

## *Real Options Application Framework for Shipbuilding Enterprises*

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**Abstract**—This paper presents a real options framework to help shipbuilding business evaluating investment project properly and making a correct investment decision. In China, shipbuilding enterprises' fixed assets investment evaluation methods used are almost based on the traditional DCF methods, nonetheless the DCF methods are have many defects. The paper begins with analyzed and summarized the advantages of real options, and then analyzed the options characteristic embedded in shipbuilding enterprises fixed assets investment. Furthermore, as an example, the paper applies the framework to the case of JD shipyard expansion investment. Its result suggests that real options indeed can reflect the value of flexibility and the framework can help management making investment decision.

**Keywords**—project evaluation; real options; shipbuilding enterprises; fixed assets investment; application framework

### I. INTRODUCTION

The traditional analysis of project investment evaluation is based on discounted cash flow (DCF) method, including net present value (NPV), payback period method (discounted) and internal rate of return (IRR), etc. In China, shipbuilding enterprises' fixed assets investment evaluation methods used are almost based on DCF method. However, the traditional DCF method has its own obvious shortcomings[1,2,3]: (1) It assumed that investment is reversible. In fact, once the project started, the initial investment will be sunk costs, and these costs can not be recovered, even through abandon projects, (2) The DCF overlooked the opportunity of choice in the investment. DCF method requires investors to make an immediate decision, but actually, the investors have choice to wait, give up, conversion or expansion during the decision making process, (3) Insufficient consideration of the investment risk. DCF method assumes that the status of investment projects is certain in the future, or is measurable, and so just selects a single discount rate, and (4) The DCF has not considered a follow-up investment projects.

In the 20th century, the late 80s, early 90s, in the west, a large number of scholars began to use real options theory in enterprises strategic investment areas, representing a breakthrough and new trend in the field of business management. But in China, the process using this method is far slower than the west, the current project evaluation method is still the DCF (including NPV, IRR, etc), many of

the investment decision-makers even do not understand real options tools, and not to thinking the options characteristics of the project during investment decision-making[4].

At present, in China, the shipbuilding industry's fixed asset investment is still in a rapid growth state, while the financial crisis affecting the world economy is still significant uncertainty in the future. The investment in the shipbuilding industry is requires a relatively high inputs, and traditional methods of investment evaluation often can not properly reflect the value of investment projects, and then leading to errors in investment decision making.

### II. REAL OPTIONS IS SUPERIOR THAN THE TRADITIONAL DCF

Real option was first raised by Myers (1977)[5], the professor of MIT Sloan School. He said that the company's real assets with growth potential could be seen as "call options" and defined as Real Options. He believes that assets can generate income from two aspects: (1) The using of assets. (2) The right of disposal, that mean investors have rights to obtain or sell an asset at a certain price in the future.

Using Real Option for investment decision making is not discard the traditional approach. In the view of real options, Shipping enterprises evaluate the value of fixed assets investment projects, usually including two parts: the net present value (NPV) and option value (OP). That is:

$$ENPV=NPV+OP$$

Therefore, we must obtaining the net present value of fixed assets investment project, then calculate the flexibility of investment---the value of real options. If the total values of the project, which  $ENPV > 0$ , indicated that project is feasible, investors can invest in the project. And if the ENPV is negative, the project is not feasible.

#### A. The superiority of real options

When the shipbuilding enterprises using real options approach to evaluate the value of fixed assets investment and make a decision, compared with the traditional DCF method, real options is not forecast the future cash flows, but focuses on the uncertainty of the project, so can more truly reflect the value of the project, The advantages of real options are as follows:

1) *The real options can increase flexibility in decision making*

Shipbuilding enterprises fixed assets investment is huge investment, high risk. It needs more flexible forms of investment, and then enterprises can adjust their investment strategies and tactics, avoid blind investment, and avoid huge economic losses. While the traditional DCF method does not reflect the flexibility of decision-making, and can hard to make change according to the environment and technical uncertainties.

