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Exploration Decision-Making on Energy Based On Improved Real Option Model and BP Neural Networks

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Abstract

Based on real options method to construct a petroleum exploration and development projects of integrated economic evaluation model, application mechanism real option method in oil and gas exploration and development projects around the expansion, the option value to identify and analyze the process of exploration and development projects exist. Finally, select the appropriate option pricing model, instance data analyzed by gas exploration and development projects, and its contrast with the traditional analysis, pointed out that application of real options method can effectively improve the investment project economic evaluation of science. In this paper, to build an economic evaluation method based on real options method of energy development projects, and to explore applications based on the principle of real options to develop economic evaluation method, proposed mostly for exploration stage oil and gas exploration and development project abandonment option binomial model and the development phase stop start option of partial differential equations, is determined based on the actual parameters of such projects, and to provide solutions to parameter estimation.

Keywords*: Real option method; model; economic evaluation; Monte carlo simulation*

1. Introduction

In industrialized countries, the economic evaluation is referred to investor's insurance policy [1]. Because of the complexity of the oil and gas exploration objects and technical and economic environment, even though the economic evaluation may not be able to achieve the expected benefits objective, but after the evaluation of oil and gas exploration project success rate will be greatly improved [2]. Western oil companies each, to be carrying out oil and gas exploration business in one block, economic evaluation should be carried out, and make decisions based on evaluation results [3]. However, these oil companies in the development of resources and evaluation of the economic effects of oil and gas exploration investment resources in the country, and more is to consider the time and resources owned oil companies in oil and gas exploration and evaluation of the economic effects of investment to develop the country's resources, more is to consider and the interests of the country's resources division, on this basis, re-evaluation of the profitability of the project [4-7].

Real Options from the financial options theory, is present in the nature of the right to have the option of which investment in physical assets, that is, concepts and methods of application options on physical assets [8, 9]. Fully take into account the real option value management flexibility, an important factor in investment decisions fully into account, which is very different from the traditional method of investment [10]. Therefore, the real options theory into oil exploration project investment decisions, provide scientific tools for oil exploration project value calculated correctly, it is conducive to scientific and petroleum exploration investment decision. Currently, the scope of application of a wide range of real options, such as land development, mineral resources development,

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investment and business valuation and other overseas. In recent years, scholars began to study the real options theory and method used in oil exploration and development, but has not yet established a model for evaluation of petroleum exploration project investment decisions [11].

This paper is to establish the economic evaluation of oil and gas exploration class new method based on real options method, it is not to negate the traditional NPV method, but the real options contained in the project taking into account the economic evaluation, evaluation of the project in order to make more consistent reality. However, oil and gas exploration projects because of the time span large, real options contained there are many, such as the option to abandon stop start option, the development phase can be considered when the stage investments, strategic study of extended options for the project, contained options like. Application of Real Option method mechanism studied in this paper for a variety of real options, but the study of economic evaluation based on Real Options, but only to give up the option of including oil and gas exploration projects contained in the value of investments and the stage stop start option value development stage, so make sure the model design and parameter estimation method, will focus on these two values the real option to expand.

2. Improvement of Real Option Investment Evaluation Models Based On BP Neural Networks

2.1. B-S Option Pricing Model

Based on the principle of B-S [12] option pricing, it is assumed that the underlying asset value CVt of an enterprise obeys the following geometric Brownian motion process is shown as equation (1).

$$\frac{dCV_t}{CV_t} = \mu dt + \sigma dZ_t \tag{1}$$

where CVt is the underlying asset value at time t; μ is the underlying expected return; σ is the instantaneous standard deviation of underlying asset value, or the value fluctuation ratio; Zt is a Wiener process, as shown in equation (2) below:

$$dZ_t = \varepsilon\sqrt{dt} \tag{2}$$

where ε accords with standard normal distribution.

According to Itō's Lemma, then:

$$\frac{\partial DV_t}{\partial t} + \mu V_t \frac{\partial DV_t}{\partial t} + \frac{1}{2}\sigma^2 V_t^2 \frac{\partial^2 DV_t}{\partial V_t^2} = rDV_t \tag{3}$$

where Vt is the real option value of an enterprise at time t; r is the risk-free rate of interest.

