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Decision Model of the Best Investment Opportunity in Coal Mine Project Based On Real Option

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Abstract

The traditional decision-making methods of investment decision about coal mine projects have many deficiencies. Decision model of coal mine project option is proposed in paper. Firstly, analysis the characteristics which include uncertainty and irreversibility of physical option and build a suitable model after researching the significance, then decide the best time though the coal mine project. Finally, case analysis presents the application of this method and provides strong theoretical basis for decision in coal mine project.

Keywords*: coal project, project option, best period, decision model*

1. Introduction

Coal industry is a pillar industry of national economy development, however, in the rapid development of China's coal industry process still faces many problems, such as the coal resources disordered development, the recovery rate of resources is low, environmental pollution and ecological damage serious and so on. Aiming at these core problems to be solved urgently, accelerating the construction of large-scale modern coal mines becomes the important task of the coal industry which develops rapidly. To build a large-scale modern coal mine is a very complex and large system engineering which characteristic is invested amount, the investment capital is long and has Complex techniques. At the same time, there are a large number of random factors produce during the development process. As a result, it is led to the high risk and uncertainty on the large modern coal mine construction. Coal mine project investment decision through each stage of the coal mines' construction, how to evaluate the value of construction projects according to the science method and timely make reasonable investment decision become a important subject restrict China's coal production which should be solved immediately [1-2].

In foreign, Brennan and Schwartz combined the asset pricing method with the real option method firstly, they built the mining investment value evaluation model from the point of view of the mining optimization after considering the flexibility of mine management sufficiently. However, this model is too complex and unable to get analytic solution. Cortazar expanded the natural resources investment model proposed by Brennan and Schwartz and solved by using LSM. This model considers random fluctuation of the convenience income, but not considers random fluctuation of interest rates and mining cost. There are some worth researching place in theory and application about the coal resources development project decision of the real options method from the existing domestic research situation. The existing theory of real option method in coal resources development investment project application is explained insufficiently and just from the shortage of net present value method, but it does not discuss and research the base of the real options method application [3-5]. At the same time, from the domestic application research perspective, there have been no specific application model of empirical research and most of these just stay in concept discussion from the domestic application research perspective.

From this viewpoint, this paper introduces real option theory and builds coal mine project investment decision model, so as to determine the best coal mine project investment decision time aim at the characteristic of multistage, uncertainty, dynamic about the mine project investment.

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2. Characteristic Analysis on Coal Mine Project Investment Option

2.1. The Necessity and Adaptability of Introducing Real Options

Coal mine investment project has many stage and flexibility. The real option in investment project evaluation and decision analysis has great flexibility. It can completely according to the changes of the environment make advantageous to the enterprise's behavior, making the economic benefits maximization. At the same time, it can give full play to the project manager's subjective initiative. Real option can manage the coal mine investment projects in a flexibility way, so we can seize the favorable investment opportunities to avoid influence of adverse condition and carry out coal mine investment projects successfully [6]. The uncertainty of coal mine investment project is valuable, the real options in the rights and obligations of the asymmetric is reflected through the uncertainty. The value of coal mine investment projects not only displays in the financial net present value, also reflected in strategic interests. Traditional investment decision methods are difficult to assess these values and will make the enterprise miss valuable long-term profit project.

Therefore, if introduce the concept of real options to the coal mine investment project and combine with the coal mine investment will be helpful for managers to deep understanding of the uncertainty of the project how to influence project investment value [7]. So the managers can choose flexible strategy to reduce the uncertainty of the project.

2.2. Characteristic Analysis on Coal Mine Project Option

2.2.1. Investitive Irreversibility of Coal Mine Project

The geographical position will be fixed after the early location and exploration of coal mining project investment. The early exploration, well construction planning, feasibility report preparation and so on will be a permanent fixation which difficult to along with the change of environment and conditions and adjust accordingly after the implementation of investment behavior [8]. The loss cannot be avoided even if sell it. Seal or restart it also need a fee and the formation of the sunk cost will cause coal mine project investment irreversible.

2.2.2. Multiple Uncertainties of the Coal Mine Project Investment

The uncertainties of the coal mine project investment mainly come from the preparation stage of pre-investment project, the period of mine construction and the operation period of mine production. Accordance with the nature, they can be divided into five categories of the building environmental risks, economic risks, technical risks, manage risk and public relations risks. Investment in coal projects must also take into account the complex social, economic, cultural and other environments, such as the relationship with the local government, banking and labor.

