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Research on the value estimation of ship optional orders

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Research on the Value Estimation of Ship Optional Orders

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Declaration

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

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

Supervised by

Professor Zhao Gang

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Abstract

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The shipping market plays a vital role in the international trade and global economic integration, with the characteristics of large investment scale, long payback period and high risk. After the financial crisis, the contradiction between supply and demand in the shipping market was further deepened, and the global capacity was seriously over-supplied, which made the market competition more intense and severe.

As the most important means of production for the entire shipping industry, ships are often the hot spot for many researchers. The order quantity of the ships directly determines whether the shipowner and the shipyard are able to develop sustainably and healthily. In order to better adapt to the changing shipping market, the mode of optional orders like 8+4, 2+2 come into being for the benefit of ship owners and builders. This kind of mode means that the plus parts are optional clauses of adding additional orders based on those decided parts. And also the optional parts can be viewed as special options and their values can be calculated.

The main topic of this paper is to estimate and quantify the value of these ship optional orders in the method of real option analysis, while the corresponding summary and prospect are also included in the end of paper. The general work may be some primary steps in similar field but they can still be effective and significant and provide reliable ship investment suggestions for relevant parties.

Key Words: Optional Orders; Real Option Analysis; Value Estimation

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List of Abbreviation

AHP	Analytic Hierarchy Process
BDI	Baltic Dry Index
B-S	Black Scholes
DCF	Discounted Cash Flow
IRR	Internal Rate of Return
JMU	Japan Marine United
LNG	Liquified Natural Gas
NPV	Net Present Value
TEU	Twenty-foot Equivalent Unit
UNCTAD	United Nations Conference on Trade and Development

Chapter 1 Introduction

1.1. Topic Background

In 2018, global seaborne trade appeared good, which showed a 4 percent growth rate. The total volume reached 10.7 billion tons while around 410 million tons increased by the last year, nearly half of which were made of dry bulk commodities. The prospects for seaborne trade are positive and the UNCTAD is forecasting a 3.8 percent compound annual growth rate between 2018 and 2023.

According to the UNCTAD review of maritime transport in 2018, global containerized trade increased by 6.4 percent, following the historical lows of two previous years. Dry bulk cargo increased by 4.0 percent, up from 1.7 percent in 2016, while growth in crude oil shipments decelerated to 2.4 percent. During the year 2018, a total of 42 million gross tons were added to global tonnage, which equals to 3.3 percent growth rate. However, the freight rates remained a low level and the recovery is still fragile at present.

In the meantime, the modes of optional orders are widely adopted by many ship buyers and builders. I have sorted out a table of new ship building market with optional orders according to L&S report from Oct. 2018 to Mar. 2019.

No.	Type	DWT	Builder	Buyer	Price (Mill USD)	Delivery	Remark
5+5	Capesize	180,000	Waigaoqiao	Shandong Shipping	53	2020-2021	Tier III; Scrubber-Ready
4+6	Ultramax	63,500	Wuhu Shipyard	Glory Maritime International	24	2019-2020	
2+2	Newcastlemax	209,000	Hantong HI	Oldendorff Carriers	c.47	2020	Tier II
2+2	Newcastlemax	210,000	New Times	Polaris	54	2020-2021	Scrubber fitted
3+2	Newcastlemax	210,000	New Times	H Line	54	2020-2021	Scrubber fitted

Table 1 Optional Order in Dry Bulk Ships (Oct.2018- Mar.2019)

No.	Type	TEU	Builder	Buyer	Price (Mill USD)	Delivery	Remark
4+2	Bangkokmax	1,900	Huangpu Wenchong	Wan Hai Lines	26	2020	Tier II
6+2	Bangkokmax	1,900	JMU	Wan Hai Lines	26	2020	Tier II
4+4	Feeder	2,500	Jiangnan	Evergreen	28	2020	Tier II
1+1	Feeder	1,000	Daesun	Namsung Shipping	Undisc	Undisc	Scrubber fitted
8+4	Feeder	3,036	JMU	Wan Hai Lines	41	2020.1	Tier II
12+4	Feeder	2,038	Huangpu Wenchong	Wan Hai Lines	26	2021.1	Tier II
2+4	Feeder	1,800	Zhoushan Changhong	MTT Shipping	Undisc	2020	
2+2	Sub Panamax	2,500	Chenfxi	Dole	42	2020	Scrubber Fitted

Table 2 Optional Order in Container Ships (Oct.2018-Mar.2019)

No.	Type	DWT	Builder	Buyer	Price (Mill USD)	Delivery	Remark
2+2	Chemical Tanker	7200	Wuchang	Sinochem	Undisc	Undisc	Stainless steel
1+2	VLCC	300,000	DSME	Hunter Tanker AS	91	2020	Scrubber fitted
2+2+2	Chemical Tanker	19,700	Wuchang	Raffles Shipping	Undisc	Undisc	
5+4	Pulp Carrier	62,000	COSCO Shipping HI	Cosco Shipping Specialized Carriers	34	2020	
1+1	Suezmax	156,000	New Times	NGM Energy	Undisc	2020	Tier III exercised
2+1	Handy	22,000	Wuhu Shipyard	Donsotank	Undisc	2020	
2+2	Chemical Tanker	7,000	AVIC Dingheng	GEFO	Undisc	Undisc	Dual-fuel; Stainless

Table 3 Optional Order in Wet Ships (Oct.2018-Mar.2019)

No.	Type	Size	Builder	Buyer	Price (Mill USD)	Delivery	Remark
2+2	ro-pax	2700lm	CIMC Raffles	Bohai Ferry	RMB 207million	2020	
2+4	Cruise	135500-gt	SWS	CSSC Carnival; Cruise Shipping	770	2023-2024	
4+6	Tug	90t-BP	Nichols Brothers Boat Builders	Foss Maritime	Undisc	2020-2021	Tier 4
2+4	LNG	174000-cbm	DSME	BW LNG	185	2021	Dual fuel; FRS
1+1	LNG	30000-cbm	Hyundai Mipo	Knutsen	77	2021	
1+1	ro-pax	866p+200v	Jinling	TT-Line	Undisc	Undisc	Dual fuel
1+1	VLGC	86000-cbm	Jiangnan	Wide Shine	Undisc	Undisc	Tier Ⅲ; LPG-Diesel powered
2+1+1	PCTC	3600v	Jiangnan	UECC	Undisc	Undisc	LNG+Hybrid

Table 4 Optional Order in Gas Offshore & Other Ships (Oct.2018-Mar.2019)

It is apparent that the mode of optional order is widely applied in ship investment decisions, including various types of ships. Therefore, it is vital to solve such a problem relating to the estimation of option value for ship builders and buyers, which will be analyzed based on a recent and real case in the following content.

1.2. Problem Statement

Ship investment has the characteristic of strong uncertainty, which means the investment risk is greater. The major reasons for high risks are because of the volatility of the shipping market, large amount of investment and long payback period.

Optional order can be a good way to decrease the uncertainty and minimize the risks. The shipping company has the right to choose which option to exercise or abandon. The invisible cost of optional order is actually included in the first stage of the investment. On the one hand, the shipping company can choose longer-term options in the contract or operate new ships on routes with large market fluctuations, so as to actively increase the uncertainty of investment and increase the value of optional orders. On the other hand, the shipping company can also passively adjust their investment strategy and avoid losses according to the change of market and operation.

