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The real option theory application in ship finance—HB company as an example

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DECLARATION

I hereby certify that all the material in this dissertation that is not my own work have all been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and not necessarily endorsed by the University.

(Signature):_______

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Abstract

Ship owners often make the decision to finance the ship, and the ship investment is the basis of ship reproduction. But the traditional approaches such DCF(discounted cash flow) and NPV(net cash flow) are localized by its own limitations. Additionally, ship investment has its own specialty characterizes other kind of investment, such as massive investment; long period for investment; many managerial flexibilities and so on. All this make it difficult to solve the problem of ship investment with traditional investment decision method. As concerned as that, HB Company want to find a more suitable and effective way to solve this problem, so they select the Real Options method and which utilizes the idea of financial options , treat the investment project as option, and to correctly price the managerial flexibilities. The utilization of Real Options approach can consider all kinds of characteristics of ship investment comprehensively, and objectively appraise the value of project. Even more, it can help ship owners to avoid the eyeless ship investment for the reason of lacking the analytical tools.

This article exhibits 3 kinds of Real Options in ship finance (convertible option, abandonment option and waiting option) and computed the value of real option in HB Company's examples, which benefit from this process. Lastly, this trend will be both benefits for the ship owners and the investors in ship finance area and real option in shipping industry will be consummated in future.

Keyword: ship investment, real options, managerial flexibility, investment decision making

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Chapter 1 Introduction

1.1 Background Information

In spite of economic recession, the dry bulk industry fundamentals remain attractive by many traders and ship owners which are full of demand for dry bulk commodities and the trend seems to be positive continually.

The first driver force for the dry bulk shipping industry persists to grow demand sustainably due to the East Asia countries' contribution such as China and India, in those countries, the GDP growth cause the demand of such dry bulk commodities.

The Chinese 11th Five Year Plan contains China's infrastructure building programs illustrates that Chinese will continue to stimulate the demand of steel so that it will incentive demand for iron ore and coal reasonability. Own to the budget and action of Chinese government, I believe, in the near future, China will become the holy land of dry bulk consume country. Also, the demand for two commodities - coal and iron ore will drive the dry bulk industry in the near future.

HB COMPANY, one of the biggest shipping company in China, was established in 1980， and has mainly been engaged in global ocean transportation and ship management. Ever since the beginning of 1998, HB COMPANY has made great progress and outstanding achievements in its management, fleet growth and operation profit. With over 1800 staff, HB COMPANY has managed and controlled more than 100 vessels amounting to a total capacity of more than 10 million deadweight tons. There are also 28 vessels with 5.243 million DWT under construction. The carried cargoes mainly include iron ore, grain, crude oil and coal .HB COMPANY has been in the course of rapid and sustainable development and is going to seize the opportunity to develop itself into a first-class international shipping company in terms of fleet scale, profitability and quality via this golden opportunity.

1.2 Literature Review

1.2.1 Definition of Real Option

The traditional method to evaluate a target and make investments usually adapts discounted cash flow (DCF) or discounted present value (DPV) approaches. Explicitly these 2 approaches assume the target objects will receive the expected cash flow on the condition of no intervention or interruption as the arrangement plan within the whole process. The whole static process via (risk-adjusted) discount rate covers all uncertainty. Meanwhile, investors obtain the expected value of the cash flow which incorporated with the analysis and make the final investment decisions. On the assumption of this methodology, all the management flexibility analysis as reveals of nature is stated. Usually, the target project's management discretion is valuable, which is not added into the DPV. The real options methodology is more precisely evaluates the valuation and the approach is more suitable for the firms operate. It is suitable for the investor to accommodate the nature and flexibility decision to abandon, contract, expand or vice versa modify its actions .essentially this is very important to policymakers who are willing to emulating the competitive process, they cannot depend on the naive DCF methods' application.

Decision-tree analysis (DTA) develops forwards one step which allows it possible for alternative states of nature. But as a matter of fact that indeterminate appropriate risk-adjusted discount rate as in the case of DCF is a paradox. it is hard to determinate the appropriate the risk-adjusted discount rate if the target object does not correlate with the company's cost of capital , using the company's opportunity cost of capital is unseemliness.

The DTA's another insight recognition is the portfolio theory applies which applied to the evaluation of asset or project. This allows the investors use decision-tree analysis to do the capital budgeting issues integration with physical assets .with this process a portfolio of securities whose price and return are known is created perfectly correlated with the investment project. This portfolio analysis incorporates the probability density function rather than consider the factor of the expected value of outcomes, which can analysis without the determination of a risk-adjusted discount rate. Using the financial options mythology as the Black-Scholes methods of option valuation (Black and Scholes, 1973) which can measure the uncertainty due to the density function and the portfolio.

1.2.2 Real options

Real options theory originates by comparison and the contrast between the real options and financial options. A financial option is a type of the so-called underlying asset, whose value should be reflected by another financial security's worth and characteristics. Further, financial option holder has the right to execute the target asset at a specified price on or before a given date without obligation. Black and Scholes (1973) and Merton (1973) firstly formulate a financial option valuation, which opened up the way to research on the pricing of financial assets and real options theory.

The concept of real options was mentioned by Myers' (1977) whose important insight that we can think a project's discretionary investment opportunities as a financial call option on real assets similar to the financial option which gives decision rights on financial assets. Moreover, a real option consists its underlying asset 's gross project value which equals to expected operating cash flows; exercise price which is the t required payment to gain this target asset; and the maturity time which is the period defer the investment before the investment opportunity until expires (Myers, 1977; Trigeorgis, 1996). Real options are investments in real assets, have right to burden certain actions in the future without obligation, opposed to financial assets (Trigeorgis, 1996; Amram & Kulatilaka, 1999). These 2 kinds of options' differences can see

(Brealey, Myers, & Allen, 2006). In spite of this, the real options theory has many improvements which can overcome the traditional present value technique's deficiencies via the known of interdependencies and competitive interactions.

Real options are an approach to reveal the uncertainties while do the management flexibility. Traditional Capital budgeting approaches fails to illustrate the flexibility and to integrate the strategic planning flexibility .The capital asset pricing model (CAPM) also has its own limitations, like many of the traditional methods deal with uncertainty as decision-tree analysis, sensitivity analysis and simulations. Real options methodologies can make full use of best features of DCF and DTA without their disfigurements. The intuition is simple and profound .Real options method makes a great different way to the valuation, which broadens the notion of the manager's flexibility in investing. Compare to the results of the traditional DPV analysis, the analysis with financial options allows for gains on the upside for increasing the valuation. Also this methodology is benefit for strategic considerations which magnified or explicated the result. Thus compared to traditional economic theory, this methodology suggests that the traditional sayings need reevaluation.

Research on common Real options has evolved a taxonomy system usually involved in an investment project, besides deferral options, abandonment options, switching options, options to stage investments, options to alter operating scale, and growth options etc. Additionally, like other financial derivatives, an investment is a combination of some of the common real options, and the value of this combination portfolio often not the same as the sum of the value of each option separately (Trigeorgis,1993). With the technology development, multistage investments or venture capital comprise compound options, whose underlying asset is not a real option rather than asset (Roberts & Weitzman, 1981; Trigeorgis, 1996). Further, simultaneously investor can obtain a portfolio of options (Merton, 1973), a company may meet the situation that when execute multiple investments at a point of time may cause option portfolio interactions, on the condition that options in one investment may influence the value of other options and therefore influence the sum value of portfolio (Luehrman, 1998; Smit & Trigeorgis, 2004).

The real options tend to show an analytic focus to evaluate firms' investments under uncertainty and to simulate the optimal conditions for burdening such investments. For example, earlier research emphasis on the analysis with natural resources and flexible manufacturing (Brennan & Schwartz, 1985; Triantis & Hodder, 1990), to find the optimal timing of investing (Titman, 1985), and researched the relationship between options to alter operating scale and the value (McDonald & Siegel, 1985; Majd & Pindyck, 1989). Secondly, people also used real options theory to analyze strategic resources investments such as R&D, as well as acquisitions, diversification and other corporate strategy (Childs & Triantis, 1999; Bernardo & Chowdhry, 2002; Pacheco-de-Almeida & Zemsky, 2003).

Also this research developed few large-scale empirical studies in finance and economics. Those analysis have largely continued the focus on natural resource investments and real estate development (Quigg, 1993; Moel & Tufano, 2002), and have also examined the implications of particular options for the firm value (Berger, Ofek, & Swary, 1996). Empirical work on this topic is young and I believe with the computer technique developed, this will be flourished.

1.3 Methodology-- Option Pricing Model

1.3.1Black - Scholes Option Pricing Model introduction

The Black–Scholes model is a mathematical description of financial markets and derivative investment instruments. The model develops partial differential equations whose solution, the Black–Scholes formula, is widely used in the pricing of European-style options.

The model was first articulated by Fischer Black and Myron Scholes in their 1973 paper, "The Pricing of Options and Corporate Liabilities." The foundation for their research relied on work developed by scholars such as Jack L. Treynor, Paul Samuelson, A. James Boness, Sheen T. Kassouf, and Edward O. Thorp. The fundamental insight of Black–Scholes is that the option is implicitly priced if the stock is traded. Robert C. Merton was the first to publish a paper expanding the mathematical understanding of the options pricing model and coined the term Black–Scholes options pricing model.

1.3.2 Black–Scholes Formula:

The Black Scholes formula calculates the price of European put and call options. It can be obtained by solving the Black–Scholes partial differential equation.

The value of a call option for a non-dividend paying underlying stock in terms of the Black–Scholes parameters is:

$$C(S,t) = SN(d_1) - Ke^{-r(T-t)}N(d_2)$$

$$d_1 = \frac{\ln(\frac{S}{K}) + (r + \frac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T-t}}$$

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

… （**1-1**）

The price of a put option is:

$$P(S,t) = Ke^{-r(T-t)} - S + (SN(d_1) - Ke^{-r(T-t)}N(d_2)) = Ke^{-r(T-t)} - S + C(S,t).$$

… （**1-2**）

For both, as above:

- N(•) is the cumulative distribution function of the standard normal distribution

- T - t is the time to maturity
- S is the spot price of the underlying asset
- K is the strike price
- r is the risk free rate (annual rate, expressed in terms of continuous compounding)
- σ is the volatility in the log-returns of the underlying

1.3.3 Binomial Pricing Model

in finance, the binomial options pricing model (BOPM) provides a generalizable numerical method for the valuation of options. The binomial model was first proposed by Cox, Ross and Rubinstein (1979). Essentially, the model uses a "discrete-time" model of the varying price over time of the underlying financial instrument.

(1). European-style options.

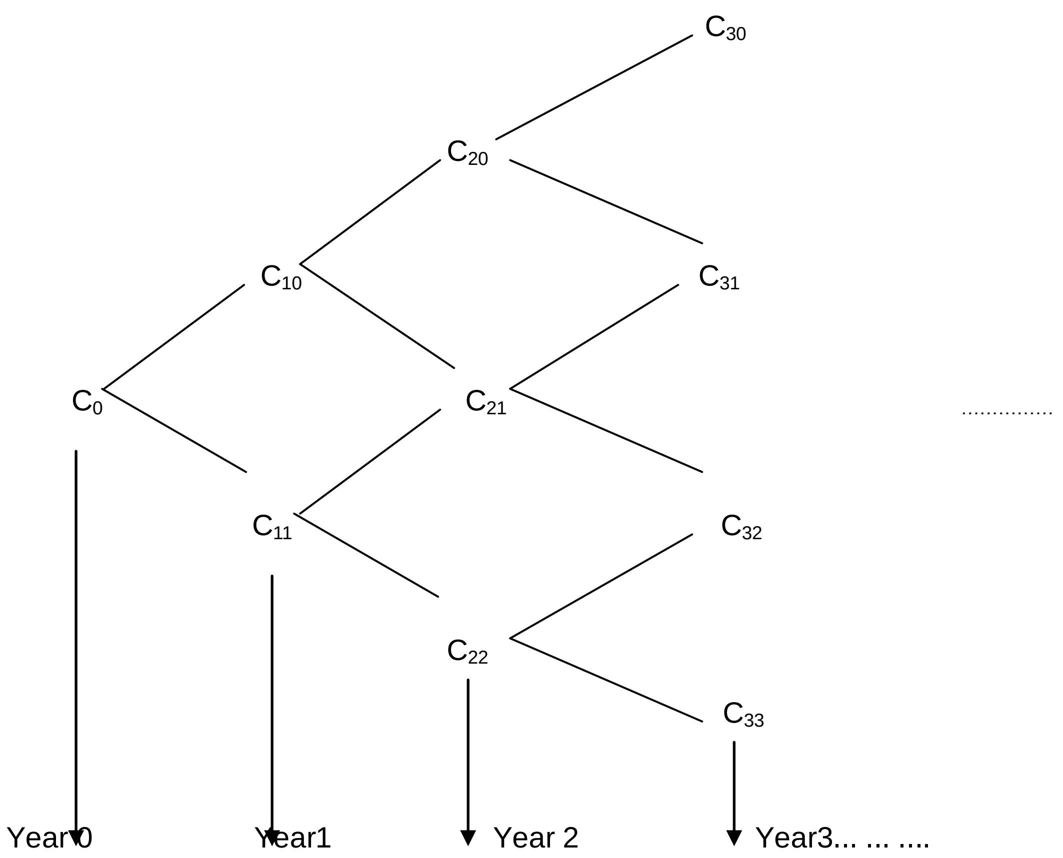

Figure 1.1 European-style options binomial model

In Figure 1.1, the binomial model, each called a node with a value Ci, t to express, on behalf of Options in the first i, t state the value (s i of that time in which a node , while the state said the risk of variable t by the i of the increase or decrease in the decline in t times, by (i-t) times); each line as the path leading to the node, a node is often based on the passing path above; will be divided into a number of options such as maturity period, the number of issues through the use of n to represent; each period of the underlying asset price increases the probability p, as only two possible rise and fall, then prices The probability 1-p, while u and d are, respectively, as the underlying asset value of each rate of rise and fall. So they built a European-style option binomial pricing model that each node the value Ci, t is the next issue of the value of the corresponding two nodes along the tree down with a calculated push method out of order type (1-4) said:

$C_{i,t} = pC_{i+1,t} + (1-p)C_{i+1,t+1}$ … (**1-3**)

N starting from the back of each period calculated to promote each node the value options, and then can type (1-5) calculated the value of options at the beginning

$$. \; C_0 = \frac{1}{(1+r)^n}\sum_{j=0}^{n}\left[\frac{n!}{j!(n-j)!}p^j(1-p)^{n-j}\max(S_0u^jd^{n-j}-X,0)\right] \ldots \text{ (\textbf{1-4})}$$

Where, C_0 = option beginning price

S_0 = price of underlying asset at the beginning

r = risk-free interest rate during a single period

X = option strike price

Depending on the style of the option, evaluate the possibility of early exercise at each node: if (1) the option can be exercised, and (2) the exercise value exceeds the Binomial Value, then (3) the value at the node is the exercise value.