2.2.3. Dynamic Flexibility of the Coal Mine Project Investment

The coal mine project investment has stage characteristics. Investors can constantly adjust the expected cash flows, reassess economic value of its development and make the appropriate investment decisions, basing on the development results of the previous stage and the grasp of the latest market information. The coal mine project investment includes geological exploration, project planning, feasibility studies, project approval, design, construction, commissioning, operation and other stages. Investors make different investment decisions according the different conditions each stage and flexibly choose investment timing or investment strategy basing from the uncertainties of the market, technology, policy, funding and other aspects [9-10].

3. Decision Model of Coal Mine Project Investment

3.1. Principle of Decision Model

Determine coal mine investment projects option value $f(V)$ and according to the option value need to determine the optimal investment execution rules of project which need to be evaluated. That is to find out the optimal investment threshold V^* and compare with the market price of investment. The optimal investment strategy is similar to the critical value V^*.

Coal mine investors will invest when a project's value is greater than the V^* and they will put off When the project's value is less than the V^*. When the value of the project is equal

to V^*, $f(V)=V^*-I$, it is indicate that investment opportunity value equal to the investment of net income at the V^*.

The characteristic of coal mine investment project is high risk and irreversibility, so it determines that investors must consider all aspects of influence factors when invest the coal mine in order to ensure the rationality of the decision. However, the traditional investment decision method less consider the uncertainty of the project and ignore investment opportunity cost when make investment decision, thus giving up the value of waiting for opportunity [11-12]. Therefore, using the real option theory is helpful for investment decision-making for coal mine based on the reasonable scientific basis after analysing and discussing the best opportunity of coal mine investment project.

3.2. Building the Decision Model

The revenue V^* of the coal mine investment projects follows geometric Brownian:

$$dV = uVdt + \sigma Vdz \tag{1}$$

In this, V is the present value of the mining project, u is the expected return rate of the investment unit time, and σ is the volatility of the value of the project.

Assuming the option value of the coal mine project investment is f, where f is a function of V and t, that is

$$f = f(V,t) \tag{2}$$

Using the theorem Ito can be obtained:

$$df = \frac{\partial f}{\partial V}dV + \frac{\partial f}{\partial t}dt + \frac{1}{2}\frac{\partial^2 f}{\partial V^2}(dV)^2 \tag{3}$$

It can be obtained from (3):

$$(dV)^2 = (uVdt + \sigma Vdz)^2 = \sigma^2 V^2 dt \tag{4}$$

Using (1) and (4) into (3) can be obtained:

$$\begin{aligned} df &= \frac{1}{2}\frac{\partial^2 f}{\partial V^2}\sigma^2 V^2 dt + \frac{\partial f}{\partial V}(uVdt + \sigma Vdz) + \frac{\partial f}{\partial t}dt \\ &= (\frac{1}{2}\frac{\partial^2 f}{\partial V^2}\sigma^2 V^2 + \frac{\partial f}{\partial V}uV + \frac{\partial f}{\partial t})dt + \frac{\partial f}{\partial V}\sigma Vdz \end{aligned} \tag{5}$$

In period of time dt, $(\frac{1}{2}\frac{\partial^2 f}{\partial V^2}\sigma^2 V^2 + \frac{\partial f}{\partial V}uV + \frac{\partial f}{\partial t})$ indicates the expected return rate of investment.

The coal mine investment project is a derivative asset and their return depends on the value of V. According to the pricing process of derivative assets, we build the following combined option by coal mine projects f and revenue V, with Π representing the value of the combined option, then:

$$\Pi = -f + \frac{\partial f}{\partial V}V$$

After Δt time, the value changes of the portfolio is $\Delta\Pi$: $\Delta\Pi = -\Delta f + \frac{\partial f}{\partial V}\Delta V$

ΔW represents the combined option holders' wealth change during the period of Δt:

$$\Delta W = (-\frac{1}{2}\frac{\partial^2 f}{\partial V^2}\sigma^2 V^2 - \frac{\partial f}{\partial t} + \frac{\partial f}{\partial V}\delta V)\Delta t \tag{6}$$

As can be seen by the above formula (6), ΔW does not contain random items Δz, and after the period Δt, portfolio constructed Π is the risk-free portfolio. Therefore, there is the following equation:

$$\Delta W = rW\Delta t \tag{7}$$

That is obtained by the equation (6) and (7):

$$(\frac{1}{2}\frac{\partial^2 f}{\partial V^2}\sigma^2 V^2 + \frac{\partial f}{\partial t} - \frac{\partial f}{\partial V}\delta V)\Delta t = r(f - \frac{\partial f}{\partial V}V)\Delta t \tag{8}$$

The coal mine investment project is "eternal life", that is, the investment horizon is infinite, then the value of the investment opportunities is only about V .Simplifying equation (8), the results are as follows:

$$\frac{1}{2}\frac{\partial^2 f}{\partial V^2}\sigma^2 V^2 + \frac{\partial f}{\partial V}(r-\delta)V - rf = 0 \tag{9}$$

