ANALYSIS OF THE METHOD ABOUT THE PROJECT INVESTMENT RISK DECISION MAKING

Ze Hong LI, Shu Jing XU, Li Ping YAN
School of Economy and Management, North China Electric Power Univ., Baoding, China

Abstract: The enterprises will face up with many uncertainties when they make the project investment risk decisions. The uncertainties can lead to the deviation between the actual result and the expectant result, reduce the return rate of investment and extend the investment payback period. The key of making scientific decisions is to measure and analyze the project investment risk accurately. Traditional methods about the project investment risk decision include three layers: Payback Period Method without considering the monetary value of time; Net Present Value Method (NPV) and Internal Rate of Return Method (IRR) with considering the monetary value of time; Risk-adjusted Discount Rate Method and Certain-equivalent Method that combine the monetary value of time with the risk. The first layer method cannot be treat as the main method, because it does not consider the monetary value of time, the risk and the revenue after investment recovery period. Because of the same reason, the second layer methods are not consistent with the actual situation. The third layer methods make more progress than the two previous layers methods, but they also have some defects. Basing on the different degree project risks, the Risk-adjusted Discount Rate Method uses the suitable discount rate to calculate the NPV. This method will increase the risk lately, because it mixes the monetary value of time with the risk value. The Certain-equivalent Method uses different factors to adjust uncertain cash flow to certain cash flow and then calculate NPV. But the most difficult thing is to confirm the suitable factor. Normally the enterprises use one method to make decisions, it is very incomplete. Basing on the prior analysis, this paper will construct an index system, including non-risk-adjusted NPV、PI、PP、comprehensive standard deviation and Coefficient of variation. Then using the Entropy Weight Evaluation Method to confirm the best program. This will enhance the science and feasibility of the investment risk decisions.
Keywords: project investment; risk; decision; Entropy Weight Evaluation Method

1 Introduction

Project investment is a very complex process faced up to the future. It need to consider many uncertain factors and has several methods to be chosen. The decision methods of project investment can be divided into two kinds: one doesn't consider the risk value factor, including static payback period (PP) and dynamic net present value (NPV)、profitability index (PI) and internal rate of return (IRR); The other considers the risk value factor, including Risk-adjusted Discount Rate Method and Risk-adjusted Cash Flow Method. But all methods have advantages and defects (Chen 2005). In order to make the decision more scientific, this paper uses a new method of project investment risk decision——Entropy Weight Evaluation Method that it combines all kinds of methods' advantages with defects and overcomes the impact of their defects to decision.

2 Analysis of Advantages and Defects to Present Project Investment Decision Methods

2.1 Decision methods without considering risk value factor

2.1.1 Static project investment decision method

It doesn't consider monetary value of time and deal the different period's equal amount cash flow in the same way. PP is the representative. It need to calculate the PP that makes the input cash flow equal to the output cash flow, and uses this index to measure projects.

Advantage: calculate simply, cheaper costs, part factors replace whole factors; measure the liquidity of project (payback period is short, payback speed is fast, liquidity is strong), reflect the project risk indirectly (payback period is short, uncertainty is little relatively, risk is low).

Defect: without considering the impact of time value and risk value; without considering the revenue after payback period (Qiu 1999).

2.1.2 Dynamic project investment decision methods

They consider the impact of monetary value of time to different period's cash flow. According to the different emphases , they can be divided into three methods: NPV、PI and IRR. Taking advantage of these indexes, they assess all projects.

Advantage: consider the monetary value of time. Because of the project horizon, the value of equal cash flow is different in different period, so they can't be added directly. They must be discounted. Only by doing so, the decision methods are in accord with objective economic reality and reflect the sum of value correctly.

Defect: without considering the risk factor.

2.2 Decision methods of considering the risk value factor

2.2.1 Risk-adjusted Discount Rate Method

The principle of this method is to use a higher discount rate to calculate NPV for high-risk project, and then choose different projects according to the rule of NPV.

Advantage: it considers time value and risk value, is in accord with logic, has reasonable theory and is used widely.

Defect: it mixed time value with risk value, and makes the risk higher with the passing of time. In fact, some projects are contrary.

If using this method to decide, we will draw a false conclusion, and eliminate the feasible program.

2.2.2 Risk-adjusted Cash Flow Method

The principle of this method is to use a coefficient to adjust the risk cash flow into non-risk cash flow, and then calculate NPV based on the non-risk discount rate.

Advantage: it overcomes the defect of exaggerating long-term risk of Risk-adjusted discount rate Method.

Defect: it is very difficult to confirm reasonable coefficient. If the coefficient is unreasonable, the decision will be false (Guo 2005).

