Study on the Education Investment Risk of Enterprise Human Capital Based on Monte Carlo Simulation Method

Jianhua Yang
Shandong Institute of Business and Technology, Yantai, 264005, China
Email: billyang1973@gmail.com

Zhaojin Gao
Shandong Institute of Business and Technology, Yantai, 264005, China
Email: billyang@eyou.com

Abstract—**After a critical literature review, this paper studies the risk of enterprise investment in human capital education from two aspects, economics and management. It firstly analyzes the main computation steps and simulation procedure of Monte Carlo Method, and then, with relevant case studies, probes into the employee efficiency development risk of that investment, the result of which shows that quick and simple, Monte Carlo Method can be a reference to the decision of enterprises, and to the perfection of relevant theories.**

Index Terms—**Monte Carlo Simulation Method, Enterprise Investment in Human Capital Education (EIIHCE), Risk, Employee Efficiency**

I. INTRODUCTION

The competition between enterprises is essentially the final competition of talents in an age of knowledge economy. Since the value of human capital is being recognized, the investment in its education is also greatly emphasized. However, there are still many unrevealed secrets in this field concerning the various aspects of the investment.

In the Enterprise Investment in Human Capital Education (hereafter EIIHCE), there are many uncertainties. So it is important to consider the influences of these uncertainties on the effects of investment so as to get an accurate evaluation of the investment program. Thus, it becomes a necessity to analyze and evaluate those uncertainties with the risk analysis technologies for the investment evaluation.

II. LITERATURE REVIEW

Alfred Marshall (1961)[1] had new understandings of the economic meanings of human capital, and a dominant concept run through his ideas—human capital investment is motivated by profits. Represented by Theodore Schultz (1962)[2]and Gary Becker (1962)[3], other economists developed the early theory of human capital, and included it as an important part in modern economics.

The risk of human capital investment was explained, to different degrees, when the theory of human capital was put forward. Schultz (1964) defined three sources of human capital investment risks (the uncertainty of one's own talents, the uncertainty of employment, and the uncertainty of the capital market) in his *The Economic Value of Education*[4]. Becker (1976) thought that there were great risks for higher education investment, which were really difficult to avoid. Therefore, the income from education should be equal to the profits from economic investments, which were untransferable and full of risks. This idea of Becker[5] shed lights on the income of human capital investment under risks. David Levhari and Yoram Weiss (1974) proved that human capital investment had more risks through his Two Periods Model. They used Expected Utility Theory in the model and concluded that the expected marginal revenues of human capital were greater that those of material capital[6]. Chen H. Stacey contrasted the income difference between those who received college education and those who received only high school education, which proved the risks of higher education[7]. Yoram Weiss and Gray Becker also pointed out that in cases of Risk-Averse, or Risk-Neutral, and with no regard to the individual differences, the Income Fluctuation Ratio was an effective index to measure education risks. As to the causes of Human Capital Investment Risk, Chinese researchers (such as Cheng Chengping, et al.[8]; Yang Yan, et al.[9]; Zhang Xiaoqing[10], etc) thought that there were mainly three levels: exterior environment (government), interior environment (enterprise), and individuals. Meanwhile Kong Lingfeng (2002) believed that the risks were caused mainly by the multi-natures of the investment subject—enterprise, the uncertainties of the objects, the long cycle of investment, and the indirectness of investment revenues[11]. Tang Zhenrong, et al. (2000) recognized that life span, brain drain, effectiveness of education investment and the proper

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employment of talents were the major influencing factors to education investment risks[12].

According to their close relationship with human behaviors, investment risks were classified into Human Risks and Non-human Risks by Gao Yongqiang, et al. (2000)[13] and Liu Maofu (2003)[14]. Liu Jiaguo (2003)[15] divided risks into the following categories according to what caused them: by the improper choice of investment carriers, by the unfair institutions, by the changes in exterior environment, by the carriers' death or their loss of ability to work in employment, by the incoordination between the cultural construction of enterprises and the perception of their employees, and finally by the running off of investment carriers.