According to the conditions upon option expiration, equation (3) should meet the boundary conditions:

$$V_T = \max(S_T - X, 0) \tag{4}$$

where T is the time a project terminates; S is the current market value of an enterprise; X is the option strike price.

According to the boundary conditions, or namely equation (4), the initial value of the differential equation above can be resolved and expressed as follows:

$$V_t = S\phi(d_1) - Xe^{-r(T-t)}(d_2) \tag{5}$$

where

$$d_1 = \frac{\ln(\frac{S}{X}) + (r + \frac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T-t}}, d_2 = \frac{\ln(\frac{S}{X}) + (r - \frac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T-t}} \quad (6)$$

$\phi(\xi) = \int_{-\infty}^{\xi} \frac{1}{\sqrt{2\pi}} e^{-\frac{r^2}{2}dt}$ is a distribution function N(0, 1); r is risk-free rate of interest.

2.2. BP Neural Network

Thus, a BP neural network containing one hidden layer was selected. Its topologic structure is showed in Figure 1.

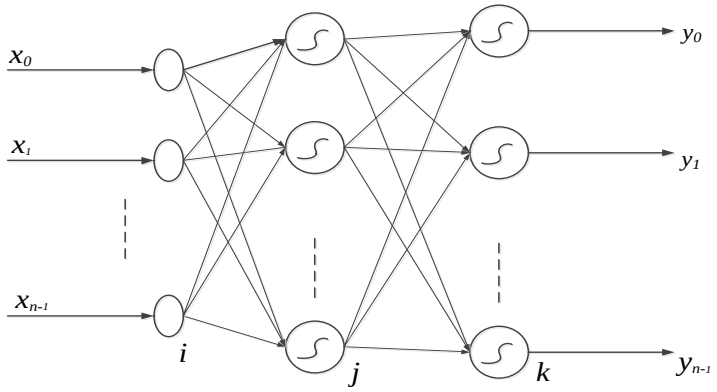

Figure 1. Topologic Structure of BP Neural Network

The input vectors of the BP neural network are assumed as x∈Rn, where x=(x0, x1,…, xn-1)T. The hidden layer has n1 neurons, whose outputs are $x \in R^{n_1}$, $x' = (x'_0, x'_1, \ldots, x'_{n-1})^T$; the output layer has m neurons, whose outputs are y∈Rm, where y=(y0, y1, …, ym-1)T. The weight from the input layer to the hidden layer is wij; the threshold is θj; the weight from the hidden layer to the output layer is w'_{jk}, the threshold is θ'_k. Thus, the neurons at each layer output:

$$\begin{cases} x'_j = f(\sum_{i=0}^{n-1} w_{ij} x_i - \theta_j), j = 0,1,\ldots,n_1 - 1 \\ y_k = f(\sum_{i=0}^{n_1-1} w'_{jk} x'_j - \theta'_k), k = 0,1,\ldots,m-1 \end{cases} \quad (7)$$

where f(x) is expressed as a Sigmoid function:

$$f(x) = \frac{1}{1+e^{-x}} \quad (8)$$

BP neural networks are a type of teacher-guided learning algorithm. It is supposed there are n input variables P1, P2, …, Pn, which are used as learning samples. The n input variables correspond to teachers T1, T2, …, Tn, respectively, and to real outputs Y1, Y2, …, Yn, respectively. For the n samples, a squared error function was used to compute the learning errors as follows:

$$E = \frac{1}{2} \sum_{i=1}^{n} \sum_{i=1}^{m} (T_1^i - Y_1^i) \quad (9)$$

where T_1^i is the teachers corresponding to the first group of samples; Y_1^i is the real outputs from the first group of samples. We preset a learning precision ζ . If E<ζ, the learning process terminates. The learning process of a BP neural network is illustrated in Figure 2.