- For a European option, there is no option of early exercise, and the binomial value applies at all nodes.

- For an American option, since the option may either be held or exercised prior to expiry, the value at each node is: Max (Binomial Value, Exercise Value).

As the binomial pricing model in the pricing of real options has incomparable superiority in the model application, in this article I will use some binomial pricing model applications in ship investment.

1.4 Research Background

Try to estimate forward-looking costs usually on the basis of traditionally applied discounted cash flow analysis — exactly the method that real options methodology has shown can give different results. The literature demonstrates valuation due to the investment uncertainties analysis has been enhanced with real options theory, obedient to probability distribution, which lacks the DCF analysis. Application of the real options methodology to DCF analysis can make a significant valuation change. As well as all current cost models may ignore this enhancement.

Real options have implications for strategic planning; can integrate strategic planning, capital budgeting, and control. The real options theory is scarcely used in the maritime industry and HB Company is trying to do ship purchase budget via this methodology.

Chapter 2 The general introduction of real option theory application in ship finance

2.1 Analysis of the shipping market risk sources

Ship investment is very important to a shipping company, due to shipping is undoubtedly a risky business, how to grasp the investment opportunity accurately under a high degree of uncertainty market, how to do risk management in ship finance becomes a priority to consider.

2.1.1 Systemic risk in the shipping market

(1) Market Risk

Shipping industry is a industry with clear shipping market cyclical, periodic cycle. In fact the past century the market is obvious to see the existence of such a cyclical: generate huge profits boom, also exists unexpected recession which lasted more than a decade sometimes.

The shipping market demand and supply balance determined the freight rate. The demand for transportation depends on the global economy and international trade, at a particular time is relatively stable, the sensitivity of the freight rate is not high, but shipping supply always lags changes in demand, the world economy cyclical fluctuations and changes in supply caused the lag of the dynamic imbalance between supply and demand in turn formed the cyclical shipping. The existence of the shipping market cycle has formed the basic risk of the shipping industry, which is a major source of systemic risk that the investors should face up.

(2) Finance Risk

The nearly 50% total cost is the composition of financing costs, so ship operators will face huge impact on financial factors, owners have to bear a huge financial risk. Here, the financial risks including interest rate risk and exchange rate risk.

Fluctuations in market interest rates arising from interest rate risk. The risks are generally presented in commercial bank loans and bond issues. Interest cost of debt financing is a very important issue in the fixed cost, fixed-rate financing to bank loans and bonds will decline in market interest rates, because of its difficulties in distribution to floating rate loans and bond financing ,will also exist due to rising interest rates to increase the risk of financing costs. In addition, different interest rates also affect ship owners ‘s investment timing, high interest rates make owners tend to invest as soon as possible, while the low interest rate, investment will be delayed. It shows that the interest rate risk is an important factor need to be considered.

Meanwhile, ship owners may be subject to foreign exchange risk in ship financing, because the cash flow in different stage may be in different currency. So the investors may be vulnerable to burden the risk of currency exchange loss, so they have to pay attention to the foreign exchange risk.

(3)Cost Risk

To determine the owner's profit goals, maintain strong competitiveness and market share, one of the key points is the transportation cost. In fact there are a number of the ship transport costs risk factors, such as fuel price risk, the crew cost risk and etc. those costs have great impact on ship operations.

(4) Country Risk

Country risk refers to the target country's ship operations risk, political risk and legal risk. The country-specific risk influences operator a lot, Such as currency controls and war.

2.1.2 Non-systemic risk in the shipping market

(1) Technical Risk

Technical risk means that the vessels are in order or in operation, ship owners have to burden the impact on the technical conditions which affect the profitability. For example, order ships in the shipyard which does not meet technical standards; the same ship is put into different shipping market while the technical conditions are different, these situations will bring the investors tremendous business risk.

(2) Financial Risk

Ship owners sometimes use debt financing way to buy new ships, while this approach will bring the investors to burden the risk of finance leverage, and many of the ship-owners are bankrupted due to lack of payment ability.

(3) Ship Operational Risk

Ship operation is a very professional and risky business; it needs a lot of professional knowledge and knowing of some conventions. In this process, the ship-owners also burden the risk of loss such as cargo loss or general average, for shipping companies , the liability to afford the loss depend on the C/P.

Chapter 3 Real Option in Ship Investment

3.1 Characteristics of Ship Investment

Ship investment is the major capital investment projects in shipping industry, before the application of investment decisions the ship owner should to have an understanding of characteristics of the real options method

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(1) Ship investment contains enormous investment risk. As mentioned above, shipping is a risky and uncertain industry, for example the fixture market, mainly reflected fluctuations in freight rates, and also in liner market is reflected by fluctuations in demand, which is the fundamental risk in ship investment . In addition, they have also burden exchange rate risk, interest rate risk and non-systematic risk.

(2) The ship investment projects have a long and uncertain duration. Normally ship life span is 20-25 years, the vessel operating time sometimes across several times

shipping cycle. In addition, shipping companies will have to make the decision whether scrap or buy a second-hand ship according to the market, which makes the operational life of the ship, is not really matches its useful life.

(3) The ship investment is a capital-intensive projects investment. General investment into new ships, up to 10 million U.S. dollars, individual ships can reach 100 million U.S. dollars. Even second-hand ship market prices ships have reached millions of dollars. The risk for such a large scale investment projects, the shipping company's decision-makers before make investment decisions on their assessment should fully reveal the true economic viability of the project.

(4) The ship investment projects contain much management flexibility. Ship investment projects in high-risk correspond greater flexibility management space, including management flexibility of temporary outages or rental of ships; timing flexibility whether to give up operating the ship or its dismantling transfer of management flexibility and phased investment strategy for the ship management flexibility, etc. The management flexibility has a significant impact on the whole process of investment decision.

3.2 The feasibility of real options method applied in ship investment decision

Given the characteristics of ship investment projects, a complete investment decisions should take full account of these characteristics. Major investment decisions adapt the net present value (NPV) method, supplemented by sensitivity analysis, Monte Carlo simulation or using decision tree analysis tools. However, due to ship investment contains high-risk, high management flexibility, long and uncertain duration characteristics that make the evaluation of investment projects on the ship decision cannot be accurate and fully reflect the true economic viability of the project. As the previous chapter mentioned, the real options approach is a full account of uncertainty, management flexibility and irreversibility method, which is suitable for economic environment with high uncertainty like shipping industry that determines the real options approach has applicability in this area. In addition, the ship investment is a long-term project requires a dynamic analysis system, real options method is effective for uncertainty long term investment, that achieve the needs of decision maker rather than the tradition approaches.

3.3 Existing ship investment management flexibility and the corresponding real options

Compare with other investment projects, ship investment projects have lots of management flexibility. Real option approach is applicable in this area and design appropriate option pricing models to calculate its value. Existing real options in ship investment at least the following three:

(1) Convertible option- the rental of ships

shipping company policy makers have to adjust ship operational flexibility based on the annual level freight rates. Generally, when the freight rates are so low that cause the revenue cannot compensate the operating costs, policy makers may consider outage the vessels in order to reduce losses; or they can operate the ships by themselves or transfer the ship to the lessees according to the charter market conditions (here, can be based on some freight index to predict the route freight rate). The real option which the ship owners have the rights operate the ship by their own or rented to tenant management or decommission the ships in corresponding period, here called ship convertible option, the option value constitutes an important part of ship investment value.

(2) Abandon option—the ships quit the market

When the freight market significant decreased and the ship-owners become unsustainable to continue to operate and are difficult in predicting the foreseeable future, it is a more feasible method that the ships neither quit the market and neither outage ship nor scrap the vessels. When the value of operating ship below scraping the ship or sold in the second-hand ship market, the owners should consider exercising of this management flexibility. This management flexibility is corresponding to the abandonment option in ship investment projects.

(3) Waiting option- the timing of investment

As mentioned above, the shipping industry is a risky and very clear cyclical industry, the shipping company's decision-makers always hope they are at low prices to invest in ships before the maritime industry into prosperity, and sell their ships or scrap the ships at a high price before the industry into depression. But as investors in stock market, they have no idea about where the top is and where is the end at speculative perspective. The phenomenon with real options theory to explain the investors who are waiting for the timing is wait option. When the owner decided to invest in a ship immediately, that the option value is actually an opportunity cost, and when the owner decided to postpone the investment, this real option is an integral part of the project value.

The management flexibility of ship investment projects cannot be all summed up into the above 3 real options, but these four is the most typical of ship investment which have the greatest impact on the ship investment management flexibility and real options.

This following section will present these three real options in ship investment and adapt some examples of HB Company, with the binomial option pricing model and the Black-Scholes option pricing model to illustrate these issues.

Chapter 4 Real options applications in ship investment

4.1 Convertible option pricing model in ship investment

As the dramatic freight shipping market volatility, and the time period and region imbalance volatility of shipping market. The shipping company is hard to deliver the transport capacity which matches the actual needs that transport imbalance often occurred. When the capacity is more than demand, it will appears excess tonnage, then we must consider the issue of decommission the ship. When the ship operating is at a loss, we should consider the following 3 conditions due to the maintenance costs as a "closed" cost. As we know, we still should pay the maintenance expenses such as the crew salaries, fuel consumption for maintain the ship, cost for anchorage, etc. for ship outage. So we should distinguish this issue into 3 approaches. Firstly, When loss is less that the "closed" cost , the ship-owners should maintain the operation of the ship; secondly, when the operation of the ship's loss is equal to the ship's "closed" cost, in theory, stop or continue the operation there is not much difference in the economy, consider the ship operation ‘s social benefits and impact, ship-owners are usually more favorable to business; only when the ship's operating loss is greater than the ship's "storage" costs, it should stop operating, the implementation of "closed." On the other hand, when the market rebounds in freight rates, the ship-owners will pay corresponding expenditure costs for restart the outages ship, including the start-up costs and inspection repair certification fees. The former situation made only when the freight rates down to a certain level, the costs of “closed” the ship is less than the loss of ship operation, thus the shipping companies select the outage ship. While the latter makes only when the freight charges is more than the total cost which including the fixed cost and variable cost, the shipping company will consider re-start the ship.

For a shipping company, the point is not only to determine whether storage the vessel on an economic boundaries, but also consider many other issues. For example, how much time the market downturn will last. If the ship-owners expected the market conditions could be restored to the profitability level in a short-term, the freight rates even lower than the storage point they continued operating. Because this issue is very complex ,which refer to the charge of change the crew and re-recruitment, the time and money need to be considered. In addition, the impact of social issues should not be ignored such as the attitude of ILO. Only when the shipping company expected that when the poor market prospects could be last for a long period of time, they decided to outage the ship. In short, the question for idle ships, not only to consider the economy factor, but also combined with enterprise development strategies, so it’s hard for market forecasts made the final decision .

In addition, the shipping companies solve the imbalance between capacity and transport demand is Chartering. Charter hire rate will directly affect by the shipping market price fluctuations. Different charter parties have different way to compensate the Ship Operating Costs and voyage cost. Also In the lease term, the lessee can use the lease arrangements for tramp ship transport, or the liner can also be re-leased to third parties. Here we consider the period of one year charter time. When the freight market is weak, or for economic and political reasons, the shipping companies operating on the route were in less than adequate supply, the managers could consider rent to the lessee for to compensate unnecessary losses. Therefore, according to the annual forecast market reports, the shipping companies can decide the way to operate their ships in order to have the right to choose the most profit margins or make a minimum loss. Due to the shipping companies are all in process of this kind of flexibility, in the paper, the author is about to construct a real option, here called the Convertible option.

