Study on Investment Risk Assessment Model of Real Estate Project Based on Monte Carlo Method

Bowen Zhai¹, Huilin Chen²*, Aijuan Chen³

¹Departments of Materials and Construction Engineering, Guizhou Normal University, Guizhou Guiyang, 550025, China
²Departments of National University of Science and Technology Park, Guizhou Normal University, Guizhou Guiyang, 550025, China
³Departments of Kindergarten, Guizhou Normal University, Guizhou Guiyang, 550025, China

Email: 780898453@qq.com, 124910194@qq.com, 792947682@qq.com

TEL: 13985530258

Abstract: In view of the uncertainty of investment caused by many unstable factors and complex situations in real estate development, the variable content and risk identification affecting investment are analyzed in combination with the project characteristics, the probability distribution function of variables and the framework of Monte Carlo algorithm are given, and the investment risk assessment model of real estate projects based on Monte Carlo Method is constructed. The optimal investment scheme is determined by computer simulation calculation based on the comparison and selection of specific real estate investment projects.

1. Introduction
Real estate projects have a lot of risks due to large investment, long cycle, multiple links involved, strong regional and uncertain factors. Most real estate development enterprises in China lack systematic management of projects, and they pay little attention to risk management, with weak awareness of risk management, lack of risk management mechanism, single risk management means, and low quality of risk management personnel. As a result, many risk factors in real estate projects cannot be effectively controlled, leading to a decline in the profitability of real estate projects [1]. This article proposes an investment risk assessment model based on the Monte Carlo Method, and determines the application in real estate project proposal ration selection based on specific case.

2. Establishment of Investment Risk Assessment model
Monte Carlo Method is to build probability distribution model based on stochastic process and experience, and set parameters to analyze the risk factors of real estate investment projects. The investment risk assessment procedures of real estate projects based on Monte Carlo Method are [2]:

(1) The paper identify the source of risk. Determine the source of risk according to project characteristics, components and historical experience;

(2) The paper determine the probability distribution of each risk source. The probability distribution function of risk is determined according to the data of real estate projects collected in the past, together with various influencing factors;
(3) According to the determined probability distribution function, the probability simulation software was used to generate random Numbers, so as to analyze the factors influencing risk sources of each project's investment based on Monte Carlo simulation;
(4) The paper summarize all the influencing factors according to the analysis results and the calculation formula of the planning scheme, and obtain the probability statistics value of risks;
(5) The risk simulation value can be obtained through multiple simulations.

2.1 Risk Identification of Real Estate Investment Projects
To identify the risks of real estate investment projects, it is necessary to firstly clearly identify the contents, which include the decomposition of risks, the judgment of whether there are new risks, the determination of risk events and the definition of risk consequences. The process is shown in Figure 1[3]. Changes in government, design, construction, sales, market and competitors will affect the investment effect of the project. Therefore, the investment risk management of the project requires effective planning and management, effective risk identification and evaluation.

2.2 Distribution Characteristics of Real Estate Investment Risk Probability
The probability distribution of real estate project investment risk can be divided into deterministic distribution and uncertainty distribution, and the following can be mainly divided into poisson distribution, binomial distribution, triangle distribution, empirical probability distribution, normal distribution, uniform distribution and blind number theory. It can be seen from the characteristics and risk experience analysis of real estate projects that the probability distribution of investment analysis is mostly using triangle distribution and empirical probability distribution[4]. Triangle distribution is a continuous probability distribution in probability theory and statistics, with a lower limit of a, a mode of c and a upper limit of b. In the application, a, b and c are also called the minimum, maximum and most probable value. The probability density function formula of triangle distribution, as formula (1):

\[
f(x|a, b, c) = \begin{cases} \frac{2(x-a)}{(b-a)(c-a)} & \text{for } a \leq x \leq c \\ \frac{2(b-x)}{(b-a)(b-c)} & \text{for } c < x \leq b \\ 0 & \text{otherwise} \end{cases}
\]

The Graph of probability density function is as figure 2.
Its cumulative distribution function is shown in Equation, as formula (2).

\[
F(x) = \begin{cases} 0, & x \leq x_1 \\ \sum_{k=1}^{n} \frac{x_k-x_{k-1}}{x_{k+1}-x_k}, & x_k < x \leq x_{k+1} \\ 1, & x > x_n \end{cases}
\]

\[F\]
In formula (2), $x_1, x_2, \ldots, x_n$ is random observation value in probability distribution, and $x_1$ is the minimum. $x_n$ is maximum. Its distribution pattern is shown in Figure 3.