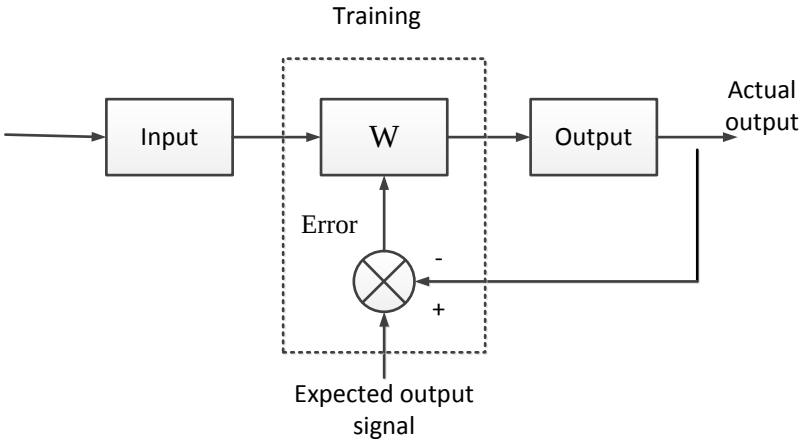

Figure 2. The Learning Process of A BP Neural Network

We used a linear processing method with its transformation expressed as follows:

$$x_i' = \frac{x_i - \min(x)}{\max(x) - \min(x)}, i = 1, 2, 3, \ldots \tag{10}$$

3. Real Option Method

3.1. Parameter Study

Increases with time, when companies do not avoid financial risks, project output decreases with time, prices follow geometric brownian motion, and thus the introduction of the option to abandon the option and invest in the development of a function of time, and then take advantage of the two options at t = 0, at the same price elasticity price elasticity parameters point to solve a series of project value, and price volatility, the stock market by using the average standard of poor assets or use the previous data disclosed transaction value reserve, the use of standard deviation seeking formulas to solve first two related parameters, ultimately solve the important parameters volatility option method.

Daily income $u_l = \ln s_l - \ln s_{l-1}$, s_l is the price at the end of time one, u_l is the standard deviation.

Total final expression:

$$s = \sqrt{\sum_{l=1}^{n} (u_l - \bar{u}) / (\mathrm{n}-1)} \tag{11}$$

Total final expression:

$$\sigma_v^j = \frac{\partial V^J}{\partial S} \cdot \frac{S}{V} \cdot \sigma_S = \varepsilon^j \cdot \sigma_S \tag{12}$$

3.2. Advantage of Real Options

Real option is a way of thinking, is a discounted cash flow method can underestimate the value of method options, it brings a whole new attitude toward risk. Real options include three components:

1. Options are or have decision-making (contingent decisions). Options you can see how things develop later, and then develop opportunities decisions. In the moment of decision, the situation in the right direction, make a decision, but if the development to the bad direction, will make another decision. This loss means that options are nonlinear, as your decision will change.

2. Option valuation and financial market valuation is consistent. Real option is to use the input and concepts of financial markets to pricing for all types of complex physical assets and losses. The result is management options, financial market options, internal investment opportunities and trading opportunities on the basis of comparable equivalent.

3. Real Options thinking can be used to design and manage strategic investments.

Real options approach is not in all cases need. Some decisions are called "nobrainers", namely investment either tremendous value, or total loss, for such decision-making, real options method is less suitable, while many decisions is the need to think calmly, real options can this provide help.

4. Experiments and Results

4.1. Real Option Characteristics of Energy Development

According to the actual investment decisions and capital investment process, we can invest classified as a learning exploration investments, namely through the investment value of the project a series of time sequences so as to continuously reduce uncertainties exist, the project worth an estimated accurately. From the perspective of real options, which is the exploration stage oil and gas exploration project consists of a series of options to eliminate the uncertainty of a regional oil and gas production, external project value of the project in addition to the traditional NPV method to obtain the value itself, but also including exploration process should value these options.

The value of oil and gas exploration project NPV of the project itself and the option value added and, while the value of the option depends on the follow-up to the level and nature of the latest geological uncertainties and oil price uncertainty. Figure 3 illustrates a simplified economic value of oil and gas exploration project uncertainty is how with the continuous investment and lower exploration process.