As in the charter market the charter party hire rate is a risk variable which has a high degree of correlation with freight rates. Generally speaking, the higher in the shipping freight market, the higher in the hire rate, in this article, the author will set up correspondence relations between charter market hire levels and freight market rates, compare the value of persistence operation and the value of charter market hire to determine whether the implementation of option pricing model and then can calculate the value of convertible options.

According to convertible option framework, the owner has right to choose whether charter the ship or not every year, so that the corresponding real options is the American style real option which is no dividends. Therefore, the calculation of the convertible options can be divided into two steps: first, construct the binominal model about ship operation; secondly, construct the binominal model about ship chartering.

1, binominal model about ship operation

Set: F0 = initial freight rates levels

$F_{i,t}$ = the freight rates level of the first years to t year and there is:

$F_{i,t} = F_0 u^{(i-t)} d^t$ ……(4-1)

Where: u = freight rates amplified annually

d = freight rates descended annually

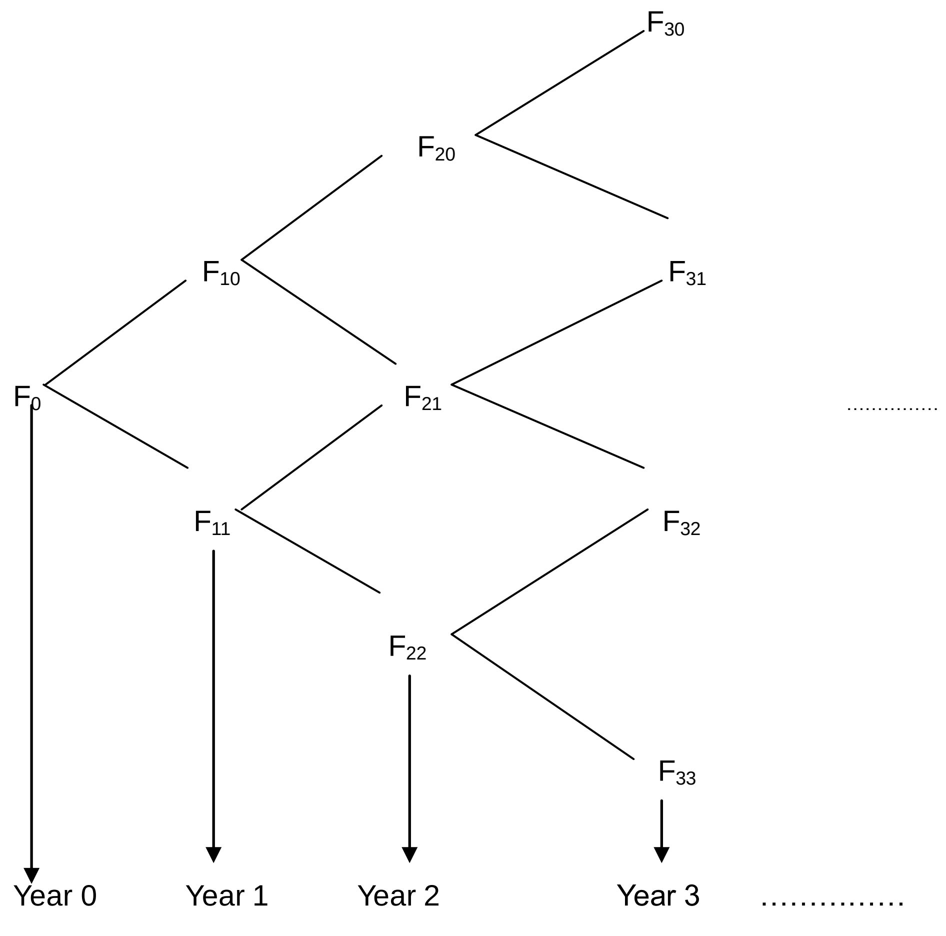

Figure 4.1 Ship operation binominal model

K_v – Unit Variable costs

K_f –fixed costs

Q - traffic volume

F_s- the freight rates When the ship in storage

G – ship "closed" cost

H – ship re-start cost

F_k- freight rates when ship restarts

The freight rate during the "closed" time is given by (4-2-2) calculation:

Because $K_v \times Q + K_f \times Q = G$

Therefore, $F_s = K_v + (K_f - G) / Q$ ... ... (4-2)

That is, when F ≤**F_s**, the ship decommission

the freight rate when the ship-owner want to restart the ship from the following formula (4-2-3) calculation:

Because $F_k \times Q = K_v \times Q + K_f + H$

Therefore, $F_k = K_v + + K_f + H / Q$ ... ... (4-3)

That is, when F ≥F_k, the ship re-start. So established binominal price model for the freight rates, the next step is to identify the outage point and restart point. Mentioned above, the outage point (**F_s**) should be as the freight rate level according to (4-2) when the freight rates level below the point the shipping company will outage the ship; restart point (**F_k**) should be as the freight rates level according to the formula (4-3), when the freight rates is higher than the point the shipping company will reactive the ship .Based on the above analysis, we can see the cash flow when ship is in operation, the formula can be expressed as following:

$$AV_{i,t} = \begin{cases} (F_{i,t} - Kv) \cdot Q - K_f, & whenF_{i,t} \geq f_s orF_{i,t} \geq f_k \\ -G, & whenF_{i,t} \leq f_s \end{cases} \quad \text{... ... (4-4)}$$

Of which: $AV_{i,t}$＝ the annual cash flow from year $_I$ to year $_t$ when the ship is under operation

According to the analysis above, we know the outage point (**F_s**), restart point (**F_k**) and the binominal pricing model, we can further construct binominal pricing model base on the ship's annual cash flow (Figure 4.2). Tree nodes means the annual cash flow $AV_{i,t}$

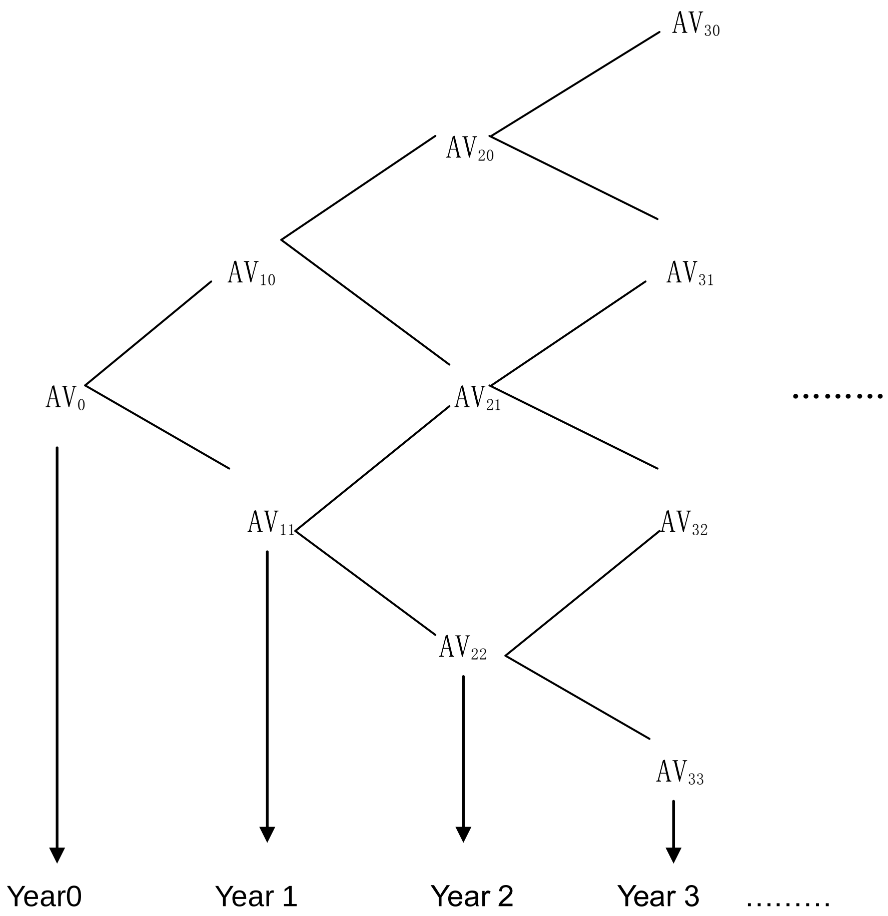

Figure 4.2 Annual cash flow binominal model

2. Binominal pricing model of ship leasing

Set: $\mathbf{F_r}$- annual rental income per DWT

DW – dead weight tonnage

then annual rental income= $\mathbf{F_r} \times DW$

Set: $\mathbf{K_v}$ – Unit Variable costs

$\mathbf{K_f}$ –fixed costs

Q - traffic volume

due to the time charter party indicate that the ship owner only burden the fixed cost of the ship, the charterer should be responsible for the variable cost, so in the charter party period the ship-owner's income as the following

$\Sigma \mathbf{F_r} = \mathbf{F_r} \times DW - \mathbf{K_f}$ ... ... (4-5)

If the ship is under the ship owner's operation, the total operating income:

$\Sigma F = F \times Q - \mathbf{K}_f - \mathbf{K}_v \times Q$ (or-G) ... (4-6)

Therefore, the shipping company's decision about whether lease or not is based on the total rental income and the total operating income:

That is, when $\Sigma \mathbf{F}_r \geq \max(\Sigma F, -G)$, it will charter the ship

When $\max(\Sigma F, -G) \geq \Sigma \mathbf{F}_r$, the ship owner will operate the ship

there is a certain correlation between freight market and the charter market, so when freight rates changes, while charter rates are also changes corresponds to the same level charter rates, the binominal model as shown 4.3 below.

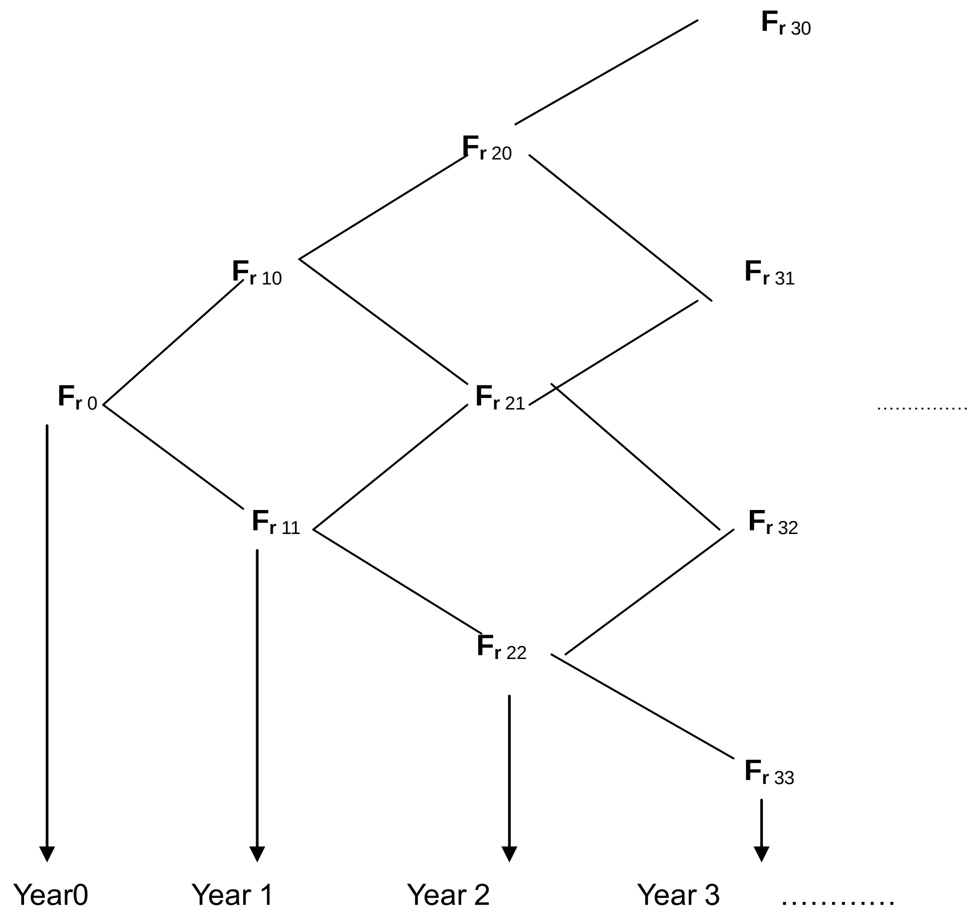

Figure 4.3 Ship leasing binominal model

Where: $\mathbf{F}_{r\,0}$ = initial charter rate level (dollars / Dwt) per year

$\mathbf{F}_{r\,i,t}$ = charter rate level from year i to year t

Construct binominal pricing model of ship leasing and the node of charter rate is calculated as follows:

$\mathbf{F}_{\mathbf{r}\,i,\,t} = \mathbf{F}_{\mathbf{r}\,0} u_r^{(i-t)} d_r^{t}$ ……(4-7)

Which: u_r = charter rates amplified annually

d_r= charter rates descended annually

The ship's gross rental income each year is as following:

$BV_{i,\,t} = \mathbf{F}_{\mathbf{r}\,i,\,t} \times DW - K_f$ …(4-8)

According to the annual gross rental income of the ship, we can construct binominal pricing model of rental income, as shown in Figure 4.4.