After determining the optimistic value and pessimistic value of the real estate investment variable, it is difficult to judge the most probable value, and only one possible value range can be determined, which constitutes a special case of triangle distribution: trapezoid distribution.

2.3 Real Estate Project Risk Assessment Model

When investing in development projects, the actual situation is varied and the important risk variables are different; this requires the analyst to identify key risk variables from a number of factors affecting the investment by appropriate risk identification based on the specific situation of the project. Generally speaking, there are 7 main risk variables influencing real estate investment: Residential Sales Revenue ($P_1*S_1$), Commercial Sales Revenue ($P_2*S_2$), Land Cost ($K_1$), Preliminary Cost ($K_2$), Development and Construction Cost ($K_3$), Marketing Expense ($K_4$) and other expenses ($K_5$).

In the financial evaluation of real estate investment projects, NPV is used to calculate and evaluate the profitability of development projects in the construction and production service years. When applying the NPV evaluation scheme, for independent scheme, NPV should be greater than or equal to 0, so that the scheme can be accepted. For the evaluation of multiple schemes, any NPV < 0 scheme is eliminated first. In the remaining schemes, NPV should be combined with investment amount and financial net present value in order to determine the scheme. In addition, it should be noted that the discount rate of investment present value and financial net present value should be consistent.

The NPV of the net present value of real estate can be expressed as Formula (3).

$$NPV = \sum_{t=1}^{n} \left( \sum_{i=1}^{2} (P_t * S_t) \left( \frac{P}{F}, i_c, t \right) - \sum_{i=1}^{5} k_i t \left( \frac{P}{F}, i_c, t \right) \right)$$ (3)

In which:

$$\left( \frac{P}{F}, i_c, t \right) = \frac{1}{(1 + i_c)^t}$$ (4)
In formula (3) and (4) i represent base discount rate, and n represents the life cycle of the project.

3. Computer Simulation and Model Test

3.1 Project Investment Plan

The main economic and technical indicators of scheme A and B of a real estate investment project are shown in Table 1.

| Content                        | Total | A | B | A | B | A | B |
|--------------------------------|-------|---|---|---|---|---|---|
| Construction and operation     |       | T1 | T2 | T3 |
| period                         |       |   |   |   |
| Cash inflow                    | 44799 | 54048 | 0 | 0 | 17862 | 31723 | 26937 | 21595 |
| Sales revenue                  | 44799 | 54048 | 0 | 0 | 17862 | 31723 | 26937 | 21595 |
| Cash outflow                   | 40890 | 48664 | 16095 | 17431 | 12191 | 19174 | 12604 | 12059 |
| Investment                     | 26285 | 30283 | 16095 | 17431 | 8407 | 10832 | 1784 | 2020 |
| Business tax and additional    | 2486 | 3000 | 0 | 0 | 992 | 1802 | 1495 | 1198 |
| Land VAT                       | 2266 | 4143 | 0 | 0 | 0 | 0 | 2266 | 4143 |
| Income tax                     | 9852 | 11238 | 0 | 0 | 2793 | 6540 | 7059 | 4697 |
| Net cash flow (after tax)      | 3909 | 5384 | -16095 | -17431 | 5671 | 13279 | 14333 | 9536 |
| Cumulative net cash flow       | 0 | 0 | -16095 | -17431 | -10424 | -4152 | 3909 | 5384 |
| (after tax)                    | Discount factor (i=10%) | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| NPV (after tax)                | 905 | 2521 | -16095 | -17431 | 5156 | 12071 | 11845 | 7881 |
| FNPV (after tax)               | 0 | 0 | -16095 | -17431 | -10940 | -5359 | 905 | 2521 |

3.2 Determining the Risk Probability Distribution

The "Delphi Method" is used to estimate the probability distribution of the above 7 risk variables and
the specific parameters in their distribution function. For example, the probability distribution of risk change in the first year of scheme a is shown in Table 2, and the probability distribution of risk variables in other years of scheme A and B is omitted [6].

| Content                  | Probability distribution | Parameter       |
|--------------------------|--------------------------|-----------------|
| Housing sales revenue    | Trigonometric distribution | No sales revenue |
| Business sales revenue   | Trigonometric distribution | No sales revenue |
| Land cost                | Uniform distribution     | a: 11057; b: 11969 |
| Upfront cost             | Normal distribution      | Mean value: 901; Variance: 49 |
| Cost of development and construction | Trigonometric distribution | a: 3077; b: 3346; m: 3239 |
| Marketing cost           | Trigonometric distribution | a: 232; b: 325; m: 309 |
| Other expenses           | Normal distribution      | Mean value: 24; Variance: 15 |

