, it is an important step for getting the scientific evaluation results to reasonably determine the weight of each risk factor influencing the economic return of a real estate investment, to ensure the consistency of all risk factors, and to reduce the subjective[9]. Therefore, based on simulation, a new quantified model of evaluating and analyzing the economic risk of a real estate project has been proposed in this article after the risk factors of a real estate project have been identified, and the weight of each risk factor in the model has been calculated by using AHP. This model can not only consider the dynamic influence of one factor or more combined factors on the outcome which developers are concerned about, such as real estate investment profit (such as NPV), construction cost and construction duration etc, but also analyze the dynamic, quantitative influence of these factors on the project investment and deals with the risk sensitivity analysis.

1 Determination of the weight of each risk factor

In the process of developing and managing a real estate project, the real estate project might be faced with different risk factors. These risk factors have been presented in some documents[6,8−12]. The common risks are natural risk, political risk, economic risk, technical risk, and management risk. These risk factors have different degrees of influence, namely, the weight on the objectives of a real estate project such as NPV, construction duration etc. There are many methods to determine the weight of each risk factor such as expert scoring method, Delphi method, etc. However, the objectivity and consistency of these methods are greatly affected by experts' subjective judgment [7,9].

The analytic hierarchy process, simply called AHP, first proposed by American mathematician Professor A.L. Saaty in 1980, is a flexible, practical, multi-objective decision-making method widely applied in construction project and risk evaluation[7,9,13−14]. The risk evaluation of construction project by using AHP is a comprehensive process combining subjective judgment and objective analysis. The complex question can be broken up into the hierarchy structure, which is easily understood. After that, the simpler hierarchy structure can be analyzed step by step, a judgment matrix judging the important degree between the risk factors built up, the eigenvalue calculated, and its consistency reviewed to scientifically obtain the weight of each risk factor.

2 Qualified analytic model

There are many risk factors influencing the profit of a real estate project. The relevant documents [1–5] dealing

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Table. Statistical results of an example

Risk variable	1st cash flow		2nd cash flow		3rd cash flow		4th cash flow	
	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum
Net inflow CI_t								
Sale or rent income	1100	1800	6210	7680	5830	7830	3989	4100
Net outflow CO_t								
Construction cost	850	1400	2860	4300	2400	8400	2200	3200
Flow cash	50	180	40	90	15	60	12	45
Foundation and utility fee	45	65	17	30	18	28	8	15
Financial cost	38	76	180	220	140	160	75	100
Total	983	1721	3097	4640	2573	8648	2295	3360

with these factors' comprehensive influence on the real estate's profit can be referred to. However, different risk factors have different weights of influencing the construction project profit; that is to say, even the same risk factor has a different weight of influence on the different project objectives, such as the investment profit, construction duration, etc. The following formula (2) indicates the regular pattern in the fixed region for influencing the economic variables about the project. Setting NPV as an analysis objective as follows, a quantified model of evaluating the economic risk of real estate project is built. On the basis of simulation, the model makes the quantitative evaluation and analysis of risk factor(s) concerned by the investors. Supposing the weight of one risk factor$j$ on one objective is w_j (obtained by AHP), the sum weight of all the risk factors on the same objective is 1, namely, $\sum_{j=1}^{n} w_j = 1$ (n — the total number of all risk factors). Meanwhile, the random distribution function of each risk factor is known by means of the relevant historical data and mathematics. Then the economic risk analysis of real estate development can be obtained by the following model.

$$NPV = \sum_{t=1}^{N} (CI_t - CO_t)(1 + i_t)^{-t} \tag{1}$$

where

$$\begin{aligned} CI_t(CO_t, N_t, i_t) &= \min CI_t(CO_t, N_t, i_t) + \\ &[\max CI_t(CO_t, N_t, i_t) - \min CI_t(CO_t, N_t, i_t)] \\ &\times [w_1 \times Rm_1 + w_2 \times Rm_2 + \cdots + w_n \times Rm_n] \end{aligned} \tag{2}$$

In the above-mentioned model, formula (1)[15] is one calculating net present value of real estate project. CI_t means the net inflow in the tth year whereas CO_t is the net outflow in the tth year.i_t represents the basic discount rate in the tth year whereas N_t represents the construction duration. In the normal economic evaluation of construction project, the above-mentioned variables are generally considered as constant. Even their being considered as variables, the relationships between the above-mentioned variables with each risk factor cannot be reflected. In this model, the mentioned variables are all regarded as random variables influenced by n risk factors. The influence rule can be indicated in formula (2), in which each symbol differs from each other in meaning. For example, MinCI_t means the probable minimal net inflow in the tth year whereas MaxCI_t means the probable maximal net inflow in the tth year. Rm_j is the random figure, which is produced by the random distribution function of the jth risk factor. Its range is from zero to one.

3 Case

In the following, the basic idea of the model is illustrated by taking an example of the development of a plot of commercial land invested by a real estate corporation. The total number of investment on the commercial real estate project is 123.91million RMB. For the purpose of concise discussion, construction duration and the basic discount rate are supposed to be constant, respectively N =4, i=10%. The annual information can be predicted or calculated by using Delphi method and necessary, financial and economic analysis method. The results are shown in Table. The development of this project should be mainly affected by the following five risk elements, land price (D_1), material price (D_2), construction techniques (D_3), social purchasing capacity (D_4), market competition (D_5). Hierarchy structure of risk analysis about the project can be showed in Figure 1. Meanwhile, coupled factors can be compared by using expert scoring, the judgment matrix built up for each risk factor to the risk variables CI_t and CO_t, and then the weight of each risk variable calculated as shown in the article.

The case is calculated on the basis of computer program of Monte Carlo simulation. Probability distribution of each risk variable, the 3rd CI, the 3rd CO, and NPV and NPV≥2500, is demonstrated in the following Figures 2–5.

CI→ D

CI	D_1	D_2	D_3	D_4	D_5	W^0
D_1	1	1	7	1/3	1/3	0.14
D_2	1	1	7	1/3	1/3	0.14
D_3	1/7	1/7	1	1/7	1/7	0.03
D_4	3	3	7	1	3	0.42
D_5	3	3	7	1/3	1	0.27

CO→ D

CO	D_1	D_2	D_3	D_5	W^1
D_1	1	1/3	3	5	0.274
D_2	3	1	5	7	0.504
D_3	1/3	1/5	1	3	0.144
D_5	1/5	1/7	1/3	1	0.078

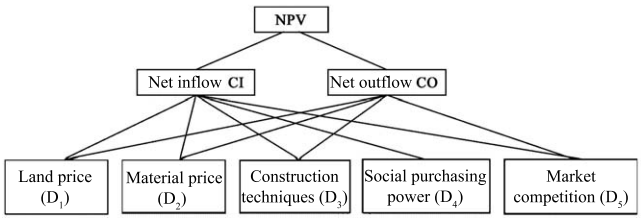

Figure 1. Hierarchy structure of an example