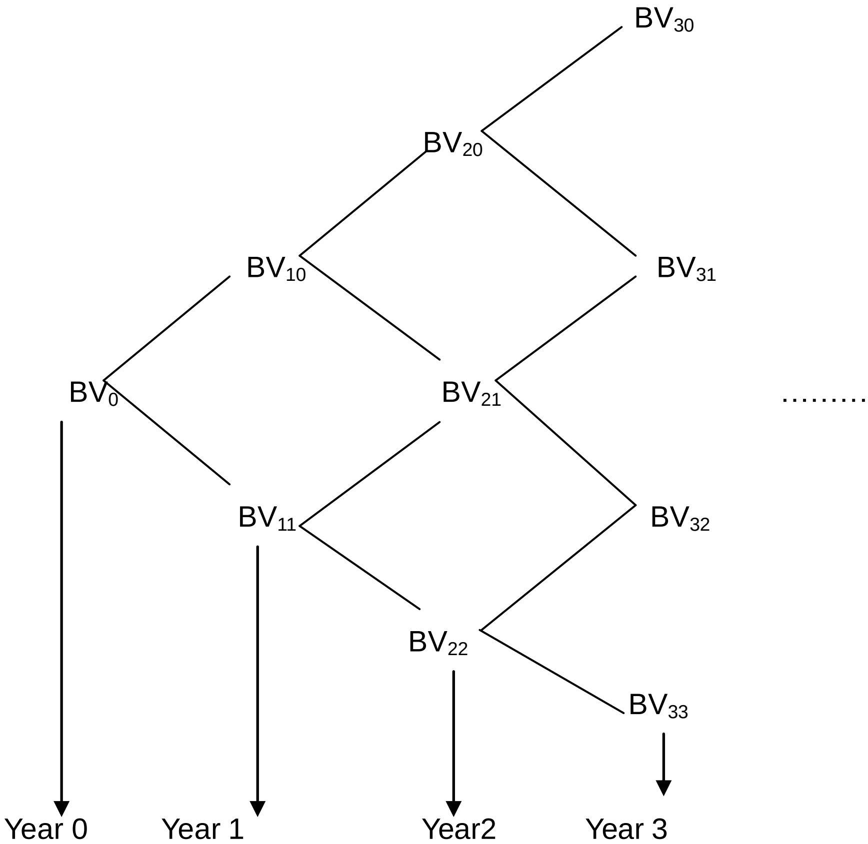

Figure 4.4 The ship's rental income binominal model

set the annual investment cash flow $PV_{i,\,t}$, there

$PV_{i,\,t} = \max(AV_{i,\,t}, BV_{i,\,t})$ ……(4-9)

Can be calculated the cash flow at different times, constructed binominal pricing modal as Figure 4.5.

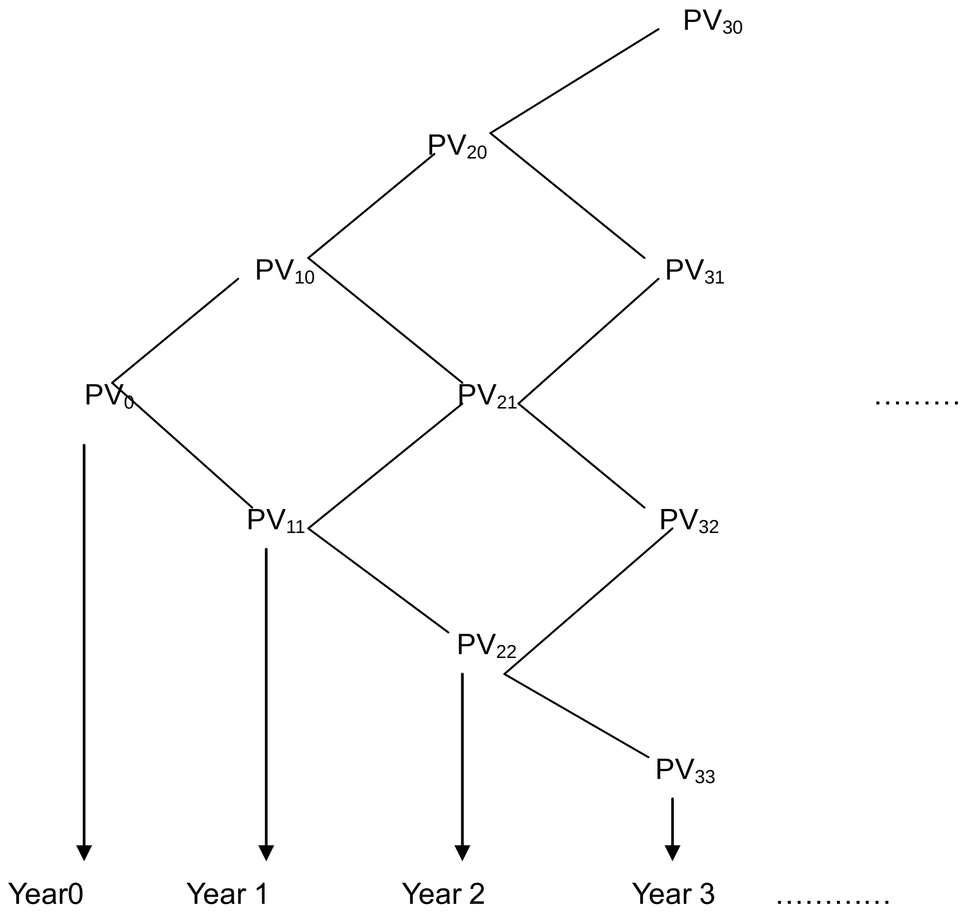

Figure 4.5 The ship's annual cash flow binominal model

Based on the above three binominal pricing models we set up European-style convertible real option pricing formula as following: the value of the convertible option can be expressed as

$$R_i = \frac{1}{(1+r)^i} \sum_{t=0}^{i} \left[\frac{i!}{t!(i-t)!} p^{(i-t)} (1-p)^t \cdot PV_{i,t} \right] \text{... ... (4-10)}$$

Where: R_i = convertible option value of i year

P = the probability of annual freight rates amplified (then (1-P) for the probability of annual freight rates descended)

Due to the formula can price the value of convertible option each year, then we can calculate convertible option value of ship entire the life cycle as the following:

$$R_0 = \sum_{i=1}^{n} R_i \qquad \text{... (4-11)}$$

Where: R_0 = convertible option value of ship

r = capital cost rate

n = the number ship's life cycle (year)

R = the residual value of the ship

so The value of ship investment projects is as following

$$V = \sum_{i=1}^{n} R_i + \frac{R}{(1+r)^n} \qquad \text{... (4-12)}$$

4.2 Abandonment option pricing model in ship investment

Shipping market has high volatility which means that the freight rates are always in sharp fluctuations. The ship owners are by all means to mitigate risks and there are 3 main means to avoid this, one is temporary outage the ship, second one is charter the ship that shift its own risks to the lessee, the other one is sold it through second-hand market or scarp the ship. But in fact outage the ship also has considerable risk, while short-term outage is acceptable to the owner, but if the owner is expected to the fact that the market will not recover soon so the owner decide to exit the market rather than temporary quit this market, they will sell or scarp the ship rather than outage the ship. This is because the ship investment project often requires a high proportion of debt financing, a long time outage period is not only unable to make any income, but also to bear the substantial capital cost, which make the owner unable to accept it. Second-hand market and demolition market provides the ship-owners an effective means to increase cash flow liquidity, but also makes the owner's exit flexibility possible.

Generally speaking, the ship in the interim always in the hands of the original owner's operation is rare, and most ships have one or more times to be sold. Many investors aimed at second-hand ship market, trying to sell or purchase the old vessels at the right time. Second-hand ship prices have not only affected by the type of ships such as size, age and the vessel characteristics, more importantly, the freight market has a high relevance with the second hand ship price. In addition, shipbuilding and demolition market impact trade volume. The demolition market's target object is the old ship, which has a long operating time, close to or exceed the useful life. The ship abandoned by the owner to sell their demolition brokers to demolish. Ship price in demolition market not only affected by its own characteristics, such as hull, machinery and equipment corrosion degree, but also the impact of the shipping market conditions. Compare the target ship in second-hand market and demolition market is that: ship in second-hand ship market is still has operating value, and in demolition market is no operational value.

During the Shipping Investment decision-making process, when the freight rates significant drop makes the ship-owner untenable to continue to operate, and also the ship-owner expects the market in the future can hardly recover, it is a feasible way to make the ship exit the shipping market and sell the ship. At this point, the owner should compare the ship price in second-hand market or in demolition market and the value of ship operation to decide whether to give up or to continue operate the ship. When the old ship price is greater than the value of the ship which to continue operating, the owner will sell the ship or vice versa. Based on the circumstance of ship-owner owned this management flexibility. This paper starting from the real options theory to construct an real options, here called the abandonment option.

Similar with the previous chapter, where the first established the binominal model on the variable of freight rates, see in Figure 4.6

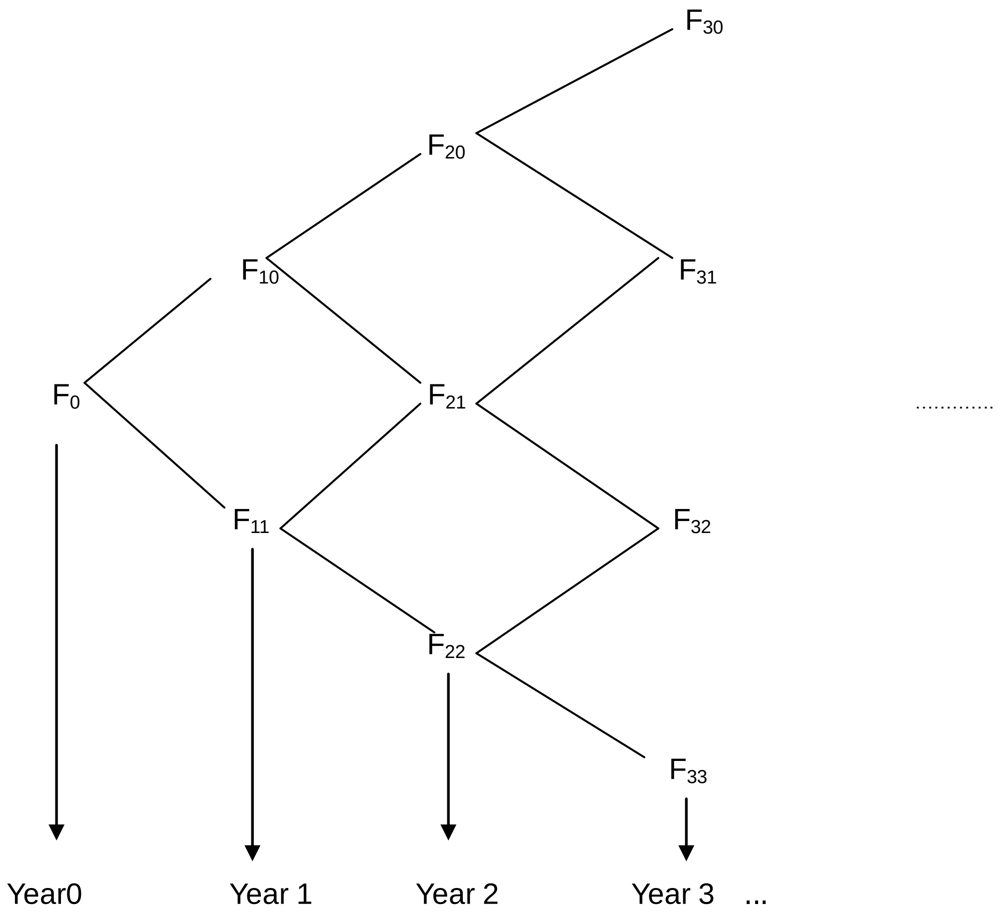

Figure 4.6 Freight rate binominal model

Set: F_0 = initial freight rates levels

$F_{i,t}$ = the freight rates level of the first years to t year and there is:

$F_{i,t} = F_0 u^{(i-t)} d^t$ ……(4-13)

Where: u = freight rates amplified annually

d = freight rates descended annually

Based on the binominal price model above we can calculate the project value when the freight rates $F_{i,t}$ as the node shows, according to the pervious chapter mentioned the basic formula (4-12), we can calculate the resident value of this project as the following:

$$S_{i,t} = \sum_{i=0}^{n-i} C_{n-i} + \frac{R}{(1+r)^{n-i}} (i = 0,1,...n-1;\ \ t = 0,1,....n-1) \quad . \ldots\ldots \text{(4-14)}$$

Note that when in n year that the residual value of this project equals the ship price in demolition market, which

$$C_{n-i} = \frac{1}{(1+r)^i} \sum_{t=0}^{i} \left[\frac{i!}{t!(i-t)!} p^{(i-t)} (1-p)^t AV_{n-i,t} \right] \text{... ... (4-15)}$$