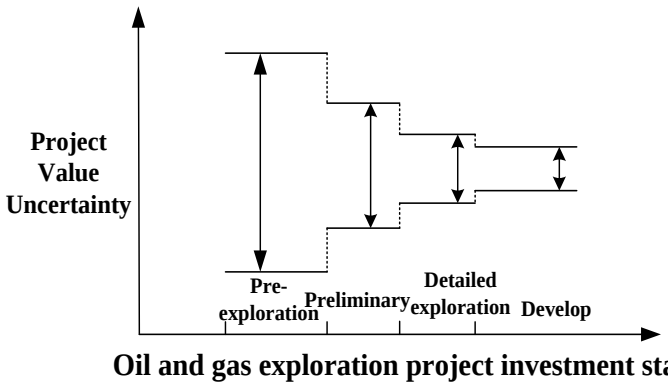

Figure 3. Simplified Economic Value of Oil and Gas Exploration Project

According to real investment and operation of oil and gas exploration project to analyze the characteristics they contain real option is obvious, it is necessary in the economic evaluation of such projects, the introduction can be processed due to the different management decisions brought the value of flexibility the real options.

4.2. Real Options Model

Binomial Option Pricing Model changes in the value of the underlying assets of a simple description based in each time period, the underlying assets can take only two possible outcomes of a value. Widely used in multi-stage uncertainty binomial model, the asset has an initial value of A, in a short period of time, it goes up or Au, or down into Ad. AuZ, Aud. Figure 4 illustrates the binary tree and how it gets the final moments of the distribution of various outcomes. In the distribution, each result corresponds to a vertical bar, vertical bar represents the length of all possible paths in the binary tree in the frequency of occurrence of the result.

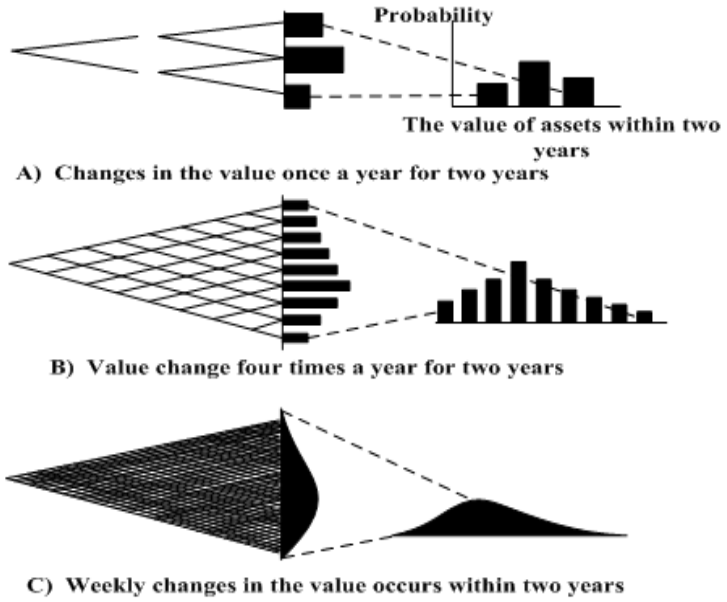

Figure 4. Shorten the Time Interval after the Results Distribution

Single-step or multi-step binary tree is not a good reflection of the uncertainty of reality fluctuations project, but a simple iterative binary tree method has the flexibility, as well as the characteristics of the model algorithm, so it is a good description of the project value the actual path of uncertainty. In general, users in the period to take more than 30 steps, the model can better describe the reality of the project value path, and with changes in the value of time interval becomes shorter, resulting distribution will become smooth.

4.3. Data Analysis and Application

Here we selected 5 listed renewable energy Chinese enterprises as a training group, and with the method for parameter estimation, we estimated the values of the samples (Table 1).

Table 1. Sample Values

Company	Factor					
	S	X	σ	r	T	V
A	3906167188.22	1857953733.14	0.3296	0.0352	1 0	2569448260.17
B	1542963835.72	632829378.43	0.4125	0.0324	8	1823981672.57
C	2754112872.89	907649162.88	0.3568	0.0331	7	1943571624.08
D	6257364826.46	4837259371.70	0.4037	0.0373	1 0	5234168215.23
E	5781249720.86	3879146280.25	0.3982	0.0325	9	4521837645.27

Since the values of (and r are both within [0, 1], they were not normalized. The other parameters were normalized. The training samples after treatment were used as input nodes in the BP network (Table 2).