To sum up, human capital theories have been in development and advancement since their birth, but most of the researches are about the human capital investment from a macrocosmic view. Microcosmic issues are relatively less talked about. Of those microcosmic researches, more are qualitative and less, quantitive. Though some studies do use quantitive methods, their maneuverability is questionable because most of them are based on abstract arithmetic models. Since it is on the frontier of academic studies, human capital education investment is a pioneering study in such a sense.

III. Basic Concepts

On the basis of the above literature review, this thesis tries to give tentative definition to human capital: Formed through investment and expected to bring in revenue, human capital is the totality of knowledge, skills, abilities, health and other traits condensed in an individual. With the final aim to increase labor production, Human capital Investment is the sum of capital invested in the betterment of human resources (in quality, ability, and levels) from the investors. As one form of human capital investment, EIIHCE is the main approach to add values to human capital. As the subject of investment, enterprises spend a certain amount of money to have their employers, the investment object, trained or educated through normal education, adult education, or vocational training, thus improving their quality, ability and levels of work, and in the final analysis, increasing the labor output.

Risks in EIIHCE refer to the uncertainties of yields (the actual yield being lower than the expected one) or the possibilities of loss (the actual yield being lower than the cost of investment) because of a series of uncertainties after a certain form of education or training of the employees. Because of the uncertainties of the future, all investments have risks and EIIHCE is no exception. Compared with material capital, human capital is characterized by heterogeneity, subjective initiative, and the indirectness and long cycles of investment revenues. Thus, human capital risks are greater than material capital.

Ⅳ. Risk Forms of EIIHCE

There are many factors influencing the effects of human capital education investment, such as the political tendency of the country, changes in macro-economic policies, changes in market demands, the advancement and innovation of the society, science and technology, the death or injuries and disabilities of employees, etc.. Though directly or indirectly, the above factors will influence investment effects, they are not subject to the control of enterprises. Risks caused by them are not peculiar to human capital education investment. Of all the risks, two forms are mainly caused by the peculiarities of human capital as will be explained in the following.

A. *Risks of employees' eEfficiency development after training or education*

Firstly, risks in this category are caused by the heterogeneity of human capital. Thomas Henry Huxley once said that the differences between men and men could be sometimes greater than those between man and apes. So, the same amount of capital investment can have different human capital yields after the training or education of different employees. Some have made great progress and become atlas-like while some others have little changed. Secondly, the employees' efficiency development may lie in their subjective initiative because human capital has a subjective consciousness. Thus, if the motivation mechanisms (rewards and punishment system and others) of enterprises are not perfect or scientific, the initiative and innovation of human capital will not be developed sufficiently, or effectively. Professor William·James of Harvard Management School（1993）made a research in the initiative of human capital, the result of which showed that proper motivation can bring 80% to 90% human capital into full play, and improper motivation, 20% to 30% (it may even bring negative effects).

B. *Risks of employees' running-off after training or education*

In the market economy, there is free flow of labor--human capital will always flow to the place or enterprise where they can better find, pursue and realize their personal values. Therefore, after training or education, employees may find favorable exterior conditions and go job-hopping. This would influence its production and management once they left the enterprise. The higher their status in the enterprise, the more special their skills, the greater the loss and influence. Besides the cost of training and education for the running-off employees, the loss of the enterprise will also include the cost to select and cultivate new employees from the market or from within; indirect loss is the delaying in work planning because the enterprise may be paralyzed due to the absence of key personals or business secrets may be let out because of the leaving of kernel personals.

The reasons for employees to leave are many and complicated, and only a limited number of them are personal factors. The following will mainly analyze the risks of employees' efficiency development.

V. RISK ANALYSIS OF EIIHCE WITH MONTE CARLO SIMULATION METHOD

Monte Carlo method is the most direct probability theory used in the field of human capital education investment risks[16]. Also called simulation sampling or statistical test method, this method is essentially to simulate the possible Random Phenomenon with the method of random numbers produced with certain probability distribution, and then determine the risks of the investment program according to the simulation results.

Monte Carlo method needs a large number of experiments in theory. The result will be more accurate with more experiments. Thanks to the development of computer technologies, this method has been popularized rapidly in the last 10 years. No traditional manual experiments in person are needed in modern Monte Carlo method. Aided with the high computation speed computers, the former strenuous and time consuming experiments can now be carried out quickly and easily.