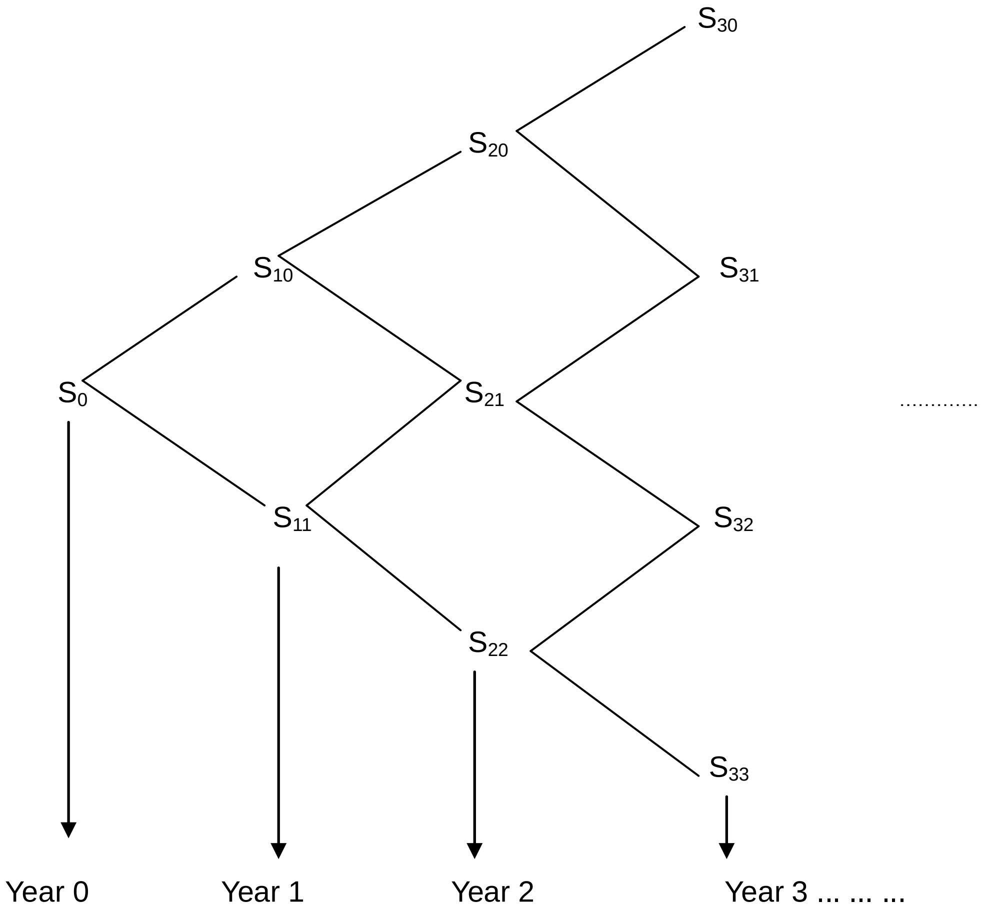

Figure 4.7 The residual value binominal model in ship investment projects

In addition, the assumptions about this real option is that the movement of freight rates lead to the price movement in second-hand market and demolition market, all freight rates correspond to the ship price in second-hand market and demolition market at the same time, see Figure 4.8.

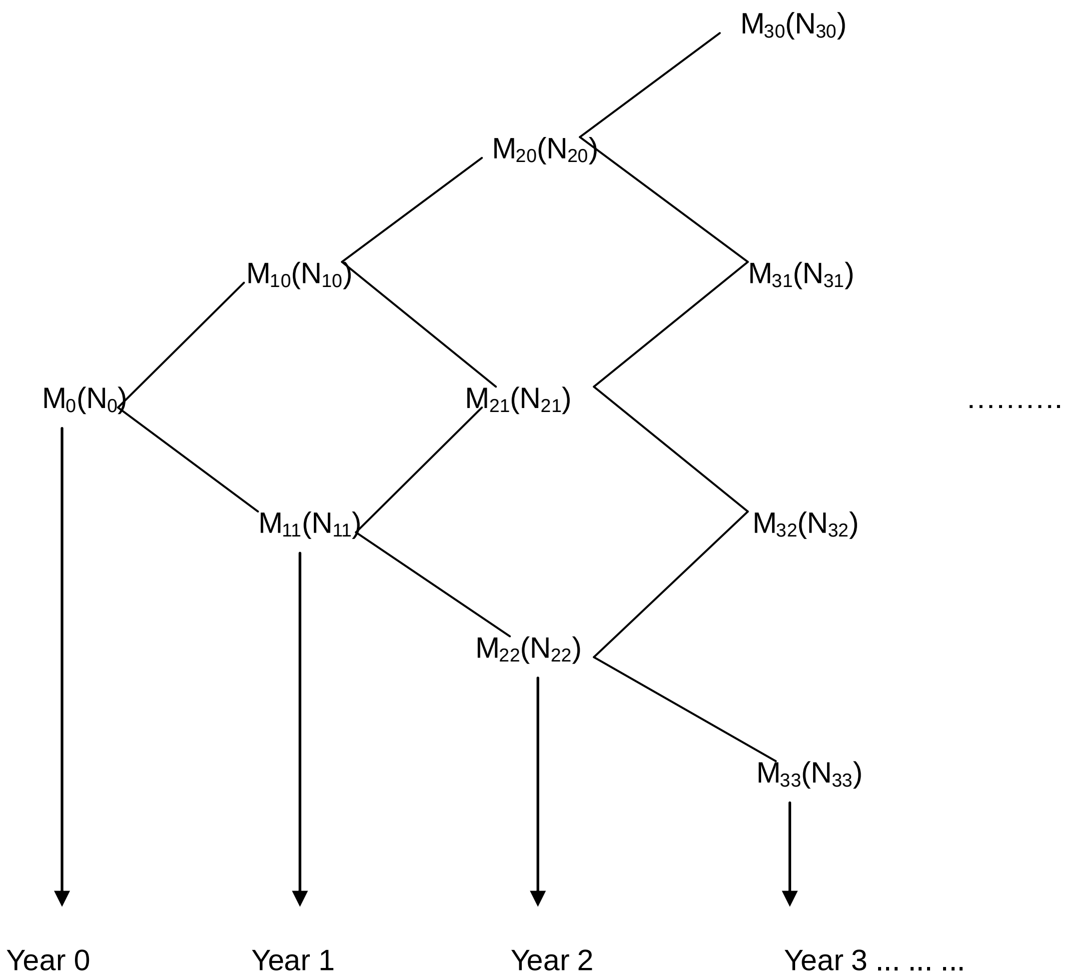

Figure 4.8 Ship price movement binominal model

According to the above binominal model above ,we can calculated the ship price as follows:

$M_{i，t}＝M_0u_m^{(i-t)}d_m^t（1－i\times a）$ ……(4-16)

Where: M_0＝ the new vessel price in the secondhand market

$M_{i，t}$＝ the ship price in the i year and in t phase

u = secondhand ship price amplified annually

d = secondhand ship price descended annually

a = annual depreciation rate

The ship price in demolition market price depends on the volume of scrap ships, scrap capacity and demand for scraped steel. And the volume of scrap ships in turn depends on the ship market and the type of ships. Construct the binominal price model of ship price in demolition market, the formula is as follows:

$N_{i,t} = N_0 u_n^{(i-t)} d^t$ ……(4-17)

Where: N_0 = new ship price in the demolition market

$N_{i,t}$ = the ship price in the i year, t phase

u = ship price in the demolition market amplified annually

d = ship price in the demolition market descended annually

Based on the 3 binominal pricing models above (4-6, 4-7,4-8), including the node figure X_i, means the intrinsic value of the abandonment option, we can calculate the value of abandonment real option, see equation (4-18)

$$X_{i,t} = \begin{cases} \max(M_{i,t}, N_{i,t}) - S_{i,t}, & When \max(M_{i,t}, N_{i,t}) \geq S_{i,t} \\ 0, & When \max(M_{i,t}, N_{i,t}) \leq S_{i,t} \end{cases} \quad \ldots\ldots (4\text{-}18)$$

Future more ,according to equation (5-6), we can reckon the value of the abandonment option when the ship price in i year t phase, as following:

$Y_{i,t} = [p\max(X_{i+1,t}, Y_{i+1,t}) + (1-p)\max(X_{i+1,t+1}, Y_{i+1,t+1})]/(1+r)$ …(4-19)

According the figure 5.4, we know the way to calculate value of convertible real option and abandonment real option, and this value increase the value of whole investment project.

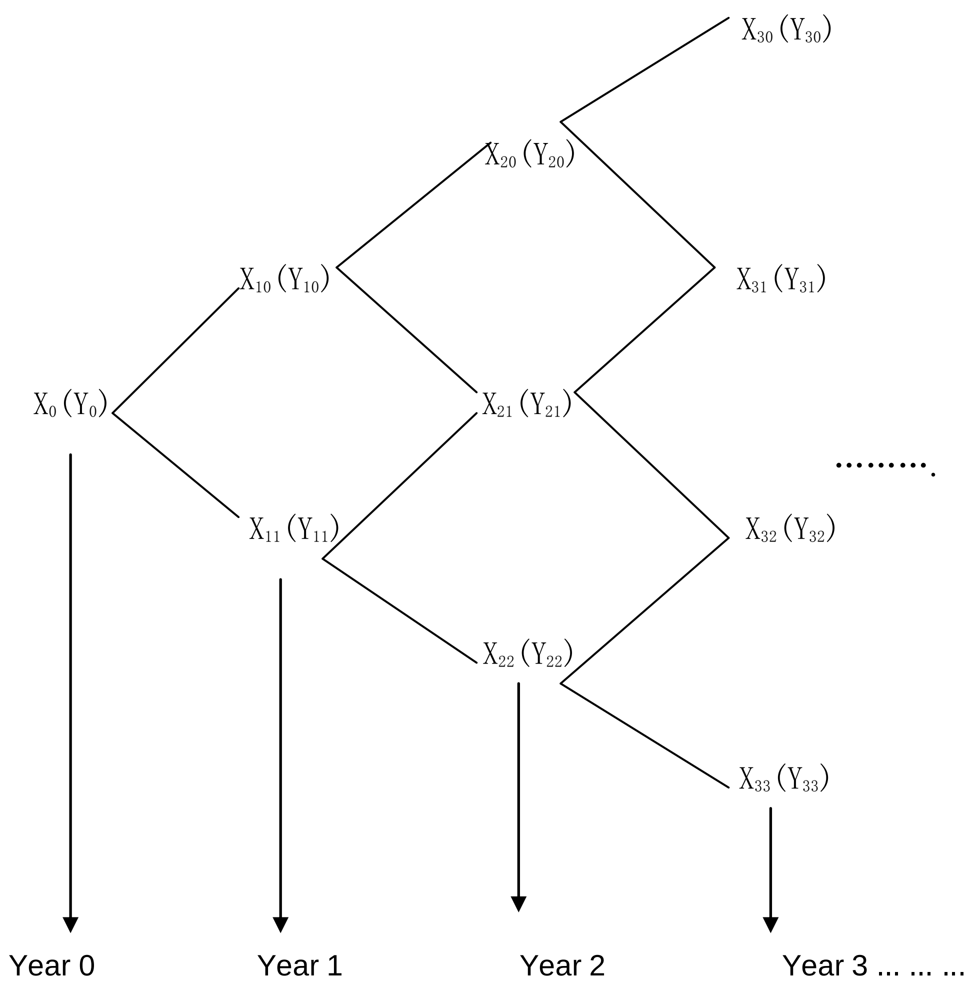

Figure 4.9 Abandonment option binominal model

4.3 Waiting option pricing model in shipping investment

The previous chapter we define the Investment opportunities timing flexibility as waiting options. As we know the future market with great uncertainty, so waiting options which significantly affect the value of investment opportunities becomes more and more important.

In this paper, we assume that the abandonment & outage flexibility happened immediately without delay when we invested, but in fact the owner is entirely possible through the exercise of delay flexibility to circumvent the freight rates uncertainty. In other words, the value of delay flexibility equals the value of the information. But the delay in investment would cause losses to the owner; the performance in this period is the favorable freight rates changes which cause the owner lose a lot of cash flow. And the key to exercise this flexibility is that whether the value-added proportion of investment projects are able to cover the loss due to delaying in investment. When present were more than the latter, the exercise of flexibility to defer investment for the ship owners is a more sensible choice, otherwise the owner should investment immediately.

If a ship investment project is to be implemented immediately, then the delay has the value to be regarded as the opportunity cost, the value of the delayed elastic performance as the opportunity cost for the project. On the contrary, if the ship owner postpones investment projects, then the delay showed the value of flexibility for ownership own this investment opportunities and gain value.

Also the value option are influenced by the freight market, the delay of investment projects alone cannot affect the freight shipping market. But when the ship-owner in non-perfect competition market, the owner's the ship investments not only influence by the shipping market but also by the behavior of competitors. In this situation the owner not only consider the risks of volatility, but also takes into account the investment strategy of rival investment strategy, in this article the consideration is perfectly competitive market, not consider the game theory under competitive market.