2) *Decision-making become more scientific*

When evaluating the feasibility of fixed assets investment projects, Real options not simply base on the positive and negative NPV, but with consideration of management factors and the future options value.

3) *Reflect the value of investment projects fully and adequately*

In the view of the traditional investment evaluation method, the risk of projects is calculated by different discount rate, the higher risk the lower the NPV of the project, so the project more feasible. The real options take the uncertainty as a positive factor, which is the essential difference between the real options and the traditional methods. In this way, the greater the uncertainty and volatility, the real options will have greater value. The real options can reflect the value of uncertainty, so that it can reflect the value of investment projects fully and adequately.

#### B. *Real options types*

Trigeorgis and Smit[6] have already generalized several basic type of real options in their literature, they think that real options is the choice of time for investors to make some commercial investment, real options help management to make the delay, expansion, abandon or re-investment decision. Brosch[7] studied the combination of characteristics of real options, and analyzed the relationships and the interactions among real options, then he generalized several real options types: causal compoundness, time compoundness, inter-projects compoundness. And scholars studied and found the dynamic programming method and the binomial model can be use in more complex compound real options pricing.

### III. OPTIONS ANALYZE FOR SHIPBUILDING ENTERPRISES FIXED ASSETS INVESTMENT

Shipbuilding enterprises can obtain fixed assets through purchase, construction, financing lease, non-monetary asset exchange, donations, debt restructuring, investment and other recipient. Our study is in the point of investment, so we mainly consider purchase, financing lease and construction. The financing lease, it can be seen as similar to the installment of purchase, so we won't discuss separately in our thesis.

#### A. *Options analysis for fixed asset purchase investment*

From the perspective of real options, the purchase expenditures in fixed assets, is equivalent to option fee. Enterprises have rights to arrange the fixed assets, including

prosecution, dispose, and so on. There are a lot of flexibility and uncertainty in purchase expenses and its follow-up decision-making. Enterprises management can get information from many aspects, such as market situation, technology, management, capital, and thus choose the best to carry out the fixed asset investment plan.

Shipbuilding enterprises through purchase to obtain the fixed asset, during its decision making process, enterprises has the right to delay investment. When investment carried out, the enterprises has the follow-up right to dispose the fixed asset. After the enterprises to obtained fixed assets, it can choose whether to abandon the project or make an additional investment or sell off the assets, so the purchase investment contains the expansion option, conversion or give up the option.

#### B. *Options analysis for fixed asset construction investment*

Shipbuilding enterprises through construction to obtain fixed assets can be divided into two stages, which contain project construction phase and operational management phase. As the investment in fixed assets completed, long duration of its operations in the entire business process, there is a high degree of future cash flow uncertainty, including the management uncertainty, macroeconomic uncertainty, and the uncertainty of national policy and so on, thus building investment decisions, it is difficult to use DCF method to evaluate the project accurately.

From the perspective of real options, the construction expenditures in fixed assets in investment is equivalent to an option fee. Enterprises management can also obtain information from the market, technology, management, finance and any other aspects, and then select the point to begin construction. The shipbuilding enterprises' fixed asset value is huge, and at the same time as the uncertainty of the project and investment irreversibility, sometimes, investors may choose phased-development approach rather than a one-time investment. When investment began, the management can reducing the risk of investment in fixed assets by get the latest market conditions, consider whether there is need to adjust the investment plan before the next phase building. It is easy to find that during the project construction phase is including the expansion and contraction options.

Following completion of the project, the fixed assets will go to the production stage. If the economic, market and fixed assets run good, the management will consider a number of new investment or expansion projects, making businesses to getting greater profits. If the economy and market conditions poor, management can reduce losses by change the way of disposal fixed assets. As a result, during the project's operational phase, there are an expansion options, conversion options and give up options.

### IV. BUILDING REAL OPTIONS FRAMEWORK FOR SHIPBUILDING ENTERPRISES FIXED ASSETS INVESTMENT

At present China's shipbuilding enterprises do not viewed the real options as a way of thinking, not to mention studying the options characteristics of the investment project in-depth. The fixed asset investment decision-making

method is still dominated by the traditional DCF method, but investment projects analyze by options can be reflected the value of flexibility, then determine the value of investment projects more accurately. This article will systematically build a real options framework to guide business investment and decision-making when they plan to make a fixed asset investment.