Table 2. Trainable Samples

Company	Factor					
	S	X	σ	r	T	V
A	0.5013	0.2914	0.3296	0.0352	1.0000	0.2186
B	0.0000	0.0000	0.4125	0.0324	0.3333	0.0000
C	0.2569	0.0654	0.3568	0.0331	0.0000	0.0351
D	1.0000	1.0000	0.4037	0.0373	1.0000	1.0000
E	0.8990	0.7721	0.3982	0.0325	0.6667	0.7911

The network training and simulation were performed on MATLAB7.0. After the 5 samples were used in network learning, we worked out a connection weight matrix between the input layer and the hidden layer as follows:

$$\begin{bmatrix} -3.5213 & 3.1953 & -2.2987 & -0.3987 & 1.4604 \\ -1.6792 & -3.5770 & 6.5030 & 1.4976 & 1.9022 \\ -2.2379 & 5.2254 & 3.9799 & 1.0117 & -1.8652 \\ -2.0351 & -5.2525 & -4.1773 & 1.1208 & -2.1766 \\ 3.2640 & -1.5205 & -0.2222 & -2.4762 & -0.0931 \end{bmatrix} \quad (13)$$

The threshold vectors of the input layer and the hidden layer are:

$$\begin{bmatrix} -0.8061 & -0.1210 & -3.2121 & -0.4622 & 1.7491 \end{bmatrix}^T \quad (14)$$

The weight matrix between the hidden layer and the output layer is:

$$\begin{bmatrix} 0.2509 & -0.1920 & 0.8640 & 0.1637 & -0.8128 \end{bmatrix} \quad (15)$$

The threshold between the hidden layer and the output layer is: 0.0286.
The error variation is showed in Figure 5.

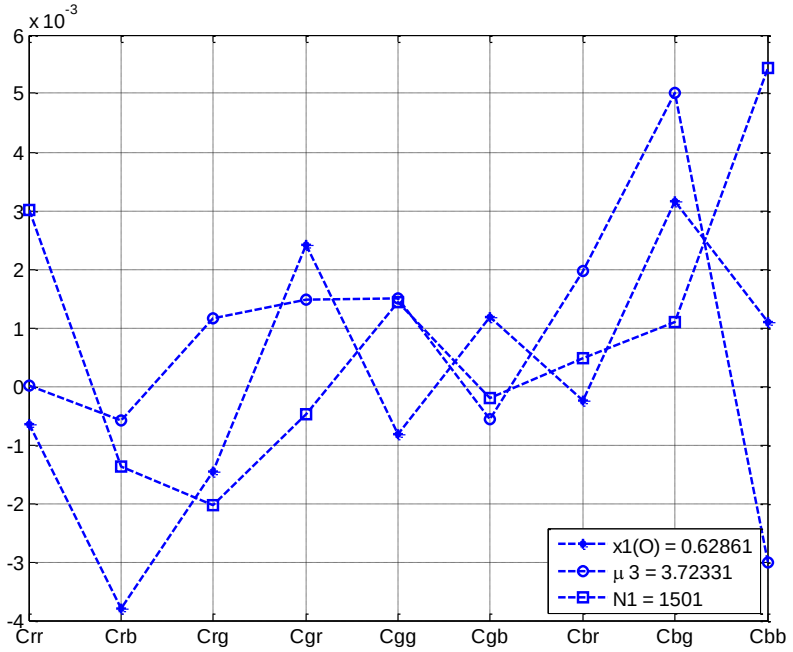

Figure 5. Network Error Variation Curve

The relative errors between the simulation results obtained from the BP neural network and the real values of the sampling companies are listed in Table 3.

Table 3. Comparison between BP Network Training Results and Real Data

Company	Real data	Training result	Error
A	0.2186	0.218	0.27%
B	0.0000	0.0009	-
C	0.0351	0.0355	1.23%
D	1.0000	1.0001	0.01%
E	0.7911	0.7922	0.14%

As showed in Table 3, the maximum absolute error between the training results and the real data is 1.23%, indicating the expected effect. Thus, this model can be used to assess the values of listed enterprises.