In a word, it is practical to do some researches on the estimation of option values of ship optional orders. Roughly, the shipping market, financing market and the management of shipping company are major three influencing factors, which directly or indirectly affect the five variables, that is the execution price, the expiration time, the risk-free rate, the underlying asset value and its volatility, which determine the value of options.

1.3. Research Methods

By applying the idea of real option theory and combining the uncertainty of shipping market and the flexible management strategy of shipping companies, this paper will estimate the value of optional orders in the new ship building contract. Firstly, according to the distribution of recent freight rates, a reliable option pricing model will be established. What's more, in order to figure out the underlying asset and its volatility, I will choose the method of Monte Carlo simulation. Through the B-S option pricing model, the real option value of optional order will be calculated. Finally, from the analysis of simulation results, I will draw the relevant conclusion, and the summary and prospect will be further pointed out at the end of the paper.

1.4. Organization

Chapter 2 makes a summary of prior studies and research status in the field of ship investment decision and real option theory. Chapter 3 describes real option analysis and presents a theoretical model, which is further explained in characteristics, types, methods and a relevant case. Chapter 4 makes a concrete analysis on ship optional order while Chapter 5 builds a reliable model in details along with distribution and calculation. Chapter 6 presents a general summary and conclusion of the thesis, following with the prospect of this direction for future researchers.

Chapter 2 Literature Review

2.1. Ship Investment Decision

The research of ship investment decision-making began from 1980s. At that time, the method of evaluating the ship investment project was mainly to conduct profit analysis of the project through financial indicators. Later, with the growing questioning of the evaluation effect of the financial evaluation method and the emergence of the new decision theory, the ship investment decision-making method was developing in diversified directions, and more and more decision-making methods were applied to the research in this field, such as analytic hierarchy process, multi-objective programming approach, real option theory and etc.

Traditional financial evaluation method, like British ship finance expert Sloggett (1984), introduces how to apply NPV, IRR and other financial indicators to evaluate the economic benefits of investing in new ships, and the use of NPV and IRR indicators in different situations. It also made a deep discussion on factors such as depreciation, inflation and financing methods in the impact of investment evaluation.

AHP: Huang Weizhong (2000) proposed an analytic hierarchy process based on entropy weight to solve the comprehensive evaluation problem of multiple indicators and multiple schemes in ship investment decision-making. The entropy weight determined by this method is obtained by combining the objective weight determined by entropy and the subjective weight given in the analytic hierarchy process, which can overcome the shortcomings of the analytic hierarchy process whose weight is completely determined by subjective factors.

Multi-objective programming method: From the perspective of shipping companies, Jia Haiying (2001) made a systematic introduction to the issue of ship investment decision-making, including investment environment, financing methods and financing risks. She used the multi-objective programming method in operations research to establish a multi-objective programming model for ship investment decision-making. In the aspects of economic effects of ship operation, decision utility value, opportunity loss, etc., the different characteristics of various investment plans were compared and selected in her master dissertation.

2.2. Real Option Theory

2.2.1. Early Real Option Studies

The option pricing theory was first proposed by French mathematician Louis Bachelier in his doctoral thesis "Speculation Theory" in 1900, who was therefore called the ancestor of option pricing theory. The model proposed in his paper laid a solid foundation for option pricing theory.

In the 1970s, the famous B-S option pricing theory was formed, marking the maturity of option theory. It was first proposed by Black and Scholes (1973) in a classic paper published in 1973, and then promoted and refined by Merton, eventually forming Black-Scholes option pricing theory, which greatly promoted the development of modern finance. Merton (1977) and Scholes and others also won the 1997 Nobel Prize in Economics for their pioneering work in this area and for their outstanding contribution to the financial industry.

At the beginning of the option pricing theory, scholars found that the theory could play an important guiding role in the investment of physical assets and also have a broad application prospect. Myers (1977) first introduced the idea of options into the field of substantive investment, and he believed that management flexibility and financial options have the same characteristics. It was the first time that he proposed to consider investment opportunities as growth options and created a new term “real options” which aptly expressed the applicability and importance of option pricing theory in terms of physical investment. Later, after the development made by scholars such as Brennan (1985), Schwartz, McDonald and Siegel, option pricing theory had attracted extensive attention and a large number of applied researches had been made in the field of project investment, which had supplemented and improved the traditional net present value method. At present, the real option theory has been widely used in project investment evaluation in many fields, such as natural resource development and land resource development. For example, Nga-Na Leung (2007) used real option theory to establish a valuation model for acquisition of a property with excessive land which can be potentially converted into a new development. Daniel Jacob Landman (2017) used it to value the transferability of excess railcars just as a European put option. The effectiveness and practicability of this method have been well recognized by operators and investment experts.

2.2.2. Real Option Theory in Shipping

In the field of shipping industry, real option theory is widely adopted in the process of analysis. Bendall (2005) used the real option method to conduct an empirical analysis of the selection of container ships on the Singapore-Klang-Penang route, by doing which, he obtained the optimal investment plan. The paper also compared the results of real option method with those of the traditional NPV method and pointed out the similarities and differences between the two methods in ship investment decision-making. In 2007, the author further deepened and broadened the research contents, applying the conversion option and compound option theory to the value evaluation of ship investment projects. Shao Ruiqing (2003) applied the real option method to the ship investment decision-making for the first time, and he used the binary tree model to study the single option existing in the ship investment decision-making. Alizadah and Nomikos (2009) offered a comprehensive summary on derivatives and real options in shipping, who also made a concrete description on the shipping derivative market. Examples are provided for options to abandon, expand, contract, lay-up, switch, delay investment. Mao Minmin (2011) used the B-S model to evaluate the single option existing in the ship investment decision. Siqin, Bin, and Jinhai (2013) used Spence-Dixit real option model to decide on when shipping companies should enter and exit the market according to the timing of investment and trigger prices.

In recent five years, more relevant theses have made great contribution to the real option theory in the shipping industry. Michele Acciaro.A(2014) presented an analysis of the options available to ship owners taking into account the value of deferred investment decision compared to the advantages obtainable from the exploitation of fuel price differentials. His model shows that there is a trade-off between low LNG prices and LNG capital expenditures. Zhang Shengze (2015) selected the BDI index from 1999 to 2014 to do empirical research and established a fractal option pricing model to calculate the risk value of ship investment. Compared with the traditional B-S pricing model, it is beneficial to lift the ship investment decision of domestic shipping companies. With more accuracy, thereby it decreased the probability of irrational and inappropriate investment. Rau and Spinler (2016) established a real option model to decide on optimal vessel capacity within the container industry under oligopolistic competition. It shows that competitive intensity, number of players, volatility, fuel-efficiency, lead time, and cost, which are influential factors from the results, all affect the optimal capacity. Wei Lili (2017) combined the real option theory and fuzzy theory to build a trinomial tree model in order to fully consider the flexibility and uncertainty of the option value in the process of ship investment, making the decision more efficiently and providing a different solution of uncertainty. JingboYin, Yijie Wu, and Linjun Lu (2019) investigated liner companies' timing of investment and sealing up container ships based on real option theory, who also built a Dixit model to test on the data of a 9000 TEU container ship on Far East-Europe route, with the result being positive comparing to the number of ship orders.

To supplement the integrity and reliability of real option theory, there are some articles that have made great contributions. George N. Dikos ·Dimitrios D. Thomakos (2010) presented an industry equilibrium framework for testing real option hypothesis with aggregate data, with uncertainty and irreversibility, in which investment cases relate to new ship orders in the oil tanker industry. Alex Lennart Marten (2009) presented a series of three essays that examined applications and computational issues associated with the use of stochastic optimal control modeling in the field of economics.