Making $f(Y) = AY^{\beta}$ as a solution of differential equation (9), there is

$$\frac{\partial f}{\partial V} = A\beta V^{\beta-1}, \frac{\partial^2 f}{\partial V^2} = A\beta(\beta-1)V^{\beta-2}$$

Putting $f(V)$, $\frac{\partial f}{\partial V}$, $\frac{\partial^2 f}{\partial V^2}$ into equation (9):

$$\frac{1}{2}A\beta(\beta-1)V^{\beta-2}g\sigma^2V^2 + A\beta V^{\beta-1}g(r-\delta)V - ugAV^{\beta} = 0$$

After simplifying, the result is as follow:

$$\frac{1}{2}\sigma^2\beta(\beta-1) + (r-\delta)\beta - r = 0 \tag{10}$$

The solution is that: $\beta_1 = \left(\frac{1}{2} - \frac{r-\delta}{\sigma^2}\right) + \sqrt{\left(\frac{r-\delta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}}$

$$\beta_2 = \left(\frac{1}{2} - \frac{r-\delta}{\sigma^2}\right) - \sqrt{\left(\frac{r-\delta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}}$$

Thus, the general solution of the differential equation (10) can be written:

$$f(Y) = A_1Y^{\beta_1} + A_2Y^{\beta_2}$$

Three boundary conditions of $f(V)$ to be combined when counting A_1 and A_2 were that:

$$f(0) = 0, f(V^*) = V^* - I, f'(V^*) = 1$$

In which, V^* represents the critical value of the optimal investment.

The solution is that: $V^* = \frac{\beta_1 I}{(\beta_1 - 1)}, A_1 = \frac{V^* - I}{(V^*)^{\beta_1}}, A_2 = 0$

Therefore, the option value of the coal mine investment projects is $f(V) = A_1 V^{\beta_1} = \frac{(V^* - I)}{(V^*)^{\beta_1}} V^{\beta_1}$, and the best time to invest is $V^* = \frac{\beta_1 I}{(\beta_1 - 1)}$, representing that when investing the coal mine at V^*, the market value of the mine investors can maximize.

4. Empirical Research

Assume that a coal mine investment enterprises ready to mining coal mine which is marked X in a region and there is no competition in the coal market at this point. Assume the risk free rate r=10% equivalent to fixed discount rate. The bonus need to be paid is δ=5%.Volatility which is estimated is 25% after analyzing the average price of coal mine in recent years. The result can be seen by taking these to the formula and calculating with the mathematic:

$$\beta_1 = \left(\frac{1}{2} - \frac{r-\delta}{\sigma^2}\right) + \sqrt{\left(\frac{r-\delta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}} = 1.12456$$

$$V^* = \frac{\beta_1 I}{(\beta_1 - 1)} = 15348000000$$

$$A_1 = \frac{V^* - I}{(V^*)^{\beta_1}} = 0.15$$

From the result, the optimal investment threshold of coal mine investment projects is V^*=15348000000. Investment decision as follows:

(1) When the value of the investment project is less than V^*=15348000000, the optimal strategy of coal mine investment enterprise is to delay investment in order to gain greater value;

(2) When the value of the investment projects more than V^*=15348000000, the optimal strategy of coal mine investment enterprise is to invest in coal mine so as to obtain income.

The results show that the value of the project is 1.55845 billion yuan which is less than V^*. So the best strategy of the enterprise x is to postpone the project development until the project value greater than the investment.

From the above results, it is not difficult to find that the decision results of traditional net present value analysis and real options analysis investment are not consistent. As long as the value of the project is greater than the initial investment, namely net present value greater than 0, it can conclude that the project is feasible by using of net present value method [13-15]. When taking the real option method, it is not a direct comparison of project value and the size of the initial investment, but a comparison of size of project value and optimal investment threshold, so as to judge immediately investment or delayed investment. To make the investment only when the project value is greater than V^*, otherwise it should be delayed. The reason leading to such a result is that net present value method ignores the flexibility of the coal mine investors' decision and underestimates the value of the investment project. Using real option method can avoid the defects and fully consider the uncertainty of project managers and flexible mobility of the decision so as to make a more reasonable decision results.

5. Conclusion

This paper analyzes the current coal mine project investment option characteristic and the coal mine investment project also has great flexibility. Using the real option method can evaluate the value of the mine investment projects from all-sided. So it improves the reliability of the investment and overcomes the decision-making errors and value underestimate caused by net present value method. Real option method for our country's has an important meaning to

coal mine project investment and this method will produce great influence if it can be widely applied to our country mineral industry.

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