The entire application process is as shown in Fig. 1.

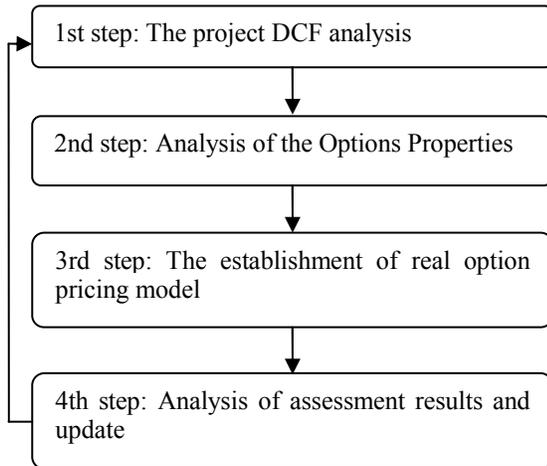


Figure 1. Application Process

## V. THE PROJECT DCF ANALYSIS

For the initial fixed assets investment projects identified by the traditional DCF analysis method to calculate the project NPV, IRR and other values. Calculation of NPV through forecast revenue and cost, with appropriate risk-adjusted discount rate.

### A. Analysis of the options characteristics and project uncertainties

Management should make a deep analysis and identify options at every stage.

#### 1) Make a description of the decision

The original investment program, clearly pointed out the existence of decisions, and the variables of changes, as well as decision-making time. Auxiliary decision tree analysis can be used.

#### 2) Analyze the options characteristics

Options implied in the project, these options may include the expansion, contraction, abandon, and change and so on. Shipbuilding companies which investment in fixed assets in several stages, including a series of related decisions, accordingly, should use the compound options, containing a series of pre and post options, which generally have a layered or continuous structure. To make more intuitive decision-making and to assess more easily, the complex compound options can be decomposition appropriate.

#### 3) To determine the sources and forms of uncertainties

The risk of shipbuilding industry is multiple and complex, when the enterprises using real options, there are

exit both market risk and non-market risk, carefully study and distinguish the risks sources and forms can help to get scientific conclusions. When there are three or more risk factors, will very difficult to calculate the options value, so the investors should analyze all the uncertainties carefully, and identify the most important risk factors.

### B. The establishment of real option pricing model

Option pricing models typically include: the pricing model obtained by methods of partial differential equations, such as the black-scholes model; obtained through dynamic programming model, such as the binomial model; obtained by simulation models, such as Monte Carlo model.

Black-scholes model formula is under the assumption of no arbitrage opportunities, through a large number of rigorous mathematical reasoning to come, but people can not well understood decision-making process only under the formula. The binomial model is highly flexible, similar in form of decision tree method, so people can be more intuitive understanding of the pricing of basic steps and the complexity of real options. But no matter which model to use, require and adjust the input variables of the model is the key problem. Options pricing model inputs include:

#### 1) Present value of the underlying asset

The value of options is attached to its underlying assets, so the value of the asset changes will affect the options value. Option pricing theory and its associated principle require the underlying asset is tradable. If the fixed asset can be transacted on the market, its market price can be considered as the underlying asset price. However, if the transaction does not exist on the market, it is difficult to determine market prices.

At present, the traditional methods of assess the fixed assets including: replacement cost method, the current market price method, income approach and the liquidation price method. Another study Xiao Lan[8] come with real options method can also be use on the asset pricing.

#### 2) The volatility of the underlying assets value

As the value of options is depend on the overall risk of the underlying assets. If fluctuations in the value of assets are greater, the fluctuations in the value of real options will greater.

The volatility of physical assets value can't be estimates directly from the market, but by the price of historical data. But the ship fixed assets, in particular, the purpose-built facilities such as berth, its price is difficult to establish in the market, so it is difficult to estimate the price volatility according to the historical data. Therefore, we argue that we can use the index of fixed assets investment price or Clarkson Newbuilding price to evaluate the volatility.