Chapter 3 Real Option Analysis

3.1. Introduction

Myers (1977) first proposed the real option theory, suggesting that the value of investment projects not only comes from the cash flow caused by investment behavior, but also comes from its own uncertainty. He pointed out that the investment value should be composed of two parts: the net present value of income in the future and the option value of project investment opportunity. In the real option theory, the stochastic process is used to simulate and determine the uncertainty value caused by the change of the project environment. The real option theory also establishes a more accurate and logical evaluation system and makes up for the defects of net present value method.

The real option is derived from the financial option, whose definition is a contract that gives its holder the right to buy or sell some certain financial products at a pre-agreed price for a certain period of time. The subject matter of real options is usually an investment in kind. Referring to financial related theories, the theoretical analysis of real options usually includes these following parameters:

(1) Underlying Asset. It is the assets involved in the exercise of the option holders' rights. The assets under the investment of the ship are usually the ships in operation.

(2) Exercise Price. It is the price of the assets subject to sale and purchase recognized by both parties in the contract. Since the price has been determined at the time of signing the contract, it won't change with the fluctuation of the market value of the underlying assets.

(3) Expiration Date. It is the expiration date specified in the option contract or the date on which the holder has the rights to exercise the option.

(4) Option Premium. It is the price of an option contract, which is the fee paid by the option holder to obtain such an option.

Option on a Stock	**Real Option on Investment**
Current value of a stock	Gross PV of expected cash flows
Exercise price	Investment cost
Time to expiration	Time until opportunity disappears
Stock value uncertainty	Project value uncertainty
Riskless interest rate	Riskless interest rate

Table 5 Financial Options and Real Options (Trigeorgis 1996)

The real option holder can flexibly adjust and transform his investment option according to the fluctuation of the underlying asset market and pre-judgment of the investment environment during the option period. When there are many uncertainties in investment projects, traditional investment decision-making methods can't be a proper choice. At this time, real options can be used as an appropriate tool, which provides a scientific theoretical basis for investment decision-making.

3.2. Characteristics

Real options and financial options have similar characteristics in the field of financial investment, but real options have some unique characteristics in the field of real investment.

(1) Not referential. When the financial option is traded, the subject matter is the stock in the market, by comparing which, the decision makers can have certain references. The subject matter of the real option is generally the cash flow of the investment project, which has no reference to compare especially in venture capital.

(2) Non-transactional. The biggest difference between real options and financial options lies in their non-tradability in the market. Real options cannot be traded in the markets like financial options. Even assets that are subject to real options, such as production equipment and patents, cannot be fully traded in the market.

(3) Longer execution period and larger option value. The settlement period of financial market is generally several months, but some are a few weeks while some can be a few weeks. The lifespan of investment projects is generally very long, due to which, the uncertainty during the lifespan, the flexible strategy brought by uncertainty, and the value of real options will all increase. Therefore, the value of general real options is relatively larger.

(4) Non-monopolization. Real options are often shared compared to financial options. Companies with real options are difficult to be alike those with financial options, for they decide whether to exercise options or not according to their own wishes. Under general circumstances, many different companies will have the same option, and they will seize the opportunity to master the option as much as possible. The corresponding reactions of different corporate competitors contribute to the result that option can’t be used freely. However, in the process of many investment opportunities, there may be non-monopolization in real options.

(5) Emphasis on opportunism. Real options emphasize flexible decision-making during the investment project lifespan, such as expanding the business when it is the booming market or suspending and even withdrawing from the market when it is depressed. The flexibility of management is well reflected in the investment project lifespan and the value of real options is also reflected.

(6) The interaction between single options and compound options. The compound nature of real options makes it more difficult to master than general financial options, mainly because that an investment project has many interrelated, interacting, and independent real options during its lifespan.

3.3. Types

According to the different content of options in the investment project, real options are divided into the following six types:

(1) Deferment options: When the project faces greater uncertainty, the option holder may choose to postpone the original investment plan to avoid the risk. Before a decision maker makes an investment, he or she usually conducts a more comprehensive investment feasibility analysis. When the investment project starts to be exercised, it will cause great losses if the investment is to be recovered. To circumvent this loss, decision makers will generally delay investment plans until they have known information well, so as to cut current uncertainty and then resume the investment process.

(2) Expansion options: Option holders have the right to expand the scale of investment projects in the future, in other words, if the investment prospect is optimistic, decision makers can choose to exercise expansion options and expand the scale of operations to obtain more profits, while if the market prospect is not so good, investors can choose to abandon their expansion, that is because expanding options will leave investors the opportunity to increase future returns.

(3) Shrinkage options: Shrinkage options are similar to expansion options, that is to say, when the market prospect is pessimistic, the option holder can reduce the investment scale within the agreed time and minimize the possible losses, and when the market prospect performs good, the option holder has the same right to abandon the shrinkage option that he owns. Shrinkage option can help its holders avoid the possibility of losses, even though there is a high risk in the investment projects.

(4) Abandon options: When the market environment is extremely unfriendly to invest and when the project's cash income is lower than the investment cost, the option holder may choose to abandon the operation of the project to reduce losses.

(5) Conversion options: In the investment operation of the project, the manager can change the investment strategy at any time according to the current market situation and his own expectations about the future. Once the conversion is decided, the conversion option will start to work.

(6) Growth options: Once the investors starting to take part in the initial investment, the company can acquire new investment opportunities and broad its development space during the project operation period. When a company entering a new investment field, the net cash flow generated by the project itself is difficult to evaluate the value of the project itself. The net present value of the project is relatively low or even negative, but it provides the opportunity for future growth of the project value. At this time, there are growth options.

3.4. Theory and Methods of Real Option Pricing

The pricing basis of real options is similar to financial options, mainly including the following three theoretical foundations.

(1) No-arbitrage equilibrium theory. Arbitrage, as the definition of Wikipedia, is the practice of taking advantage of a price difference between two or more markets. By striking a combination of matching deals to capitalize upon the imbalance, the profit is the difference between the market prices. Naturally, when there is an imbalance between supply and demand in the market, there will be arbitrage opportunities. Therefore, the characteristics of financial markets determine that it is very convenient and fast to implement arbitrage in financial markets. But this convenience is also destined to be very short-lived, that is because once there is an arbitrage opportunity, investors will implement arbitrage behavior, which will lead to the reversal of the market supply and demand relationship, and finally the market will quickly return to equilibrium and reach no-arbitrage equilibrium. Therefore, based on this characteristic of supply and demand, the arbitrage-free principle is used for real option theory.

(2) Perfect and efficient market hypothesis: It is assumed that the market is perfect, all buyers and sellers in the market can fully grasp the market information, and each of the uncertain factors can be traded in the corresponding market. It also assumes that the balance between supply and demand in the market is unique, in other words, there is no arbitrage equilibrium point. The perfect assumption guarantees that the unique asset price can be obtained under the risk neutral pricing principle. The efficient hypothesis of the market assumes that the information flow in the stock market is smooth and unobstructed, and a certain information can be quickly known by traders in the market, which lead to changes in the price of financial assets which, at this time, can fully and effectively reflect all market information, with the market at this time being an efficient one.