Three listed renewable energy enterprises are available for selection by investors, who can decide whether nor not to invest them by considering the current market and the operations. In this process, option to expand will occur. Thus, its current value was estimated by using a modified real option model, and the relevant parameters are listed in Table 4.

Table 4. Relevant Parameters in Investible Enterprises

Company	Factor				
	S	X	σ	r	T
F	68427381.25	47692813.27	0.3366	0.0329	10
G	52971643.53	35867128.54	0.3874	0.0374	8
H	57961238.91	34869275.76	0.3661	0.0383	9

Similarly, the data were normalized and inputted into the network for simulation. The results are: VF=0.6376, VG=0.0156, VH=0.1615. Since VF >VH >VG, investors can select company F.

5. Conclusions

Energy exploration projects economic evaluation law is a relatively new method based on applicable, with the evaluation of the project value method Advancement some theoretical, for energy exploration projects, the more worthy of attention and study; As China's energy formalization and deepening of the traditional NPV economic evaluation study of industry, policy makers will be more profound understanding of theoretical sophistication and ease of Real Options method has on. Sophisticated financial options pricing model and relevant parameters determined by in-depth research and analysis theory, constructed based on the exploration phase of the classical binomial model abandonment real.

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References

[1] C. Jeon, J. Lee and J. Shin, "Optimal subsidy estimation method using system dynamics and the real option model: Photovoltaic technology case", Applied Energy, **(2015)**, pp. 142: 33-43
[2] A. Horn, F. Kjærland and P. Molnár, "The use of real option theory in Scandinavia's largest companies", International Review of Financial Analysis, vol. 41, **(2015)**, pp. 74-81
[3] N. Lethanh and B. T. Adey, "A real option approach to determine optimal intervention windows for multi-national rail corridors", Journal of Civil Engineering and Management, vol. 22, no. 1, **(2016)**, pp. 38-46
[4] M. Weskamp, A. T. Braun and T. Bauernhansl, "Real Option-based Evaluation of Eco-oriented Investment Using the Example of Closed-loop Supply Chains", Procedia CIRP, vol. 33, **(2015)**, pp. 151-156
[5] S. Lampke, S. Schliecker and D. Ziegenbein, "Resource-Aware Control-Model-Based Co-Engineering of Control Algorithms and Real-Time Systems", SAE International Journal of Passenger Cars-Electronic and Electrical Systems, vol. 8, no. 2015-01-0168, **(2015)**, pp. 106-114.
[6] S. Lee and K. Kim, "Collar Option Model for Managing the Cost Overrun Caused by Change Orders", Sustainability, vol. 7, no. 8, **(2015)**, pp. 10649-10663.
[7] G. S. Milanesi, E. El Alabi and G. Pesce, "Continuity or Liquidation in Situations of Ambiguity: Fuzzy Binomial Model to Valuate Leveraged Firms", Research in Applied Economics, vol. 7, no. 1, **(2015)**, pp. 26-47
[8] Y. Hou, Y. Jiang and H. Xu, "Option Prioritization for Three-Level Preference in the Graph Model for Conflict Resolution, Outlooks and Insights on Group Decision and Negotiation", Springer International Publishing, **(2015)**, pp. 269-280
[9] C M Regan, B A Bryan and J. D. Connor, "Real options analysis for land use management: Methods, application, and implications for policy", Journal of environmental management, vol. 161, **(2015)**, pp. 144-152.
[10] R. Klingebiel and R. Adner, "Real options logic revisited: The performance effects of alternative

resource allocation regimes", Academy of Management Journal, vol. 58, no. 1, **(2015)**, pp. 221-241.

[11] C. J. You, C. K. M. Lee and S. L. Chen, "A real option theoretic fuzzy evaluation model for enterprise resource planning investment", Journal of Engineering and Technology Management, vol. 29, no. 1, **(2012)**, pp. 47-61

[12] D. Li, H. Chen and E. C. Hui, "A real option-based valuation model for privately-owned public rental housing projects in China", Habitat International, vol. 43, **(2014)**, pp. 125-132.

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