#### 3) The exercise price

Exercise price can be seen as the price of fixed asset investment pay by shipbuilding enterprises. And as financial options the higher price to buy the right to perform, then the lower the options value, sell the right to perform the higher price, the higher the options value. Shipbuilding enterprises can base on the available information that from market, economic, policy and other, to determine their own investment.

#### 4) Risk-free interest rate

Fixed assets investment projects as the construction and operation of the cycle length, resulting in risk-free interest rate uncertainty and randomness. Generally, financial options are determined by risk-free interest rate, you can directly use the government bond interest rates. For the calculation of real options, since the investment projects with longer life expectancy, the long-term bonds with interest rates will much better.

#### C. Analysis of assessment results and update

Pricing real options should make full use of market data that can be observed, but in reality, many data are can not obtained directly from the market, and even if accessed, they are just an approximate estimate that not be completely match the reality. Therefore, make a inspection for the assessment is necessary, and make sensitivity analysis for the pricing parameters such as present value of underlying asset, the interest rate, the exercise price and the volatility of the underlying assets value, then we can see and judge how these variables influence the value of real options.

Management, According to the test results, can see whether it is necessary to re-plan or re-analyze the original investment plan, or created more options, to see whether the uncertainty can be calculate more accurately, whether exit a better investment programs, whether make full use of the financial market information. Repeated this process several times, eventually the value of investment will be rise.

## VI. REAL CASE STUDY

### A. Case background

August 16, 2006, the State Council executive meeting examined and adopted the principle of “long-term planning shipbuilding industry,” pointing out: China’s shipbuilding industry is a strong international competitive edge and significant advantage of integrated development of industry, the next decade is a crucial period of shipbuilding industrial development.

JD shipyard is planning an expansion investment. The program has two phases of investments, needing to build a dock and a berth. In first phase, JD spends 1 billion Yuan to build a dock, and the construction period is 1 year. The dock can be use immediately after construction is finished and can be use for 19 years, and the dock can bring an annual net inflow of 200 million Yuan. Considering market conditions, management will plan to make the second phase of berth investment at 3 years later, which value is 700 million Yuan, the berth construction period is 1 year, and expecting to use immediately after completion for 14 years. The berth can generate an annual net inflow of 100 million Yuan. According to the risks of the project, identify the project risk-adjusted discount rate is 10%. In addition, risk-free rate of return  $r$  is 8%, the annual value of fixed assets volatility  $\sigma$  is 30%.

### B. Real options framework for specific application

#### 1) Using traditional DCF to analyze investment project

Calculate the project NPV:

The first and second phase investment  $NPV_1, NPV_2$ :

$$NPV_1 = 2 \times (P / A, 10, 19) \times (P / S, 8, 2) - 10 = 4.345 \text{ billion}$$

$$NPV_2 = 1 \times (P / A, 10, 14) \times (P / S, 8, 3) - 7 \times (P / S, 8, 2) = -0.1534 \text{ billion}$$

The total NPV:

$$NPV = NPV_1 + NPV_2 = 4.345 - 0.1534 = 4.1916 \text{ billion}$$

Seen from the result that the total  $NPV > 0$ , according to the NPV decision rules the project is feasible. But the first phase of the investment  $NPV > 0$ , so the first stage investment is feasible, while the second phase  $NPV < 0$ , if the investment in accordance with the original plan, it no doubt that the second phase investment will be loss in the end. Each phase of the investment is a separate revenue-generating project, even if the overall project feasible, such investments should not be accepted by businesses.

#### 2) Real options analysis

If making decision according to NPV method, the second phase of the original investment is not feasible. However, there are options feature in the investment project, by which management can consider using real options method to evaluate the investment. Evaluation projects using real option approach, the project should be based on the first phase of investment, and then consider the second phase of investment, and focus on the feasibility of the second phase of investment.