(3) Risk neutrality principle: Risk neutrality is relative to risk preference and risk aversion. Although in the real world, decision makers have different preferences for risk, when there is arbitrage opportunity in the market, no matter what kind of attitudes, decision-makers will implement arbitrage behavior. The behavior of decision-makers to seize arbitrage opportunities makes the positive and negative effects on option value due to risk preferences cancel each other out. Therefore, the market equilibrium price after arbitrage offset has nothing to do with the attitudes of decision makers. At the same time, investors in risk-neutral markets do not have compensation requirements for their own risks, and the expected rate of return is a risk-free one. In summary, the market risk is assumed to be neutral in financial asset pricing.

As for the method of pricing, because real options are derived from financial options, the pricing method of real option can refer to the pricing method of financial options. However, from the financial market to the real investment field, the volatility of the underlying assets makes the calculation method of real options more complicated, with the general idea of remaining basically consistent. Currently, there are two pricing methods of common options.

3.4.1. Binary Tree Option Pricing Model

The binary tree model was derived by Cox, Ross, and Rubinstein (1979), who opened up new ideas for the calculation of option values of underlying assets subject to non-normal distribution, which considers that the underlying asset is in a market with risk neutrality and complete information, and investors are not required to compensate for the transaction. The basic idea is to discretize the continuous investment process, divide the investment process into thousands of time intervals, and think that there are only two possible changes in the value of the underlying asset in any very tiny time interval: upward fluctuations and downward fluctuations.

In the binary tree model, μ is the option value ascending factor, which represents the multiple of the upward fluctuation of the underlying asset value, d is the descending factor, which represents the multiple of the downward fluctuation of the underlying asset value, and *t* represents the time node. The initial value of the underlying asset is *S*, and the option value at the beginning of the corresponding underlying asset is *f*. We suppose that the value of underlying asset rises to S_{μ}, with the probability of *P* in a very tiny time interval(Δt), and the option price at this time is F_{μ}. At the time interval(Δt), the price falls to S_d with the probability of (*1-P*), where the option price is F_d now. Figure 3.1 shows the multi-period binary tree model.

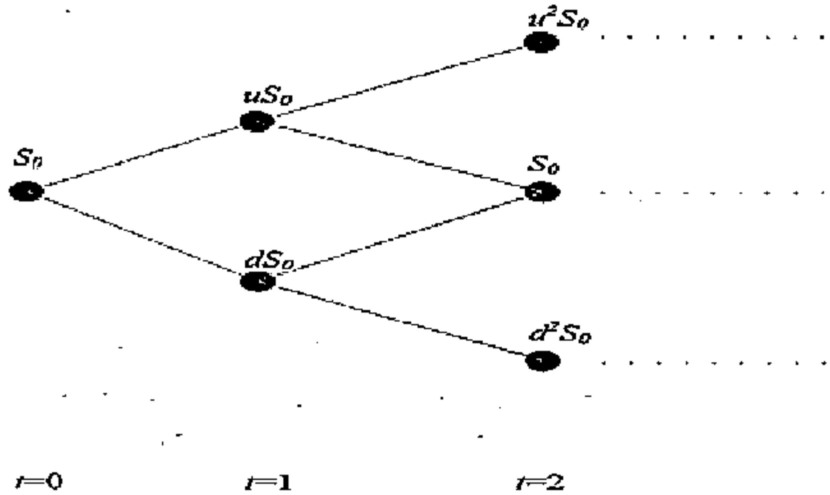

Figure 1 The Binary Tree Model

According to a study by John, Cox (1979), in a risk-neutral world, the loss of buying a share stock should be the same as the surplus to sell the same number of shares. Therefore, regardless of how the underlying asset price changes, the effective end of the option is

$$\Delta \cdot S_u - f_u = \Delta \cdot S_d - f_d \quad (3.1)$$

Therefore, the calculation formula of the number of shares(Δ) is

$$\Delta = \frac{f_u - f_d}{S_u - S_d} \quad (3.2)$$

According to the principle of no-arbitrage equilibrium, the option value of the portfolio satisfies the following formula

$$\Delta \cdot S \cdot f = e^{-r\Delta t}(\Delta \cdot S_u - f_u) = e^{-r\Delta t}(\Delta \cdot S_d - f_d) \quad (3.3)$$

Combining the formula 3.2 and 3.3, we can get the value of single-term option

$$f = e^{-r\Delta t}[Pf_u + (1-P)f_d] \quad (3.4)$$

Among these factors, *r* is the risk-free interest rate, and *u, d, P* meet the condition

$$\begin{cases} u = e^{\sigma\sqrt{\Delta t}} \\ d = e^{-\sigma\sqrt{\Delta t}} \\ p = \dfrac{e^{-r\Delta t} - d}{u - d} \end{cases} \quad (3.5)$$

According to the above method, the formula for calculating the N-Phase binary tree model can be summed up by using the backward induction of binary tree.

$$f = e^{-r\Delta t}\sum_{i=1}^{n}\frac{n!}{i!(n-i)!}P^i(1-P)^{n-i}\max(Su^i d^{n-i} - X, 0) \quad (3.6)$$

While *X* is the strike price of option

The binary tree model has the advantages of simple calculation and easy to understand, but at the same time, there are some shortcomings, including its simple structure and slow convergence. It assumes that there are only two modes of change in the underlying asset, which can’t fully meet the actual decision requirements, and it also assumes that the precise value of the binary tree tends to be slower, so it is necessary to segment the option validity as much as possible in order to obtain a more accurate value.

3.4.2. Black-Scholes Option Pricing Model

Unlike the binary tree model, the Black-Scholes model is used to solve the problem of determining the option value in continuous time. In fact, when the number of time intervals *n* of the binary tree model tends to be infinite (continuous subdivision), its option pricing formula under continuous time can be obtained, and this formula is approximately equal to the B-S pricing formula. Therefore, the B-S equation is a special case of the binary tree model.

The B-S pricing model is based on the following assumptions:
(1) The stock price process obeys the logarithmic normal distribution model;
(2) During the validity period of an option, the volatility variable of the risk-free interest rate and the underlying security is constant;
(3) There is no friction in the market. i.e. there is no tax and transaction costs, and all securities are highly tradable;
(4) Allow to use all the proceeds of short selling of derivative securities;
(5) The option is a European option. i.e. it cannot be implemented until the option expires;
(6) There is no chance of risk-free arbitrage;
(7) Securities trading is continuous;
(8) Investors are able to borrow at risk-free rates.

Set $V=V(S, t)$ is the option value of T at the moment, then when the option is valid at the end of T:

$$V(S, t) = (S-K)^{+}, \text{ Call Option}$$
$$\text{or } (K-S)^{+}, \text{ Put Option} \quad (3.7)$$

Where S is the underlying asset value, K is the strike price of the option.