A. Main steps and simulation procedure of Monte Carlo method

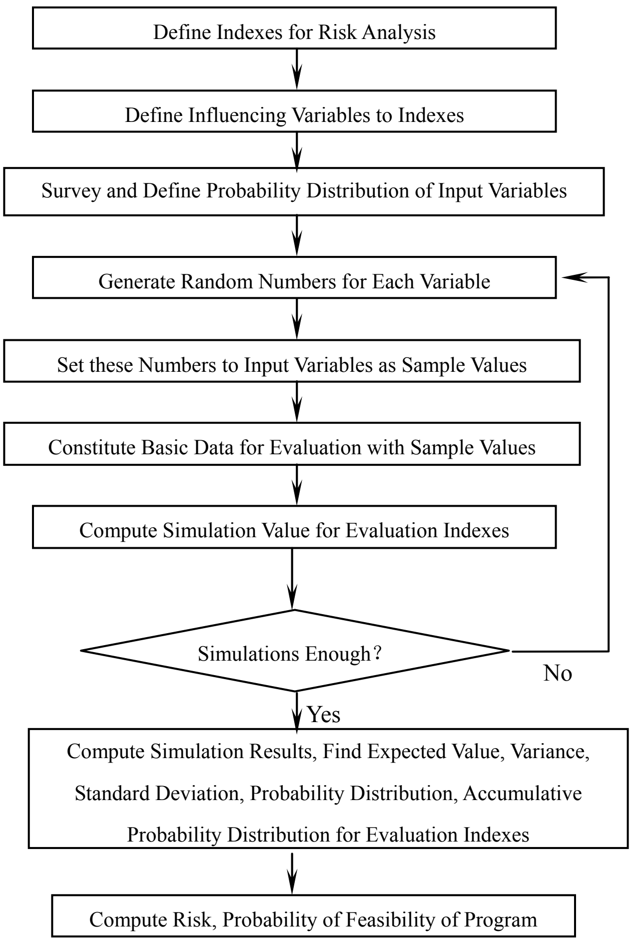

Figure1. Procedure of Monte Carlo Simulation Method

Shown in Figure 1 are the main steps of Risk evaluation of EIIHCE using Monte Carlo Simulation method.

Step 1: Define Evaluation Indexes (target variables) and influencing factors (input variables) for education investment, and construct an arithmetic formula between them, called Monte Carlo Analysis Model.

$$y = f(x_1, x_2, \cdots, x_n) = f(X) \quad (1)$$

In the above formula: y (target variable) stands for the evaluation index for education investment; $x_1, x_2, \cdots x_n$ (input variables) are influencing factors; $X = \{x_1, x_2, \cdots x_n\}$ are vectors for input variables; $f(\cdot)$ is the function between the two.

Step 2: Define the Probability Distribution for y's influencing factors ($x_1, x_2, \cdots x_n$) according to theoretical or practical experience.

Step 3: Use computer to generate independently large amount of random numbers for influencing factors ($x_1, x_2, \cdots x_n$) according to their Probability Distribution.

Step 4: Set these numbers to the values of influencing factors ($x_1, x_2, \cdots x_n$) and put them into Monte Carlo Analysis Model $y = f(X)$ to compute the simulation value for evaluation index y.

Step 5: Repeat the Simulation for enough times (usually more than 200). Then y's Expected Value, Variance, Standard Deviation, Probability Distribution, Accumulative Probability Distribution will be calculated, so are the risks and probability of feasibility of the education investment program.

B. Risks of employees' efficiency development after EIIHCE

EIIHCE brings economic revenues through the employees work in the production. Thus the employees' efficiency development after training or education, which is full of uncertainties and which may cause greater risks, is closely related to the actual EIIHCE revenues. There is a positive correlation between the two: the better the employees' efficiency development, the higher the revenues and vice versa.

Two factors influence the efficiency development of employees: the personal quality of the employees, and the stimulus mechanisms of enterprise. On the one hand, employees are heterogeneous, and the same education investment will have different effects. Aptitude and intelligent employees can improve their qualities and abilities greater than those less aptitude and less intelligent ones. On the other hand, the working positivity is obvious related to the stimulus mechanisms of enterprises—there is another positive correlation between the two: the more powerful the stimuli, the more positive they become and vice versa.