This paper analyzes the delay flexibility in investment, is to structure a real option approach to solve, and here called the waiting options. we assume that the feasibility of investment to the project remain unchanged within a certain period, that in this period at any point in time can execute investment option, and the owners choose to keep the decision-making based on freight rates investment timing . Accordingly, this period can be considered as a valid option to wait for the project during the waiting period in the performance of the American call option.

From the perspective of real options, the waiting option is an integral part of the project. When the owner decided to invest immediately, the waiting option equals to the value that give up this the project, then the value of the waiting option for investment projects should be listed as the opportunity cost which deduct value of the project; on the contrary, if the owner decided to delay investment, then the waiting option value should be as a increasing part of flexibility value.

In this article, we are based on the option pricing model to help determine the true value of investment project. In fact, waiting option analysis can be regarded as the selection of best timing for the ship investment choices. Shipping companies always want to join in the shipping market the lowest valley, which can maximize the return on investment, while by by waiting option pricing can model can find the best investment point, but limited space, not in-depth discussion of this issue in this article.

Chapter 5 three real options application in HB Company

5.1 Convertible option application

For example, according to the shipping market forecast analysis report, Handymax bulk carrier would have a good economic efficiency, so HB Company purchased a 30,000 dwt Handymax bulk carrier in 2007 which route is from India to North China to enlarge its carriage capacity, and the ship price was 30 million. The annual fixed costs (including crew wages, spare parts & repair costs, ship common costs and insurance expense) is 2 million, the annual transport capacity is of 2 million tons and running time is 11.5 months, the current freight rate is $ 95 / ton. According to the historical data , the possibility of freight rise and fall each are 50%, the range of rise is 20%, and a the range of descend is 20%, and the ship's economic life period is 5 years, the residual value is 3 million, the ship “closd” cost is 1.2 million and restart cost is 1.6 million, variable cost is 50 U.S. dollars / ton, the risk-free rate is 5%, in addition, there also needs to know the current charter market rate because the charter rates have high relevance with the freight rates. Assuming that the charter rate annual increase and decrease range is 10%, the possibility of charter rates rise and fall each are 50%, respectively, the current 30,000 dwt bulk carrier on the charter rate is 9.4 $/dwt per month.

According to the data and formula (4-2), (4-3) we can know:

$$F_s = K_v + (K_f - G)/Q = 50 + (200 - 120)/20 = 54\ (\$/dwt)$$

$$F_k = K_v + (K_f + H)/Q = 50 + (200 + 160)/20 = 68\ (\$/dwt)$$

This shows that, when freight rate is below 54 $/ton, the ship will be outage until the freight rate rise to 68 $ / ton. According to the freight rates, we can form binominal pricing model, as shown in Figure 5.1. Future more, t according to equation (4-4), we can construct binominal model of cash flow, as shown in Figure 5.2

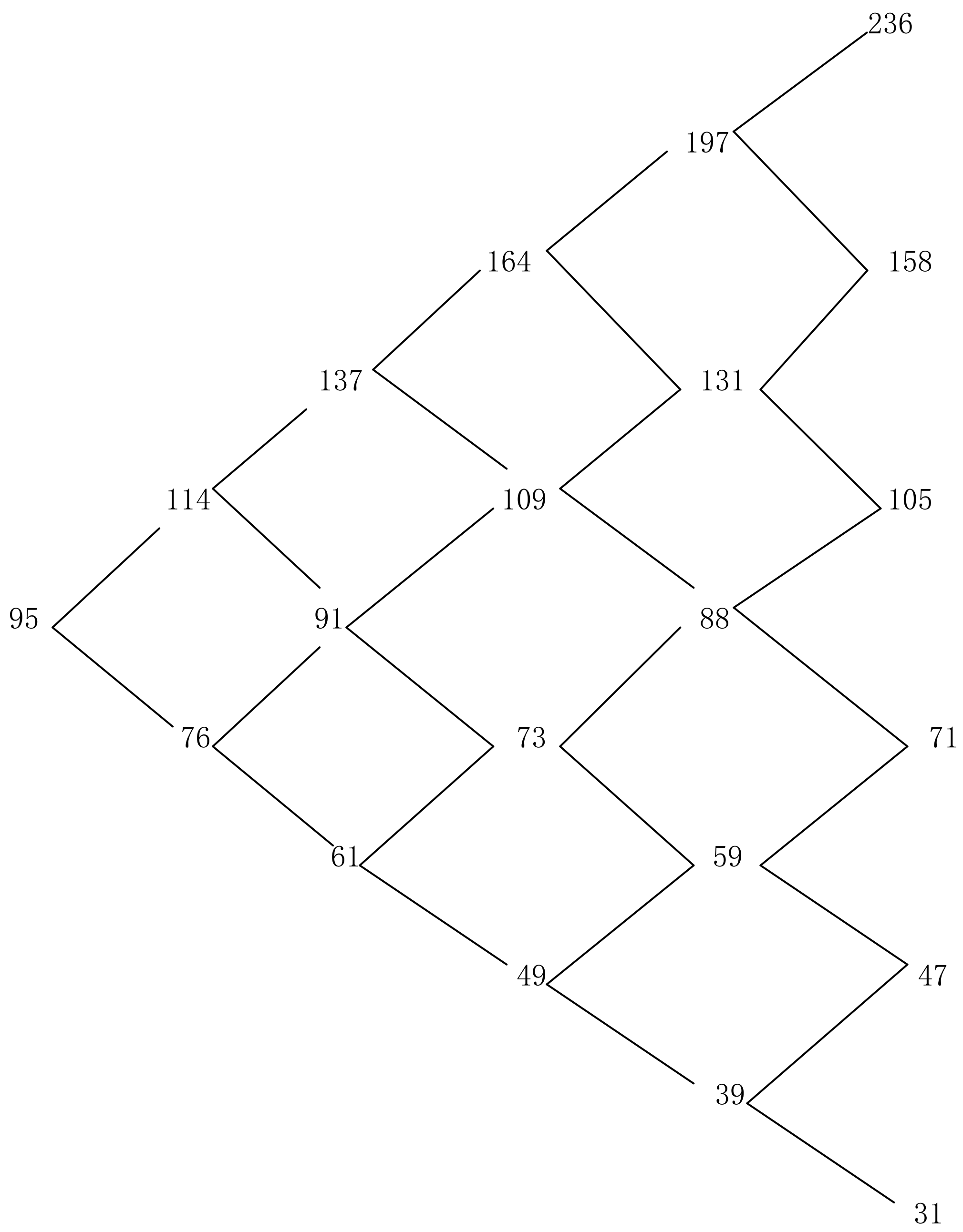

Figure 5.1 Binominal model of freight rates (Unit: USD / ton)

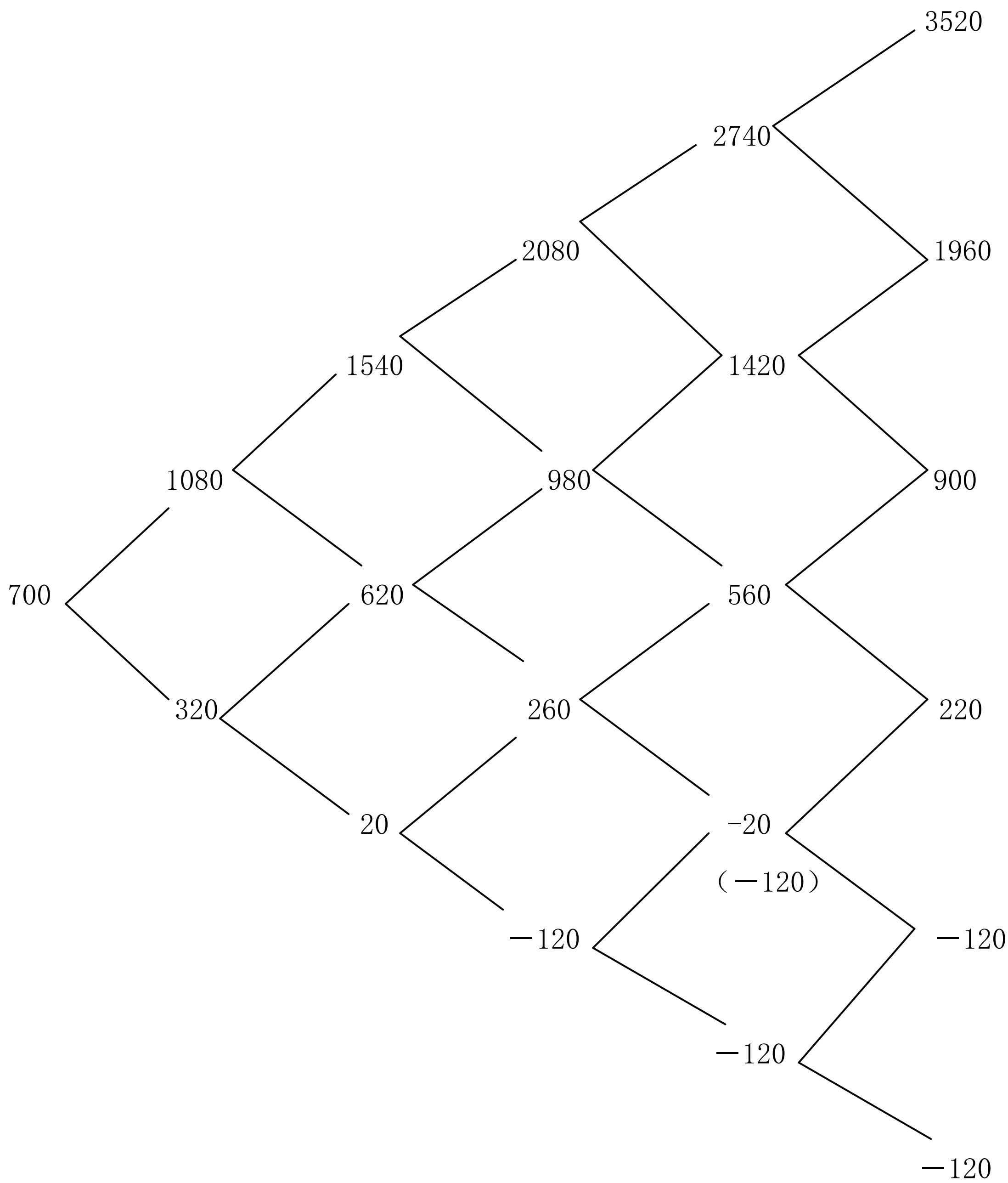

Figure 5.2 Binominal model of annual cash flow（Unit：$10000）

According to the above analysis, we can calculate the charter rate and form the binominal model as following:

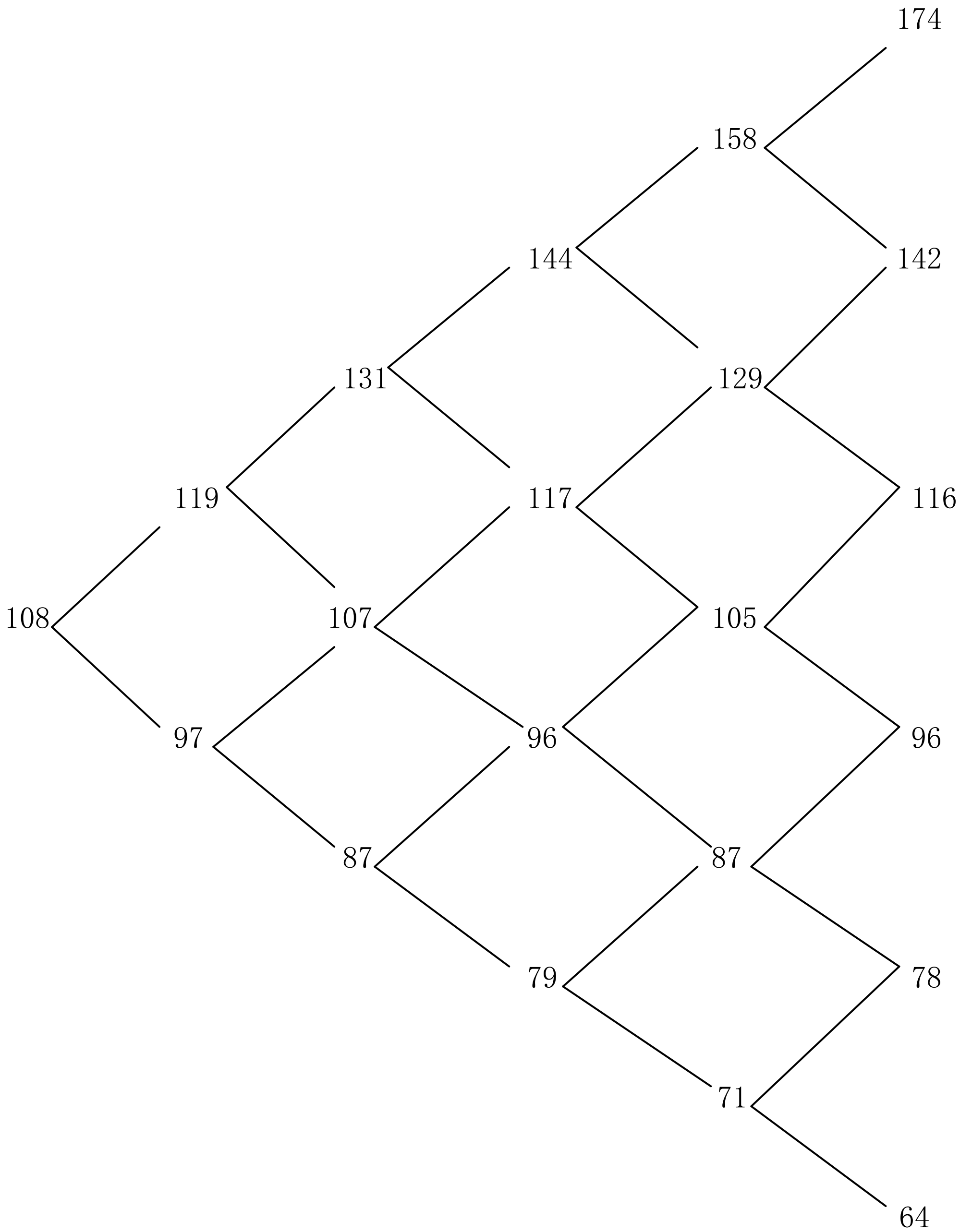

Figure5.3 Binominal model of charter rate（Unit：$/dwt per year）

HB Company has a convertible option so has the right to choose cost-effective programs, according to equation (4-9), we can form a binominal model, as shown in Figure5. 4.