Assuming Δ is the number of copies of the native asset, select the appropriate number of copies so that the Portfolio Π is risk-neutral within the time period $(t,t+dt)$. According to the hedging theory, in the Moment $(t+dt)$, the investment return of the combination is:

$$\frac{\Pi_{t+dt} - \Pi_t}{\Pi_t} = rd_t \quad (3.8)$$

$$\text{i.e. } dV_t - \Delta dS_t = r\Pi_t d_t = r(V_t - \Delta S_t)d_t \quad (3.9)$$

According to the above hypothesis, we establish the total value partial differential equation of the securities portfolio, which satisfies the normal distribution:

$$\frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2}+\frac{\partial V}{\partial t}+rS\frac{\partial V}{\partial S}=\mathrm{r}V(S,\mathrm{t}) \quad (3.10)$$

After substituting the formula (3.10) into formula (3.9) and further simplifying, we can get the partial differential equation (i.e. the B-S pricing equation) which can describe the change of the value of options:

$$\frac{\partial V}{\partial t}+\frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2}+rS\frac{\partial V}{\partial S}-\mathrm{r}V=0 \quad (3.11)$$

Therefore, in order to determine the value of the option in the contract validity period [*0,T*], it is necessary to solve the problem on the regional$\sum$*:{0≦S <∞,0≦t≦T}*

$$\begin{cases} \dfrac{\partial V}{\partial t}+\dfrac{1}{2}\sigma^2 S^2 \dfrac{\partial^2 V}{\partial S^2}+rS\dfrac{\partial V}{\partial S}-\mathrm{r}V=0 \\ V(S,t)=(S-K)^+, \text{ Call Option} \\ \qquad \text{or } (K-S)^+, \text{ Put Option} \end{cases} \quad (3.12)$$

Solving the equations, if options are European call option:

$$\begin{cases} V(S,t)=SN(d_1)-N(d_2)Xe^{-r} \\ d_1=\dfrac{\left[\ln(\dfrac{S}{X})+(r+\dfrac{\sigma^2}{2})T\right]}{\sigma\sqrt{T}} \\ d_2=d_1-\sigma\sqrt{T} \end{cases} \quad (3.13)$$

If options are European put option:

$$\begin{cases} V(S,t) = N(d_2)Xe^{-r} - SN(d_1) \\ d_1 = \dfrac{\left[\ln(\dfrac{S}{X}) + (r + \dfrac{\sigma^2}{2})T\right]}{\sigma\sqrt{T}} \\ d_2 = d_1 - \sigma\sqrt{T} \end{cases} \quad (3.14)$$

Although the derivation process of B-S pricing model is very complicated, the deduced formula is very convenient in use. As long as the variables in the model are determined, such as the exercise price of the option, the risk-free interest rate, the volatility rate, the option validity period, you can substitute the formula directly to obtain the option price. However, the biggest limitation of the B-S pricing model is that it is only suitable for European options. In the real investment world, most projects have American options, which can adjust their strategies at any time, and is more reflective of the flexibility of managers. Therefore, the complex derivation process and the limitation of the scope of use make the application of B-S pricing model not very extensive.

3.5. Case and Conclusion

In 2012, an oil tanker transport company A in Shanghai ordered a batch of ships for expansion. According to experts who are based on the development status of the shipping market and the ships in recent years, the construction cost of the ordered ships at that time was ¥ 80 million per ship, and the estimated service lifespan was 15 years. The use status, which estimated shipping business operating income and ship operating costs, is as follows:

(The risk-free discount rate is 12%, regardless of depreciation)

	2012	2013-2017	2018-2022	2023-2027
Income（Million ¥)		20	30	40
Operating Cost (Million ¥)		5	7	9
Capital Cost (Million ¥)	80			

Table 6 The Operating Income and Cost of Shipping Company A

And the company is preparing to invest an additional 150 million yuan in the development of another route after 5 years. It is expected that the probability of good return after route development is 0.6. If it is a good return, we will get 60 million yuan per year after 5 years. If it is a bad return, we will get 28 million yuan per year. Let's analyze the feasibility and income of this investment according to the following decision tree.

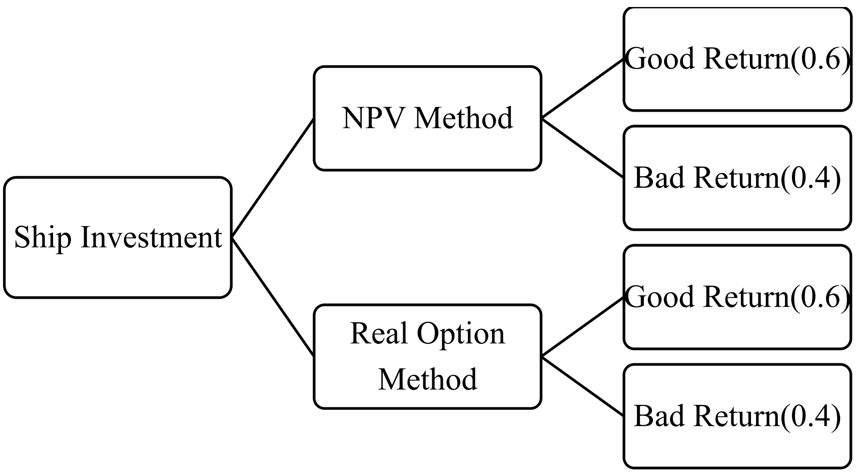

Figure 2 The Decision Tree of Ship Investment

3.5.1. NPV Method

Each cash inflow/outflow is discounted back to its present value (PV). Therefore, NPV is the sum of all terms and minus the initial investment.

$$NPV = \sum PV - C = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t} - C \qquad (3.15)$$

PV: the present value of cash flow

t: the time of the cash flow

i: the discount rate, i.e. the return that could be earned per unit of time on an investment with similar risk

R_t: the net cash flow at time t

C: the initial investment

(1) Good Return

$$C_1=80; \quad C_2=150*\frac{1}{(1+0.12)^5}=85.11$$

$$C_3=5*\sum_{t=1}^{5}\frac{1}{(1+0.12)^t}+7*\sum_{t=5}^{10}\frac{1}{(1+0.12)^t}+9*\sum_{t=10}^{15}\frac{1}{(1+0.12)^t}=42.79$$

$$C= C_1 + C_2 + C_3 =207.90$$

$$\sum PV_1=20*\sum_{t=1}^{5}\frac{1}{(1+0.12)^t}+60*\sum_{t=5}^{15}\frac{1}{(1+0.12)^t}=264.47$$

(2) Bad Return

$$C= C_1 + C_2 + C_3 =207.90$$

$$\sum PV_2=20*\sum_{t=1}^{5}\frac{1}{(1+0.12)^t}+28*\sum_{t=5}^{15}\frac{1}{(1+0.12)^t}=161.87$$

Considering the probability of return of route development, we can get NPV=0.6*(264.47-207.90) +0.4*(161.87-207.90) = 15.53 Million yuan

3.5.2. The Real Option Method

Due to the initial investment of 80 million yuan in the first year, the company A has obtained an investment of 150 million yuan after 5 years, so as to complete the ship investment on another route. The target asset of the growth option is the value *X* after the completion of the investment, whose exercise price is 150 million yuan. If the value *X* after the completion of the investment is more than 150 million yuan after 5 years, the option will be exercised and the second phase of funds will be invested with 150 million yuan, otherwise the investment will be postponed or abandoned. We use the formula 3.13 to calculate the growth option.

$$\begin{cases} V(S,t) = SN(d_1) - N(d_2)Xe^{-r} \\ d_1 = \dfrac{\left[\ln(\dfrac{S}{X}) + (r + \dfrac{\sigma^2}{2})T\right]}{\sigma\sqrt{T}} \\ d_2 = d_1 - \sigma\sqrt{T} \end{cases} \qquad (3.13)$$

(1) Good Return

S=264.47 X=207.90 r=12% Suppose σ=50% T=5

So V_1=194.68

(2) Bad Return

S=161.87 X=150 r=12% Suppose σ=50% T=5

So V_2=99.38

Considering the probability of return of route development,
the total value=0.6*194.68+0.4*99.38=156.56 million yuan.

And minus the initial investment (80), we can get the value of real option 76.56 million yuan. The result is a numerically large so it should be a wise investment.