3 New Method about the Decision of Project Investment Risk——Entropy Weight Evaluation Method

Static and dynamic methods don't think about the risk value of investment. So it isn't scientific to make investment decision using this kind of index singly. Although the methods of Risk-adjusted Discount Rate and Risk-adjusted Cash Flow make a degree progress that they use risk-adjusted NPV as the criterion to make investment decision, they still have defects themselves (Zhao 2003). Risk-adjusted Discount Rate Method uses a discount rate that mixed time value with risk value to calculate NPV, it must be exaggerate the risk with the passing of time. It is difficult for Risk-adjusted Cash Flow method to confirm the coefficient. If we adopt Experiment Coefficient Method to confirm the coefficient, that is to say, we confirm the coefficient based on the relationship between standard deviation and certain-equivalent coefficient. It is very subjective and has no persuasion. If we adopt Conversion Coefficient Method, that is to say, we make the NPV of risk-adjusted discount rate equal the NPV of risk-adjusted cash flow and then get a coefficient. This method is a change of risk-adjusted discount rate, has no practical signification. So this kinds methods use risk-adjusted NPV as the criterion of decision, but if formula isn't scientific, it will lead to distorted reflection of risk.

Writers want to construct an index system of project investment decision. It can embody all kinds of indexes, including revenue、time value and risk value, and can reflect all kinds of factors that impact the decision comprehensively. Then we'll confirm the weight of index and make a decision by Entropy Weight Evaluation Method.

3.1 Construct appraisal index system

Present investment decision methods normally use one index or one king index as the judge criterion, for example risk-adjusted discount rate and risk-adjusted cash flow. They only consider monetary value of time or risk value. Because they have defects in designing, they will lead to distorted reflection of risk. So it isn't scientific and accurate to make a decision based on the result of them.

The principle of Entropy Weight Evaluation Method is to establish a kind of judge criterion of index system, that is to say, select several representative index, and establish an appraisal system that reflect monetary value of time and risk value at the same time. This method is different from risk-adjusted discount rate method and risk-adjust cash flow method in dealing risk factor. It doesn't use risk-adjust NPV as the judge criterion, but adopt some indexes that can measure investment risk into appraisal system and make risk value as the factor that impacts investment program's decision.

3.2 Estimate the weight of index by Entropy Weight Evaluation Method

Firstly, establish an appraisal model based on the concept of entropy. Then confirm the weight of index according to the information of index and the decision-maker's subjective judgment. Finally, make a decision by calculating the weight sum of deviation between appraisal index and ideal index.

4 Construct Appraisal Index System of Investment Decision

4.1 Theory basis

It is the foundation of investment decision that assesses monetary value of time and risk value of investment.

Monetary value of time means increased value after investment and re-investment in period of some time, also is called as capital value of time. It is the social average profit-to-investment ratio without risk and inflation in amount. Because of the competition, every project must get social average profit-to-investment ratio. So monetary value of time becomes the basic criterion of appraisal investment.

When we make decision of investment by discount, we hypothesize cash flow is definite, that is to say, we can define the sum of cash flow and the time happened. Investment is full of uncertainties in fact. If uncertainty is much lower, we can neglect the risk impact and look the decision as a definite decision. If uncertainty and risk is so higher that impact the choice of program, we need to consider risk value in the process of analyzing investment.

So when we select the decision indexes, we should make the index system includes monetary value of time and look them as the measure criterion.

4.2 Index selection

Writers select five indexes in the decision system: non-risk-adjusted NPV、PI、PP、comprehensive standard deviation and Coefficient of variation.

Non-risk-adjusted NPV and PI embody the project revenue and consider monetary value of time. Non-risk-adjusted NPV is an absolute number index. If the initial investment is different, its comparability is bad. So we also choose the relative index of PI in order to eliminate the impact to investment. If initial investment is similar in amount, we should increase the weight of non-risk-adjusted NPV in subjective. If initial investment is significantly different, we should increase the weight of PI (Li 2005).

PP、comprehensive standard deviation and Coefficient of variation embody the factor of risk value. Although PP is a static index, it can reflect the investment's risk directly. PP is short, uncertainty is little relatively, risk is low. This index is very simply and cost is very cheap. Comprehensive standard deviation and Coefficient of variation are direct index that reflect the investment risk. The standard deviation of revenue can reflect the degree that revenue is different from expectant revenue. So it can measure the risk. But investment has several periods' cash flow in the future, we should calculate the comprehensive standard deviation based on considering annual standard deviation comprehensively. Comprehensive standard deviation is an absolute number index. If all investment programs are different in scale, the absolute index can't compare their risk accurately. So we adopt the index——coefficient of variation in index system.