From the above discussion can be seen a positive correlation between the revenues of EIIHCE on the one side, and the personal qualities and the stimulus mechanisms on the other side. Another function can be used to express the relationship between them.

$$CI = a + f_1(GEN) + f_2(INS) \qquad (2)$$

In the above formula, CI stands for the revenues of EIIHCE; GEN is the personal qualities of employees; $f_1(\cdot)$ is the function between CI and GEN; INS stands for the stimulus of enterprise; $f_2(\cdot)$ is the function between CI and INS; a is a fixed constant.

Suppose an enterprise put forward an Investment Program in Human Capital Education and its front line employees were to receive training in operation skills. There would be revenues after training. The probation period of this program could be three years. Besides a fixed income of ￥110, 000 a year, other profits should be in a positive correlation with two more things: the qualities of the frontline employees (the supposed linearly dependent coefficient is 2), and the stimulus mechanism of the enterprise(the supposed linearly dependent coefficient is 3).

From the above supposition, the third formula can be formed to show the relationship between the annual revenue of this education investment program and the qualities of the employee as well as the stimulus of the enterprise.

$$CI_t = 11 + 2 \cdot GEN + 3 \cdot INS \qquad (3)$$

In Formula 3, CI_t is the revenues of Education Investment Program in a certain year (t); t represents the year; and according to experience, $GEN \sim N(0.80, 0.08)$ and $INS \sim N(0.50, 0.10)$ are suggested.

In addition to the ￥200, 000 at the beginning of training program, there would be yearly expenses to stimulate the employees' positivity. Each year the stimulus cost is expressed with CO_t (in 10 thousand yuan) and $CO_t \sim N(5,1)$ is supposed.

Net Present Value (NPV) is chosen as the evaluation index for this program. Put it simply, if all currency flow happened at the end of each year and the annual average profit margin were 9%, then the NPV for this program would be calculated with the following formula:

$$NPV = -20 + \frac{11 + 2 \cdot GEN + 3 \cdot INS - CO_1}{1 + 9\%} + \frac{11 + 2 \cdot GEN + 3 \cdot INS - CO_2}{(1 + 9\%)^2} + \frac{11 + 2 \cdot GEN + 3 \cdot INS - CO_3}{(1 + 9\%)^3} \qquad (4)$$

With the above suppositions, simulation analysis of Formula 4 are made with Crystal Ball 2000. 1000 experiments are carried out and random sampling data are set to GEN, INS and CO, 1000 for each. We get 1000 values for NPV, the statistics of which will be shown in Table 1, Table 2, Figure 2, and Figure 3.

TABLE Ⅰ.

STAT. PARAMETERS FOR NPV WITH MONTE CARLO SIMULATION

Trials	1,000
Mean	2.93
Median	3
Mode	---
Standard Deviation	2.59
Variance	6.73
Skewness	-0.08
Kurtosis	3.21
Coeff. of Variability	0.88
Range Minimum	-5.38
Range Maximum	12.82
Range Width	18.2
Mean Std. Error	0.08

TABLE Ⅱ.

CENTILE DISTRIBUTION OF NPV WITH MONTE CARLO SIMULATION

Percentile	Value
0%	-5.4
10%	-0.5
20%	0.82
30%	1.67
40%	2.3
50%	3
60%	3.67
70%	4.23
80%	5.03
90%	6.21
100%	12.8