If calculating according to the traditional NPV method, it will be considered that the company's additional investment is too risky. While according to the real option, this decision would be a wise choice. The difference is that the value brought by the real option, comes from the uncertainty of the environmental factors such as the shipping market, and the optional right of investing 150 million yuan after five years.

In fact, the traditional NPV method and the real option method do not conflict with each other, they have their own application scope. In other words, in a deterministic environment, the NPV method has an advantage in investment decision-making, while in an uncertain environment, the real option method appears to be more reasonable and reliable. The decision on whether to invest or not includes not only short-term benefits, but also potential benefits of future reinvestment. In this case, the traditional NPV method considers that it is a risky investment. However, with the real option method, it is found that the investment can benefit a lot. Therefore, real option theory is an indispensable method in making investment decisions. Only by combining the traditional method with the real option method can the shipping company find its own development direction and make the right investment decision.

Chapter 4 Analysis on Ship Optional Order

4.1. Case Introduction

Wan Hai Lines Ltd was established in Taipei in 1965, and it was originally engaged in timber transportation between Southeast Asia and Taiwan. From 1976, Wan Hai officially began to engage in container business. So far, with the characteristics of small-scale operation and clear market positioning, Wan Hai Lines has become one of the top twenty global carriers with rapid development speed.

Wan Hai Lines has inked orders worth \$900m for up to 28 container vessels to be built in Japan and China. The initial contract was signed for 20 vessels of between 2038-teu and 3036-teu, which will cost around \$640m with delivery scheduled from October 2020 to January 2021.

The Taiwanese carrier agreed to pay \$41.4m a piece for the 3036-teu ships and \$26.3m a piece for the 2038-teu ships.

At the meantime, Wan Hai Lines has the right to exercise the optional order for another four 3036-teu ships at the same price in JMU, which will be delivered in July 2020 if being exercised, and also for another four 2038-teu ships at the same price in Huangpu Wenchong Shipyard, which will be delivered in July 2021 if being exercised.

From the annual report of Wan Hai Lines, it is referred that the company's annual transportation capacity is 42.6 million TEUs, the annual fixed cost is \$620m, and the freight rate on the route to be operated at the current moment is \$80/TEU. As for these small container vessel, the residual rate is usually 5% and the operation period is around 15 years.

According to the real option theory, these optional orders can be regarded as a change scale option, which equals to a 0.25-year and a 0.5-year European call option. Under such a complex and changing circumstances, this kind of optional order requires a quick and effective mind and should be taken into consideration carefully while making the final decision.

4.2. Characteristics

There are some apparent characteristics of optional orders in the ship newbuilding order.

(1) The flexible characteristics. It means that managers have the right and ability to modify investment projects at any time according to different conditions and change the original operating strategy according to the development of different situation, so as to pursue the maximum profit of investment projects. The biggest difference between real options and traditional project investment evaluation methods (such as traditional DCF method) is that real option theory places great emphasis on the value of flexible decision making, and the management flexibility is an important factor in evaluating investment decision-making. With the new acquired information and the changes of market uncertainty, the manager has the right to modify the original investment project. This flexibility is valuable because it equals to buy an option for the company, so that the company has the right to wait and exercise until it is beneficial and profitable. The optional order in the ship building contract gives the shipping company or the shipowner a right to decide whether or not to carry out the next stage of expansion in order to improve the competitiveness on the route according to the specific situation of shipping market.

(2) The irreversible characteristics. Once the shipbuilding contract is signed, it is impossible to recover the shipbuilding costs, which will be invested without any loss. It can delay investment until a large amount of uncertainty is eliminated or multi-staged investment can be used to manage irreversible investments. Part or all of the

initial investment cost is the sunk cost, which cannot be recovered when the investment direction is changed, especially when the enterprise makes major or strategic investment decisions, the irreversible cost is quite large. Shipbuilding decisions require huge capital investment and considerable irreversible costs. The optional orders in the shipbuilding contract can enable shipping companies to abandon further investment by avoiding the financial loss caused by blind expansion.

(3) The financial characteristics. There is a clear difference between international shipping investment and many other physical investment projects. There is a shipping financial trading place in the international shipping market. It is precise because of the existence of shipping exchanges that the financial characteristics of international shipping have been enhanced, which makes international shipping vessels investment possessed with the characteristics of financial derivatives, providing an opportunity for the application of real option theory in shipbuilding decision-making.

Since the optional orders in the ship newbuilding contract have the characteristics of real options, it is necessary to introduce the physical options into the decision-making of the shipbuilding contract, which can maximize the use of uncertainty in the investment process, expand investment opportunities, improve the anti-risk ability and investment decision-making level of shipping companies' investment to realize the option value of a deterministic environmental ship investment project.

4.3 Influencing Factor

The international shipping industry is a capital-intensive industry, and the investment activities of ships are accompanied by huge capital flows. Shipping companies or shipowners usually have to consider whether to invest, how to invest, and how to proceed the investment, which requires an analysis of the factors that influence the value of the option in the contract. Here are three main influencing factors.

(1) Ship investment risk

The international shipping vessel investment risk refers to the degree of change in investment income that may occur after an investor conducts an international shipping vessel investment, which mainly includes systemic risks and non-systemic risks.

Systemic risks mainly include: First, the shipping market risks. The shipping market risk mainly comes from the cyclical volatility of the shipping market, that is to say, the shipping market is always in a cycle of recovery, high growth, shrinkage, and low valley. It has a boom period of huge profits, many international shipping companies, and the shipowner's bankruptcy recession. The existence of the cycle of the international shipping market has formed the basic risk of ship investment and is the main source of systemic risks for ship investment of international shipping. For ship investors, the emergence of the shipping cycle is the main source of uncertainty for their decision-making. Second, financial market risks. The international shipping industry is a capital-intensive industry, and ship investment requires huge amounts of money. Therefore, changes in the financial market have a great impact on ship investment of international shipping, among which, changes in capital supply, bank loan policies, interest rates and exchange rates have a greater impact on ship investment. Third, public policy risks. Countries have different policies for their own shipping industry, which have a great impact on the competitiveness of international shipping fleets and has led to changes in ship investment decisions of international shipping. This is mainly reflected in the investment policy and ship registration policy for ships.

Non-systematic risk refers to the possibility that fluctuations in the investment income of international shipping vessels can be controlled by various international shipping companies to a certain extent, which mainly comes from management level of shipowners or shipping companies, and are determined by development strategy, fleet optimization, financial optimization, economies of scale and technical conditions of international shipping companies or shipowners in the dissemination of investment.

(2) Ship financing capacity

Ship financing refers to the economic activities in which enterprises raise funds for ships from outside or inside the enterprise in various forms, which is very difficult due to the huge amount of funds required for international shipping vessel investment, the long payback period of the ship, and the high risk of the shipping market. At present, ship investment of international shipping rarely uses its own funds for investment, and most of it is financed through various means. Good financing ability can effectively help shipping companies or shipowners to invest in ships in a timely manner, develop ship capacity, expand fleet size and improve enterprise competitiveness. Therefore, financing ability is also an important factor affecting the value of ship investment options.

(3) Manager's decision and strategy

International shipping investment is based on a highly volatile shipping market with fleeting investment opportunities. Therefore, the choice of the timing of investment, the determination of investment plans and etc. require managers or shipowners to keep observation ability, strong analytical ability and strategic vision when making investment decisions. Good managers can organize and manage excellent teams, grasp the timing of investment, and develop correct investment plans and development strategies. Thus, managers' decisions and strategies are also factors that influence the value of alternative orders in contracts.