4.3 Formula of index

（1）Non-Risk-Adjusted NPV

$$NPV = \sum_{k=0}^{n} \frac{I_k}{(1+i)^k} - \sum_{k=0}^{n} \frac{O_k}{(1+i)^k}$$

Where I_k is the input cash flow in k year, O_k is the output cash flow in k year; n is the investment term; i is non-risk return rate.

（2）PI

$$PI = \sum_{k=0}^{n} \frac{I_k}{(1+i)^k} \Bigg/ \sum_{k=0}^{n} \frac{O_k}{(1+i)^k}$$

（3）PP

Initial investment is disbursed in one time, annual net cash flow is equal:

$$PP = \frac{\text{Initial Investment}}{\text{Annual Net Cash Flow}}$$

Initial investment is disbursed at different times, annual net cash flow isn't equal:

make $\sum_{k=0}^{n} I_k = \sum_{k=0}^{n} O_k$, get the result of PP

（4）Comprehensive Standard Deviation

d_k denotes the standard deviation of annual input cash flow

$$d_k = \sqrt{\sum_{i=1}^{m} (I_{ki} - E_k)^2 P_{ki}}$$

Where I_k is the expectation of input cash flow in k year; I_{ki} is the possible sum of the Ith cash flow in k year; P_{ki} is the possible probability of the Ith cash flow in k year.

Comprehensive standard deviation:

$$D = \sqrt{\sum_{k=0}^{n} [\frac{d_k}{(1+i)^k}]^2}$$

Where i is non-risk return rate.

（5）Coefficient of variation Q

Expectant principal value of cash flow in the future EPV

$$EPV = \sum_{k=0}^{n} \frac{E_k}{(1+i)^k}$$

Coefficient of deviation Q

$$Q = D/EPV$$

5 Entropy and Construction of Entropy Weight Model

5.1 Entropy and its nature

5.1.1 Definition of entropy

The definition of entropy is original from Thermodynamics, and then was sued in economics and project technology. It is an effective method of multi-goals decision. Entropy can measure the uncertainty of system, When system is in n different conditions, the probability of every condition occurs is pi (pi =1, 2, 3, ⋯, n), then the entropy of system is:

$$E = -\sum_{i=1}^{n} p_i Inp_i$$

Where p_i satisfies: $0 \leqslant p_i \leqslant 1$; $\sum_{i=1}^{n} p_i = 1$

The definition of conditional entropy: hypothesize system A and system B are related in statistics, then E(A / B) is the entropy of system A or conditional entropy when system is known.

5.1.2 Nature of entropy

(1) Additivity: entropy has the nature of probability, so the system entropy is equal to the sum of every conditional entropy.

(2)Non-negative nature: the probability that system is in a condition is $0 \leqslant p_i \leqslant 1$, so the entropy of system is non-negative all the time.

(3)Extreme nature: when system has equal probability, means $p_i = \frac{1}{n}$ $(i = 1, 2, 3, \cdots, n)$, its entropy is max, $E(p_1, p_2, \cdots, p_n) \leq E(\frac{1}{n}, \frac{1}{n}, \cdots, \frac{1}{n}) = \square n$.

(4)Symmetry: entropy of system has nothing to do with the order of p_i that condition occurs. Entropy of information is the measurement of degree of non-order in system. If it is small, the reliability of system is high, the information is much. Entropy of system is related to p_i and n , n becomes bigger, entropy of system will become bigger too; p_i is closed, entropy of system is big, the information is enough that it supplies to the decision-makers。

5.2 Construction of entropy weight appraisal model

5.2.1 d_{ki}

Hypothesize n indexes, m programs, X_{ki} is the index I's sum of k program, X_i^* is the ideal sum of index I, X_i^* will vary with the different characters of index. For positive index, X_i^* is more bigger more better; for negative index, X_i^* is more smaller more better.

$$\begin{cases} d_{ki} = \dfrac{X_{ki}}{X_i^*} \qquad X_i^* = \max\{X_{ki}\} \qquad X_i^* \text{ is positive index;} \\ d_{ki} = \dfrac{X_i^*}{X_{ki}} \qquad X_i^* = \min\{X_{ki}\} \qquad X_i^* \text{ is negative index.} \end{cases} \tag{1}$$

Step1: calculate the conditional entropy of index E_i

$$E_i = -\sum_{k=1}^{m} (\frac{d_{ki}}{d_i}) In(\frac{d_{ki}}{d_i}) \qquad \text{Where} \quad d_i = \sum_{k=1}^{m} d_{ki} \tag{2}$$

Step2: calculate the relative entropy of index e_i

$E_{\max} = Inm$, Entropy is max，then relative entropy is e_i

$$e_i = \frac{E_i}{Inm} = \frac{1}{Inm} \sum_{k=1}^{m} \frac{d_{ki}}{d_i} In(\frac{d_{ki}}{d_i}) \tag{3}$$

Step3: confirm the entropy weight of index θ_i

$$\theta_i = \frac{1}{n - E_e} [1 - e_i] \qquad \text{Where} \quad E_e = \sum_{i=1}^{n} e_i \tag{4}$$

Entropy weight expresses the relative degree that the quantity of information of system supplied, not the practical significant coefficient among indexes. Entropy weight is big, the quantity of information is much, the competition is stiff among indexes. It is the stress that decision-maker should consider.