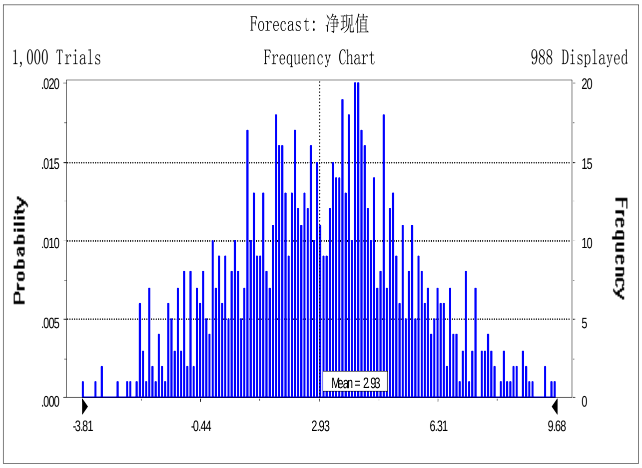

Figure2 Frequency of NPV with Monte Carlo simulation

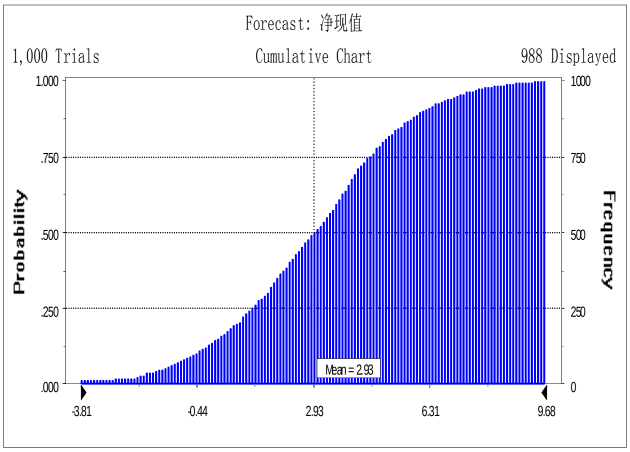

Figure 3 Accumulative probability density for NPV with Monte Carlo simulation

From the above figures and tables can be seen that values of NPV are in Gaussian distribution, the average value and the standard Standard Deviation of which are ￥29, 300 and ￥25, 900 respectively, as shown in Figure 4. The values of NVP are from￥-53, 800 to ￥120, 820.

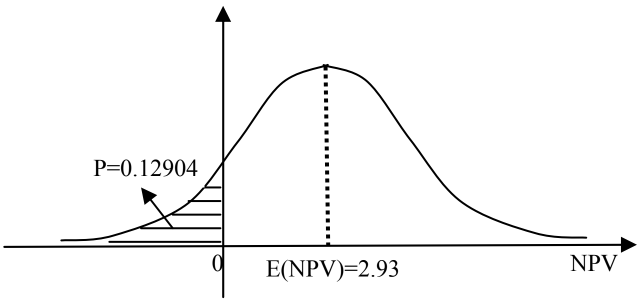

Figure 4 Probability distribution of NPV in education investment program

The value of Z is calculated as follows, $Z = \frac{E(NPV)}{\sigma} = \frac{2.93}{2.59} \approx 1.13$, according to which the value of P ($P(NPV < 0) = 12.90\%$) can be found in the Table of the Standard Normal (z) Distribution. The probability is 12.90% for NPV of this education investment program to be lower than zero, which is far greater than the confidence levels of 1%, 5%, or 10%. To sum up, since the risk for this EIIHCE program is great, the program is less feasible.

If more EIIHCE programs are put forward by enterprises, the values of Expected NPV, Standard Deviation, Probability Distribution, and Accumulative Probability Distribution for each of them can be calculated with Monte Carlo methods. The risks for each can be compared through the probability for NPV to be lower than zero, and the final decision can be made through comparisons.

VI. Conclusion

From aspects of economics and management, this thesis makes a risk analysis of EIIHCE with the help of Monte Carlo Simulation Method. Quick and easy, this method can be understood and mastered by common people because it has no complicated arithmetic calculations. It is hoped that this thesis can be a reference to enterprise decision and to the perfection of pertinent theories concerning EIIHCE.

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Jianhua Yang, Shandong Province, China. Birthdate: April, 1973. is Management Science and Engineering Ph.D., graduated from Dept. Management, Tianjin University. And research interests on human resource management and supply chain management.
He is a associate professor of Dept. of Management, Shandong Institute of Business and Technology.

Zhaojin Gao, Shandong Province, China. Birthdate: April, 1970, is a Master of English Literature, graduated from Beijing Foreign Language College. And research interests on human resource management and English Literature.
He is a associate professor of Dept. of Foreign Language, Shandong Institute of Business and Technology.