3.3 Computer Simulation
In order to ensure that the simulation results are close to the actual maximum distribution, we took 95% confidence and planned to conduct 10,000 simulation experiments. After 10,000 simulations, the NPV statistics of scheme A and scheme B were obtained, as shown in Table 3.

| Statistical value | A              | B              |
|-------------------|----------------|----------------|
| Number of simulation | 9000.00        | 9000.00        |
| Mean value        | 664.71         | 427.74         |
| Median            | 597.89         | 610.68         |
| Standard deviation | 1040.48        | 2133.28        |
| Variance          | 1094869.79     | 4602437.09     |
| Deviation         | 0.33           | -0.38          |
| Kurtosis          | 2.69           | 2.63           |
| Coefficient of Variability | 1.55         | 4.93           |
| Minimum value     | -1812.92       | -7252.32       |
| Maximum value     | 4398.93        | 5467.98        |
| Standard error    | 1040.22        | 21.33          |

3.4 Analysis and Decision Making
(1) According to the statistical value of the financial net present value of scheme A and scheme B in Table 3, we can see that the NPV expectation value of both schemes is greater than zero, but the value of scheme A is greater than scheme B.

(2) To further compare the risk degree of each scheme, the standard deviation of NPV of scheme A is 1052.27, while that of scheme B is 2157.44, indicating that scheme B deviated greatly. Moreover, NPV of scheme A is between [min: -1833.45, Max: 4448.76] and [min: -7334.47, Max: 5529.92], indicating again that NPV of scheme B is more risky than scheme A.

(3) EXCEAL can be used to easily evaluate the specific probability distribution of the indicator, as shown in Table 4.

| A of probability distribution | B of probability distribution |
|-------------------------------|-------------------------------|
| probability distribution | NPV    | probability distribution | NPV    |
|--------------------------|--------|--------------------------|--------|
| 0%                       | -1933.65 | 0%                       | -7240.81 |
| 10%                      | -628.21  | 10%                      | -2518.07 |
| 20%                      | -257.76  | 20%                      | -1429.81 |
| 30%                      | 51.55    | 30%                      | -642.65  |
| 40%                      | 338.33   | 40%                      | 37.31    |
| 50%                      | 616.02   | 50%                      | 641.66   |
| 60%                      | 903.04   | 60%                      | 1228.60  |
| 70%                      | 1201.15  | 70%                      | 1790.13  |
| 80%                      | 1567.78  | 80%                      | 2377.82  |
| 90%                      | 2074.89  | 90%                      | 3114.57  |
| 100%                     | 4483.45  | 100%                     | 5416.34  |

Therefore, Scheme A should be adopted.

4. Conclusion

Through analysis above, compared with the results obtained by traditional analysis technology, the Monte Carlo Method can not only analyze the impact of risk factors on the expected return of the whole project, but also scientifically estimate the probability of risk occurrence. Moreover, such estimation is based on the full consideration of the joint influence and action of multiple risk variables, which can provide decision basis with practical value for risk decision makers. Therefore, it helps us to screen and compare multiple investment schemes.

References:
[1] Lin Guobin, Cai Weimin, Li Zhen, Wang Yuedong, Liu, Hongwu. Risk Analysis on the Link between Tianjin Urban and Rural Construction Land Increase and Decrease under the Influence of Housing Market [J]. China Land Science, 2014, 28(05): 27-34.
[2] Li Qing. Risk Analysis and Legal Regulation Path of Intelligent Investment Advisors [J]. Southern Finance, 2017(04): 90-98.
[3] Lin Boqiang. Risk Analysis in Project Evaluation: Application and Main Problems [J]. Financial Research, 2003(11): 49-63.
[4] Xu Qian. Uncertainty, Equity Incentive and Inefficient Investment [J]. Accounting Research, 2014(03): 41-48+95.
[5] Xu Qing, He Huagang, Wei Keke. Risk Analysis and Control Study of Falling Objects in Construction Based on Monte Carlo Method [J]. Industrial Safety and Environmental Protection, 2017, 43(04): 23-25.
[6] Huang Xiaolong. Research on Risk Assessment Model of Transmission and Transformation Engineering Cost Based on Monte Carlo Method [J]. Modern Electronic Technology, 2017, 40(20): 178-180.