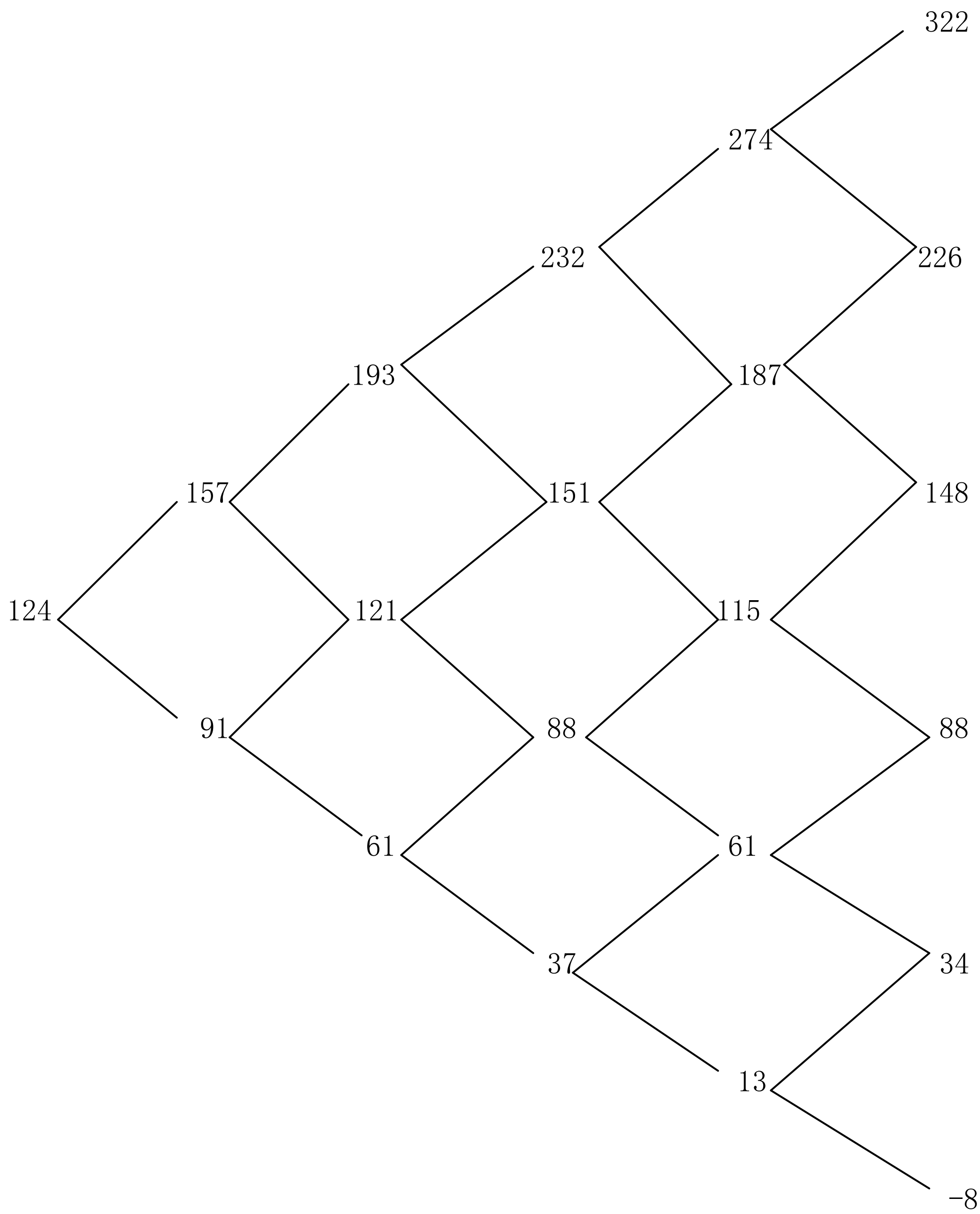

Figure5.4 Binominal model of charter hire income（Unit：$10000）

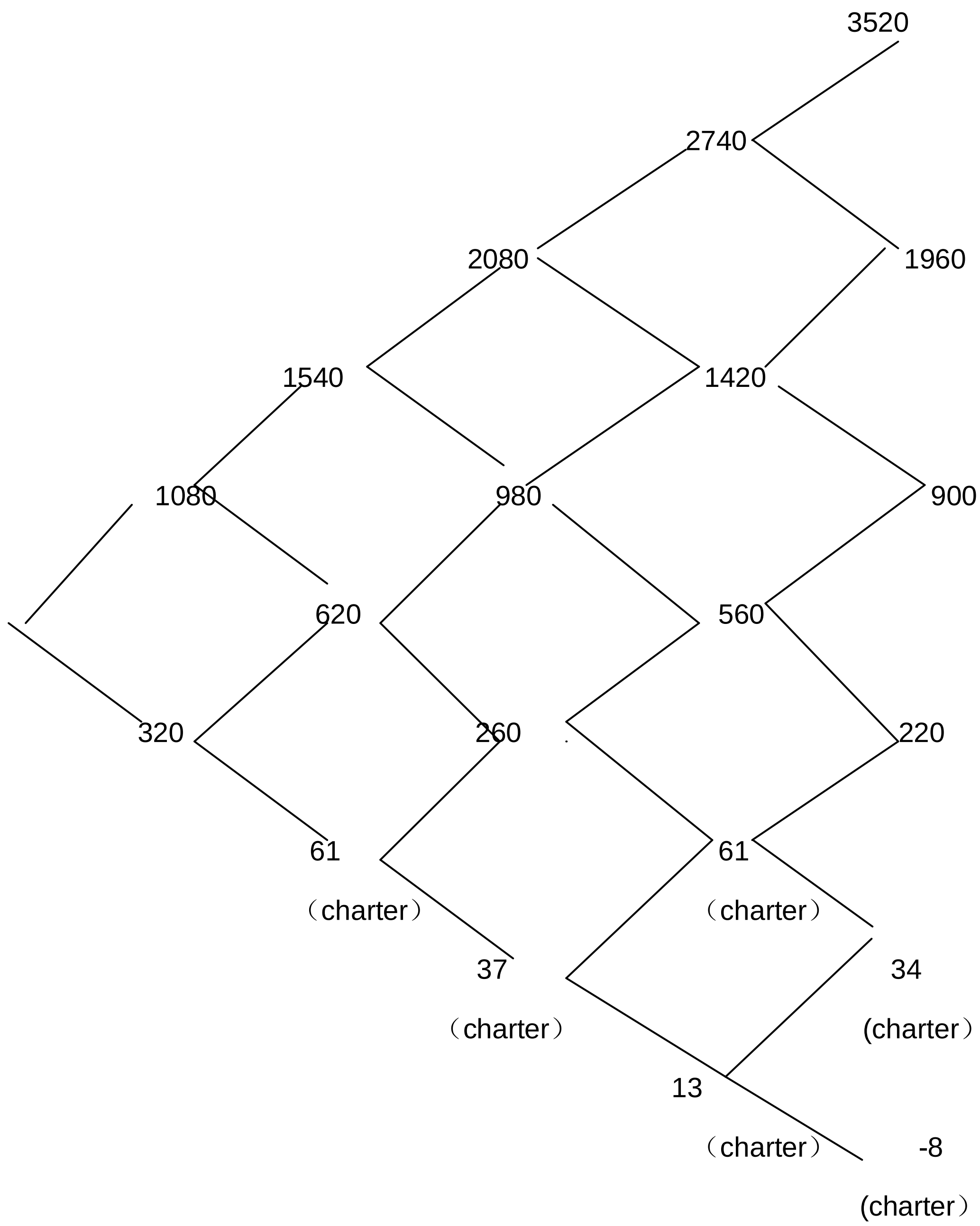

Figure5.5 Binominal model of cash flow income（Unit：$10000）

According to Figure 5.5 and equation (4-10), we can calculate the value of convertible option as following:

$$R_1 = \frac{0.5*1080+0.5*320}{1+5\%} = 667$$

$$R_2 = \frac{C_2^0*0.5^2*1540+C_2^1*0.5*0.5*620+C_2^2*0.5^2*61}{(1+5\%)^2} = 644$$

$$R_3 = \frac{C_3^0*0.5^3*2080+C_3^1*0.5^2*0.5*980+C_3^2*0.5^3*260+C_3^3*0.5^3*37}{(1+5\%)^3} = 630$$

Also:

R4＝619，R5＝604 ,so

$$V = \sum_{i=1}^{n} R_i + \frac{R}{(1+r)^n} = 667 + 644 + 630 + 619 + 604 + \frac{300}{(1+5\%)^5} = 33.99(\text{million})$$

Thus we can calculate the value of this investment project.

5.2 Abandonment option application

For the same ship, we know the ship price in second hand market is 20 million while in demolition market is 2 million, and the depreciation rate is $\frac{3000-300}{5\times 3000}\times 100\% = 18\%$, As the second-hand market and demolition market ship price have high relevance assuming ship price in second-hand market, the rate of increase and decrease is 10% per year, ship price in demolition market, the rate of increase and decrease is 5% per year, and the probability of rise and fall is 50%. Based on the above data, we can obtain the ship price in second-hand market price and demolition market as following:

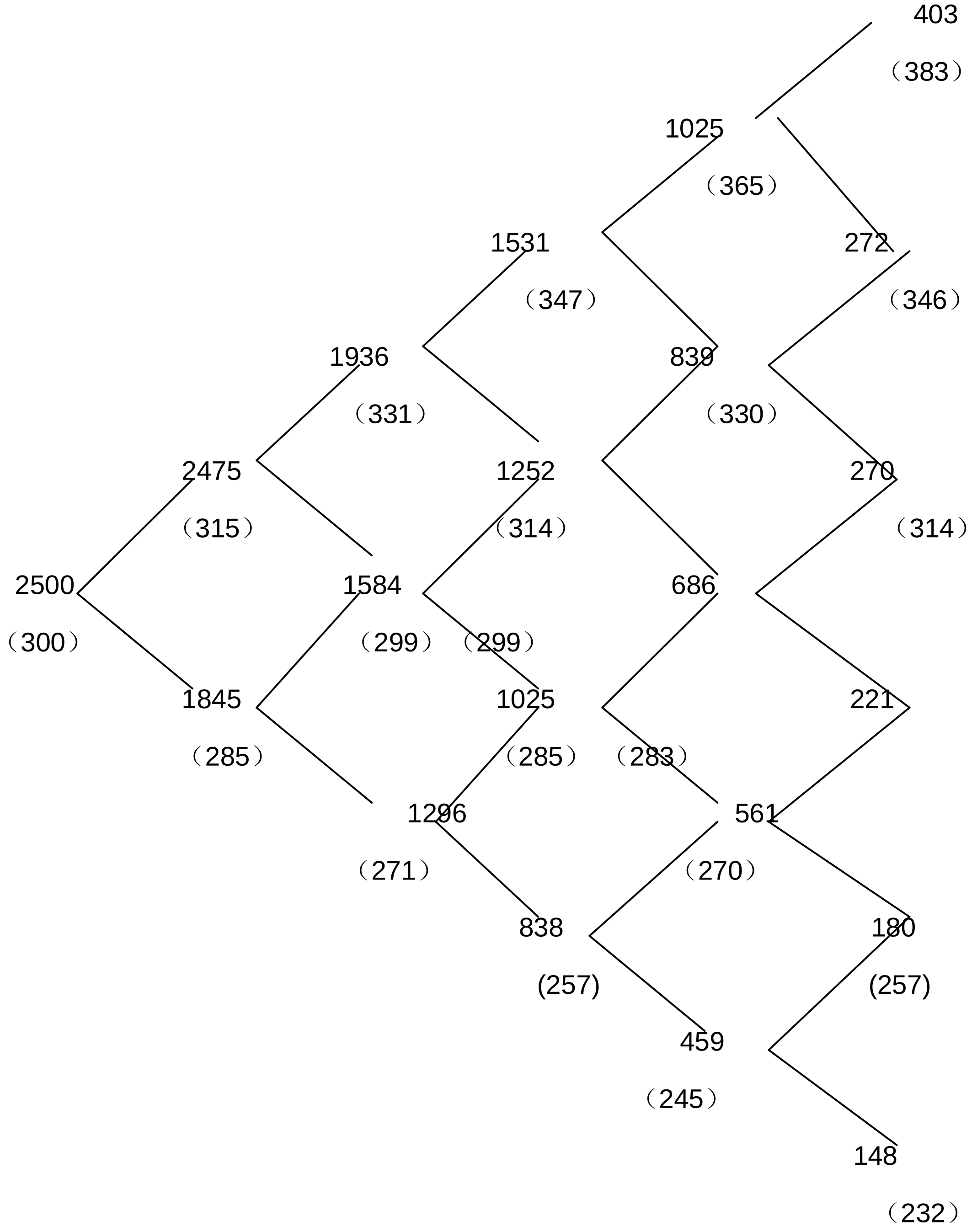

Figure5.6 Binominal model of ship price in Secondhand market and demolition market（Unit：$10000）