Chapter 5 Model for Ship Optional Order

5.1. Basic Overview

Theoretical studies by Mason and Merton show that, under the same assumptions as the standard DCF method, the pricing model of real options can be established by deriving a standard option pricing model, which means that although real options do not exist in the trading market, the pricing process can still be carried out in accordance with the basic idea of financial option pricing. Through the comparative analysis of the value calculation parameters of real options and financial options, we can use the financial option pricing model to price real options.

As for the real options in this paper, the execution price X, the option expiration time T can be obtained directly in the shipbuilding contract, the risk-free interest rate r can be observed in the market, and the underlying asset value S and its volatility σ are adopted by Monte Carlo simulation results, which are used to a certain extent, to ensure the accuracy of the input data. In the actual application of the Black-Scholes pricing model, investors' decision making can overcome some of the defects of the model by adopting a simple extended model and should not adopt more complicated and difficult to grasp and apply mathematical models or overly complex extended models. The alternative order in the shipbuilding contract studied in this paper is essentially an expansion real option, equivalent to a European call option. Based on the above reasons, the Black-Scholes pricing model is selected to calculate the value of this optional order.

5.2. Detailed Elements

From the previous contents, we can get the formula of value of European Option (Call or Put)

$$V(S,t) = \left| SN(d_1) - N(d_2)Xe^{-r} \right|$$

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

$$d_2 = d_1 - \sigma\sqrt{T} \qquad (5.1)$$

In the calculation of the value of the optional order in the new shipbuilding contract, the specific meanings of the parameters are as follows:

V: The value of real options, which means the value of optional order in this paper.

$N(d_1)$: Cumulative probability distribution of the standard normal distribution variable (the probability that the variable is less than d_1).

$N(d_2)$: Cumulative probability distribution of the standard normal distribution variable (the probability that the variable is less than d_2).

X: The execution price of the real option, that is, the cost that the shipowner or shipping company decides to build on the other four vessels, according to the contract, X=$164 million (in Japan) and X=$104 million (in China).

T: The execution time of the real option, that is, the time for selecting whether the other four ships are built, according to the contract, T=0.25 years (in Japan) and T=0.5 years (in China).

r: Risk-free rate of return. In international investment projects, the interest rate of US treasury bonds is generally recognized as a risk-free rate in the market, which is because the credibility of the US government is recognized by the market and there will be no default in general. In this case, the risk free rate is 2.38%（American one-year government bond yield on May 1st, 2019 from online resources）

S: The value of the underlying asset, that is, the discounted value of the net cash flow

from the operation of the four ships after the execution of the construction option at time *T*.
σ: the volatility of the underlying asset value, which means the volatility of *S*.

Although the present value of the underlying asset *S* and the value of the volatility σ of the underlying asset value cannot be directly observed through the shipping market. It is ideal to use Monte Carlo simulation to get the net present value of the project. Example application of Monte Carlo simulation is applied by the famous risk management software Crystal Ball, which can accurately estimate the project volatility.

In this paper, through statistical results or historical data, I can give the sliding interval and probability distribution (such as lognormal distribution, uniform distribution, etc.) of some parameters like freight rate, transportation volume, operating cost, etc. After using the random sampling and Monte Carlo simulation calculations on the computer for thousands of times, the present value *S* and the volatility σ of the project income can be calculated.

5.3. Model Setup

At first, we analyze the optional order (four 3036-teu ships) in Japan Marine United. The other optional order (four 2038-teu ship) in Huangpu Wenchong Shipyard is the same as follow.

It is well known that the formula of project cash flow like this:

$$S_k = P_k * Q_k - F_k \quad (5.2)$$

Where, $S_k$is the net cash flow generated in period *k*, $P_k$is the freight rate in period *k*, Q_k is the freight volume in period *k*, and F_k is the operating cost in period *k*. The ships are delivered according to the contract in the second year, and it is also the same year to take into operation to generate cash flow, Therefore, k=2.3…16. We can obtain the net cash flow of each period of the project.

$$NPV = \sum_{k=2}^{16} \frac{S_k}{(1+i)^{\wedge} k} \quad (5.3)$$

And generally, the discount rate i equals 10%

We can see that the main factors affecting the value of the project and the greater uncertainty are the freight rate P_k, the volume Q_k, the operating cost F_k, and then the probability density distribution function model of each influencing factor is determined according to the range and trend of the variable factors. To simplify the calculation, the traffic Q_k is assumed here, and the operating cost F_k is always constant during the ship's operation.

The sea freight rate P_k fluctuates drastically with time. It is generally considered that the change of sea freight price is a random process. People usually use geometric Brownian motion to change the sea freight price, that is, the sea freight price P_k obeys the following geometric Brownian motion:

$$dP_k = \mu P_k dk + \sigma' P_k dz \quad (5.4)$$

And μ is the expected rate of return, σ is the fluctuation ratio of freight rates, and both of them are constant.

According to Itô's lemma, if a process P is said to follow a geometric Brownian motion with constant volatility σ and constant drift μ, and if it satisfies the stochastic differential equation $dP = P\,(\sigma dB + \mu dt)$ for a Brownian motion B, then applying Itô's lemma with $f(P)$ =ln(P), we can get

$$
\begin{aligned}
& d\ln(P) \\
&= f'(P)dP + \frac{1}{2} f''(P)P^2\sigma^2 dt \\
&= \frac{1}{P}(\sigma SdB + \mu Sdt) - \frac{1}{2}\sigma^2 dt \\
&= \sigma dB + (\mu - \frac{\sigma^2}{2})dt
\end{aligned}
\tag{5.5}
$$

It follows that

$$
\ln(P_k) = \ln(P_0) + \sigma B_t + (\mu - \frac{\sigma^2}{2})t \tag{5.6}
$$

Since μ and σ are constants, this equation shows that ln (P_k) follows a Brownian motion with drift, which has a defined drift rate and a determined variance. Therefore, in the future time K, the change of ln (P_k) is a normal distribution and also

$$
\ln(P_k) \sim \varphi\left[\ln P_0 + (\mu - \frac{\sigma^2}{2})(K-k), \sigma\sqrt{K-k} \right] \tag{5.7}
$$

5.4. Distribution and Calculation

As for the Wan Hai Lines case, it is known to us that k=0 and the present average freight rate P=\$80/TEU in Asia market. From public information and annual report of Wan Hai Lines, we can get the μ=8% and σ= 30%. Put them into formula 5.7 we can get the table 7.

K	A	B
2	4.45202663	0.424264069
3	4.48702663	0.519615242
4	4.52202663	0.6
5	4.55702663	0.670820393
6	4.59202663	0.734846923
7	4.62702663	0.793725393
8	4.66202663	0.848528137
9	4.69702663	0.9
10	4.73202663	0.948683298
11	4.76702663	0.994987437
12	4.80202663	1.039230485
13	4.83702663	1.081665383
14	4.87202663	1.122497216
15	4.90702663	1.161895004
16	4.94202663	1.2

Table 7 Mean Value and Standard Deviation of The Normal Distribution of ln (Pk)

After determining the probability distribution function of these factors, we can randomly sample these variables, and substitute the values obtained in the random sampling into the formula 5.1 and 5.2. Each time a random sampling is performed, we can simulate an NPV of the project. Through 1000-5000 random sampling (by using the risk management software Crystal Ball for Monte Carlo simulation), we can simulate the probability distribution function of NPV, and obtain its average value and the standard deviation δ, which is done by using the Crystal Ball software.