From the perspective of real options, construction expenditures in fixed assets in investment, equivalent to an option fee, corporate management can obtain any information, and then select the point to begin. For the phased-investment, the management can get the latest information from market, and consider whether need to adjust the next phase of construction plan, then reducing the investment risk.

This project uses the real options method, the second phase investment can be seen as a options, management can use delay-options, to delay the second phase of investment to the fourth year.

#### 3) Real options pricing and making decision

Using B-S pricing model:

$$OP = S \times N(d_1) - K e^{-rt} \times N(d_2)$$

$$d_1 = \frac{\ln[S/K] + \left(r + \frac{\sigma^2}{2}\right) \times T}{\sigma \sqrt{T}}$$

$$d_2 = d_1 - \sigma \sqrt{T}$$

#### a) Calculate $d_1$ and $d_2$

$$d_1 = \frac{\ln[S/K] + \left(r + \frac{\sigma^2}{2}\right) \times T}{\sigma\sqrt{T}}$$

$$= \frac{\ln[5.8477/7] + \left(0.08 + \frac{0.3^2}{2}\right) \times 3}{0.3\sqrt{3}} = 0.3755$$

$$d_2 = d_1 - \sigma\sqrt{T} = 0.3755 - 0.3\sqrt{3} = -0.1441$$

b) Obtain the  $N(d)$  from normal distribution tables

$$N(d_1) = 0.6463, N(d_2) = 0.4432$$

c) Options pricing

$$OP = S \times N(d_1) - K e^{-rt} \times N(d_2)$$

$$= 5.8477 \times 0.6463 - 7 \times e^{-0.08 \times 4} \times 0.4432 = 1.6285$$

d) Calculate the second phase ENPV

$$ENPV = NPV_2 + OP = -0.1534 + 1.6285 = 1.4751$$

If using real options approach to evaluate the project, and delaying the second phase investment of the project, the project  $ENPV > 0$  and the berth investment scheme is feasible. Therefore, the entire investment plan should be changed immediately that after the first phase of 1 billion Yuan dock investment, considering at the fourth year to launch the additional second phase berth investment and construction.

Only begin the first phase investment, while there will be the second phase investment opportunity. There is a future expansion option, which makes today's investment feasible. JD shipyard's phased-investment is stress on the value of future opportunities, what we can see, using real options to evaluate the project, and taking the new investment as an options, reflects the options value of its flexibility and its value may be considerable. If only uses the NPV method for investment decision making, ignores the company owned investment options, which will underestimated the value of the fixed assets investment projects, and loss the future big growth opportunity.

### C. Case conclusion

Studying the JD shipyard investment project case, we can see the shipbuilding enterprises using real options method to evaluate fixed assets investment projects and business decisions making, have the following significances:

#### 1) Real options make up the shortcomings of DCF

Real options takes fixed asset investment characteristics and uncertainties into account, and then make up the shortcoming (assuming that investment is not reversible, did not consider the follow-up investments, etc.) of DCF, which

make the fixed assets investment project evaluation and decision-making tends to be more practical.

#### 2) Real options is fully considered the rights in the process of phased-investment in fixed assets investment

For example, investors may defer the investment plan if the project may not have a positive NPV, and choose another investment time for getting greater value.

#### 3) Reflects the relationship between the DCF and real options method

Real options method is not a simple negation of the traditional DCF method, but retains and based on the time value of money theory to breakthrough the DCF limitations.

## VII. CONCLUSION

To establish a real options framework for shipbuilding enterprises investment in fixed assets, it is critical to options-thinking in investment decisions making, rather than just focusing on the assessment of specific details. In the real options application process, if the input variables and the application framework structure are reasonable, then all methods within the allowed accuracy range will give the same results. If an application framework is complex and difficult to understand, no policy-makers are willing to spend time and effort to study the implications of the complex framework, to identify its follow-up program, or to re-design investment plan.

This application framework is seeking to become simple and transparent, clear and smooth, so that management can directly feel the options characteristics of investment in fixed assets, and the framework can be a real guide in the decision-making.

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