According to the model and equation (4-12) above, we can build the binominal model of resident value as following, and we should pay attention to the assumption that the ship scrap price equals to the resident value at the 5th year:

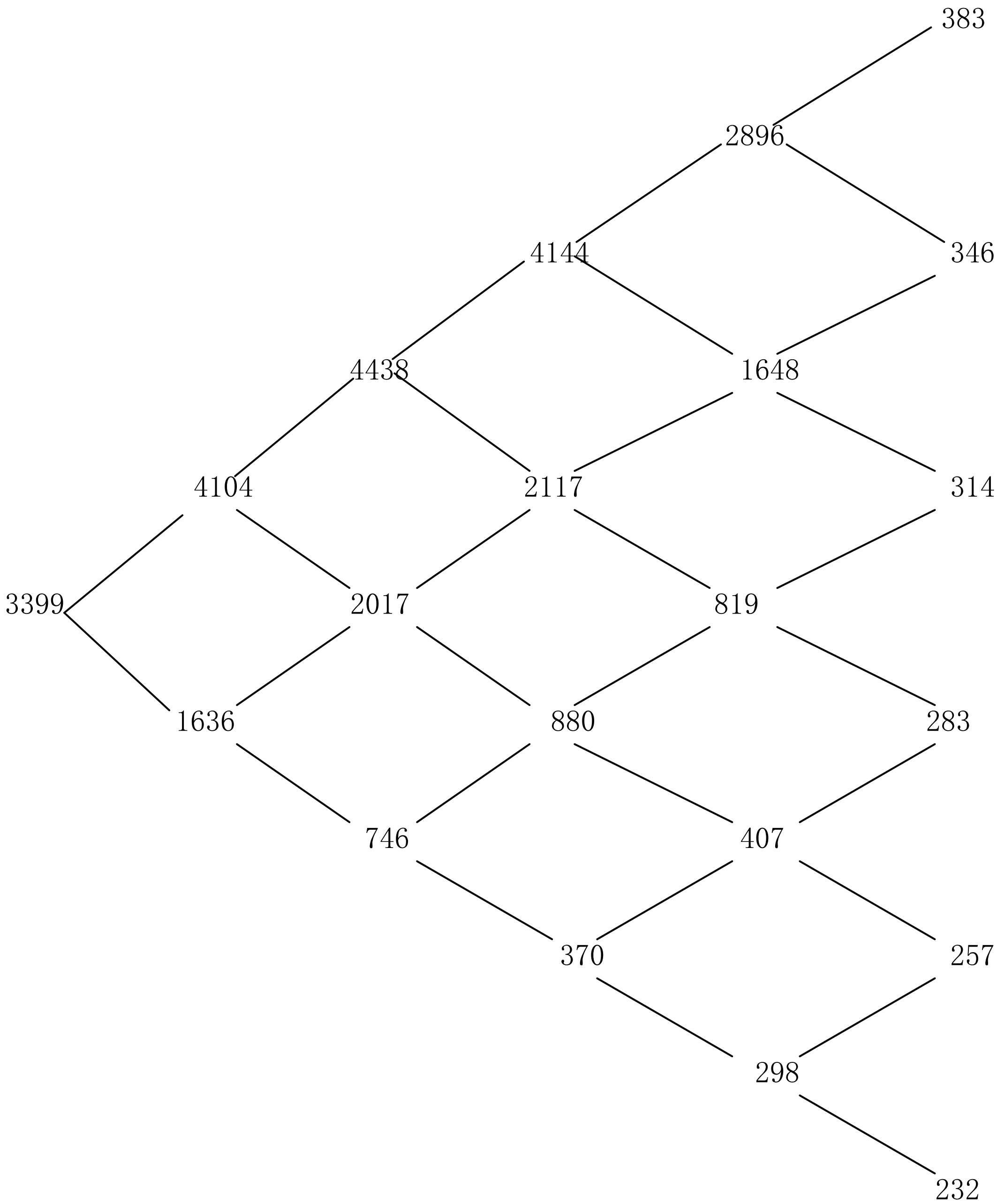

Figure5.7 Binominal model of resident value（Unit：$10000）

According to the equation (4-18), (4-19), we can calculate the value of the abandonment option as following:

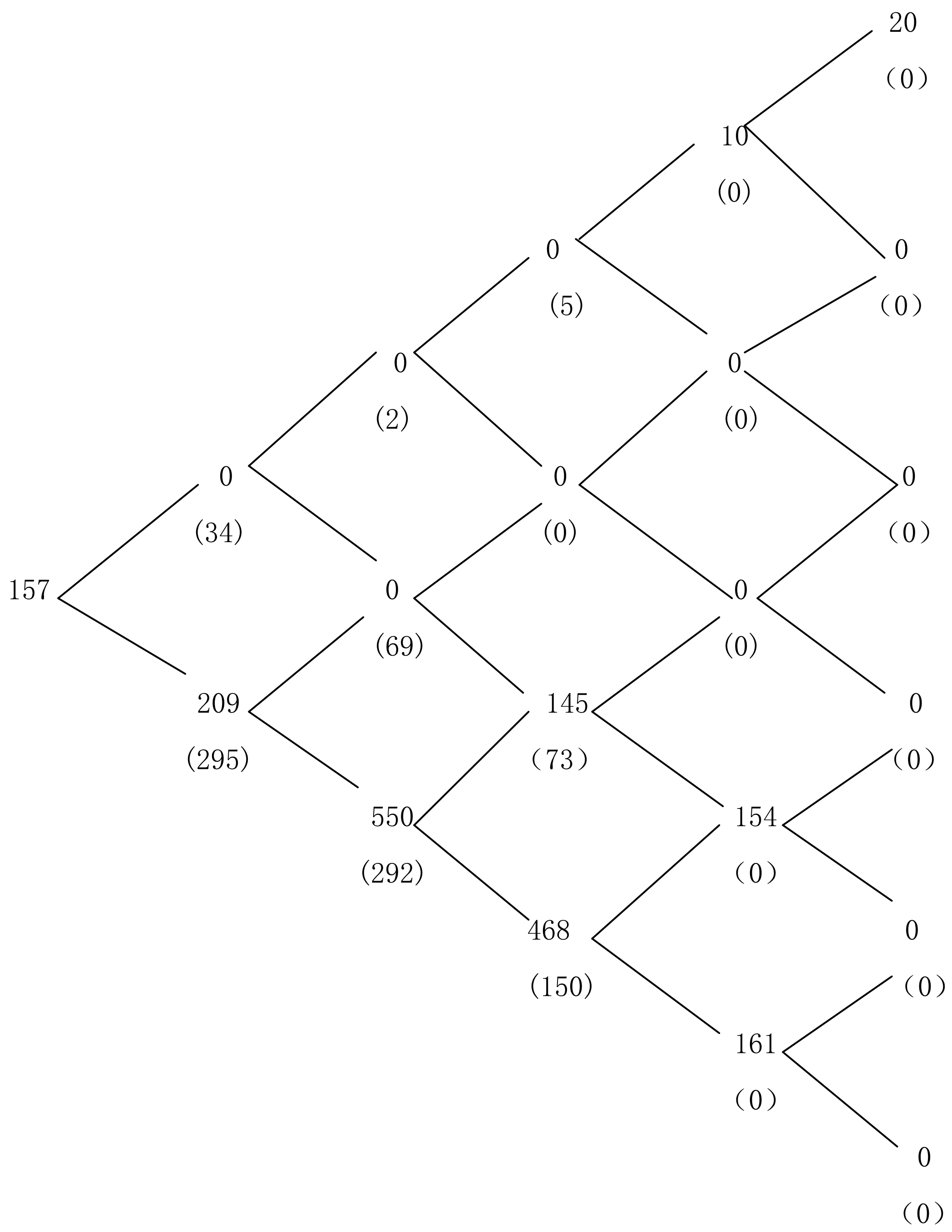

Figure5.8 binominal model of abandonment option（Unit：$10000）

By the previous introduction, we can know that the value of abandonment option is 1.57 million. This value is derived from the ship investment project, and it is an integral part of the investment project value and should be added in this project. Therefore, the real value of this investment projects, which including the value of convertible option and abandonment option, that is, the fundamental value of ship investment adjusted to 3.399 +1.57 = 35.56 million, the shipping company's net income is

35.56-30 = 5.56 million. So when HB Company considers other ship investment project, the net income should be more than 5.56 million.

5.3 Waiting option application

HB Company owned an old 29 years handy bulk carrier, due to the vessel condition , HB Company want to build up an new handy bulk carrier to instead it, and according to the previous company data and experience, forecast the annual income and expenses as follow:

A, income: 33.055 million

B, cost: 28.02 million (including fuel cost 12.71 million)

C, profit: 5.035 million

D, management costs: 0.3 million

E, financial cost (interest expense): 4.2 million

F, total profit :5.035-30-4.2- 0.3 = 0.535 million

G, net present value (risk-free rate is 7%, the ship life time is 15 years, salvage value is 10% of original value);

NPV = (total profits + depreciation + financial expenses) ×present value annuity factor + Shipping residual × present value factor - initial investment

=（0.535+3.60+4.20）×9.107＋6×0.3624－60

= 18.09 million

This is the traditional NPV (net present value) analysis for the results.

It is noteworthy that the fuel cost with of the most important uncertainty. Oil prices have been rising sharply this year, so the value of waiting option cannot be ignored.

Expected oil prices could rise in the next year about 20%, may fall about 20%, that fuel costs may rise to the S^+=12.71×(1 +20%)=15.25 million, may fall back to S^-＝ 12.71×（1－20％）＝10.17 million. In order to determine the ship's risk-neutral probability of investment projects, and here oil prices are the main factors leading to changes the freight rate, so they are relevant, therefore, which can be obtained by changes in oil prices, Risk-neutral probability $P=\frac{(1+r)s-s^{-}}{s^{+}-s^{-}}=\frac{(1+7\%)\times 1271-1017}{1525-1017}=0.675$

Respectively, the corresponding total profit is -2.005 million and 3.075 million.

Rising oil prices and the value of the context of the project were

E + = max (NPV +, 0) = max ((3.075 +3.60 +4.20) × 9.1079 +6 × 0.3624-64.2,0) = 37.02

E-= max (NPV-, 0) = max ((-2.005 +3.60 +4.20) × 9.1079 +6 × 0.3624-64.2,0) = 0

The total value of the project

$$E_0=\frac{pE^{+}+(1-p)E^{-}}{1+r}=\frac{0.675\times 37.02+0.325\times 0}{1.07}=23.354 \text{ million}$$

If using Black-Scholes pricing model,

$$E_0=N(d_1)V_0-\frac{1}{e^{RT}}N(d_2)$$

including

$$d_1=\frac{In(V_0/I)+(R+0.5\sigma^2)T}{\sigma\sqrt{T}}$$

$$d_2=\frac{In(V_0/I)+(R-0.5\sigma^2)T}{\sigma\sqrt{T}}=d_1-\sigma\sqrt{T}$$

In this case: V0 = 78.09 million, I = 60million, R = 7%, T = 1 years, σ is assumed to be 0.5, on behalf of the Black-Scholes formula into the obtained d_1=0.92.，d_2＝0.42, then the value of waiting option is E_0=27.05 million

As the NPV is also positive, indicating an immediate investment of the project is desirable. But whether using binomial pricing model or Black-Scholes pricing model the results are significantly larger than the results of NPV, indicating that investment in a year may with a higher value. Perhaps the real option pricing method used here does not affect the decision whether to invest or not, but will significantly affect the modalities of cooperation with business partners.

Chapter 6 Summary

In this article, we introduce 3 real options in shipping finance and the application in HB Company, and the real option theory application in shipping company is very scarcely seeing, most of the companies still use the tradition approaches, but the real option theory can give the investors more clear indications, Also the HB Company gain a great benefit from this process.

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