Step4: give subjective weight of index ω_i

Step5: calculate comprehensive weight λ_i

$$\lambda_i = \frac{\theta_i \omega_i}{\sum_{i=1}^{n} \theta_i \omega_i} \tag{5}$$

Decision-maker confirms weight of all indexes subjectively, at the same time should comprehensively consider the information that all indexes supply in order to make subjective weight is in accord with practice.

Step6: calculate the weight sum of difference between appraisal indexes and ideal indexes S_k

$$S_k = \sum_{i=1}^{n} \lambda_i (d_i^* - d_{ki}) = 1 - \sum_{i=1}^{n} \lambda_i d_{ki} \tag{6}$$

S_k is small, the difference between appraisal program and ideal program is short, program is better.

6 Application of Entropy Weight Evaluation Method

According to the principle of max NPV and max PI, we should choose the fourth program and the third program; According to the principle of minimum PP, we should choose the fifth program; According to the principle of minimum comprehensive standard deviation and minimum coefficient of variation, we should choose the second program and the first program. Different judge-criterion, different decision (Zheng 2000).

Table 1 The number of five indexes of five programs

Program	NPV	PI	PP(negative index)	D（negative index）	Q（negative index）
1	4720	1.94	3.10	712.30	0.073
2	2950	1.70	2.90	680.50	0.095
3	3520	2.20	2.50	870.30	0.130
4	7500	1.68	6.70	1570.50	0.085
5	3100	2.10	2.30	695.60	0.120

Entropy Weight Evaluation Method considers all indexes that reflect the revenue、time value、risk value, and confirms the weight combined the quantity of information that indexes supply with the decision-maker's judgment. The decision-making process follows as:

Step1: calculate d_{ki} of indexes according to formula (1).

Step2: calculate the conditional entropy and the relative entropy according to formula (2) and formula (3).

Step3: confirm the entropy weight of indexes θ_i according to formula (4).

Step4: give the subjective weight ω_i. Because the initial investment is different, the comparability of absolute number index is bad. So the subjective weight of NPV and comprehensive standard deviation should be small, the subjective weight of PI and coefficient of variation should be big.

Step5: calculate comprehensive weight λ_i.

Table 2 θ_i 、 ω_i 、 λ_i of all indexes

Index	NPV	PI	PP	D	Q
θ_i	0.3690	0.0317	0.2771	0.2008	0.1214
ω_i	0.2	0.3	0.1	0.1	0.3
λ_i	0.4405	0.0568	0.1654	0.1199	0.2174

Step6: calculate the weight sum of difference between appraisal indexes and ideal indexes S_k.

Table 3 S_k of five programs

	Program1	Program2	Program3	Program4	Program5
S_k	0.2180	0.3336	0.3447	0.2479	0.3164
Sequence	1	4	5	2	3

Conclusion: the first program is the best according to Table 3.

7 Conclusion

This paper uses the concept of entropy in the investment risk decision and proposes Entropy Weight Evaluation Method. This method constructs an index system that reflects monetary value of time and risk value comprehensively, makes up for the judge criterion's defects of present investment decision methods.

This method if fit for comparability of several programs and makes the decision scientific, especially in the situation that draws different conclusions according to different principles.

Reference:

Chen, X.Y., Zhao, S. (2005). *Analysis methods of investment project risk: analysis and improve*, Friends of Accounting., 2005(1), 85-86.

Guo, Q.J., Lv, N.H. (2005). *Measurement of project risk comprehensively*, Journal of Xi'an Technological College. 2005(5) ,495-498.

Li, J.J., LI, G.C. (2005). *Analysis、measurement and control of project investment risk in enterprise*, China Economist., 2005(2), 23-24.

Qiu, K.H., Gao, C.H. (1999). *Compared research on the methods of investment decision*, Journal of Electric Engineer College of Hang Zhou. 1999 (4), 34-40.

Zhao, Y., Li, H.L., and Yang, M.Y. (2003). *Discussion about analysis methods of risk investment project*, Technoeconomics & Management Research., 2003(3), 35-36.

Zheng, X.H., Zhang, Q., and Luo, M. (2000). *Application of Entropy Coefficient Method in the decision of project risk*, Scientific Technology & Management., 2000(2), 73-75.