Figure 3 The Interface of Crystal Ball Software

Set the assumption=lnP_K. Enter the parameter values in the Mean column and the Standard Deviation column according to the Table 7

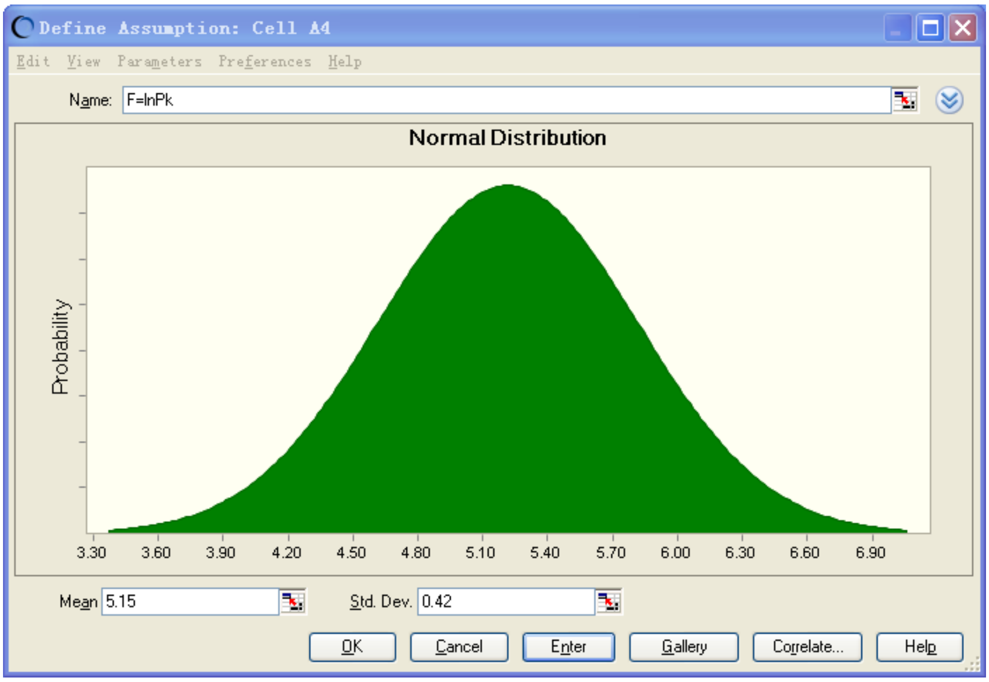

Figure 4 The Interface of the Defining Assumption F=lnP_K

Edit the formula in cell E2 according to formula 5.3 and define it as Forecast.

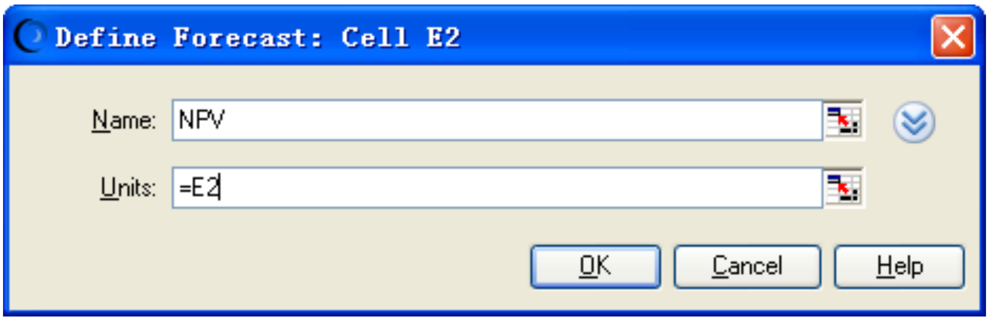

Figure 5 The Interface of Forecast Value Definition

Set the number of simulations to 5000 in Run Preferences.

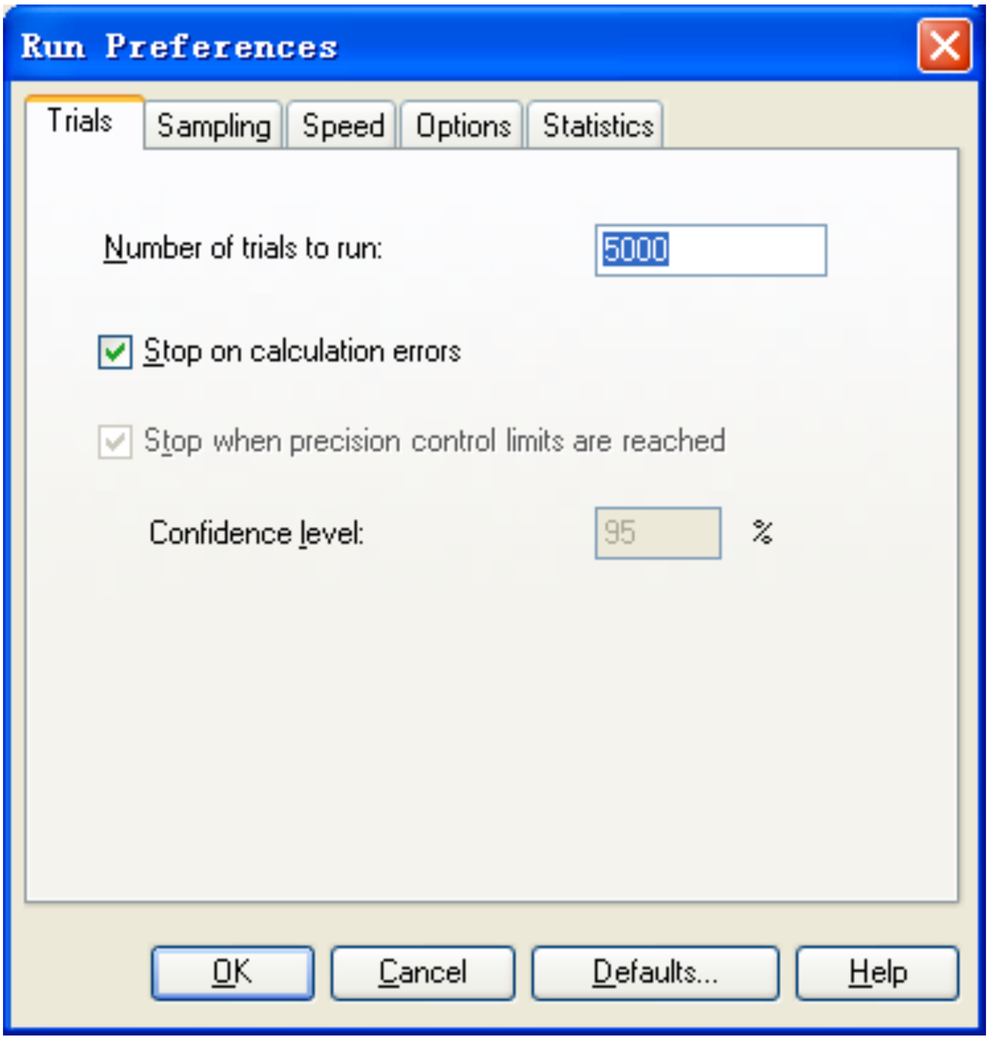

Figure 6 The Setting Interface of Simulation Parameter

After the above editing and setting and running the Crystal Ball software, we can get the sampling distribution and parameter values.

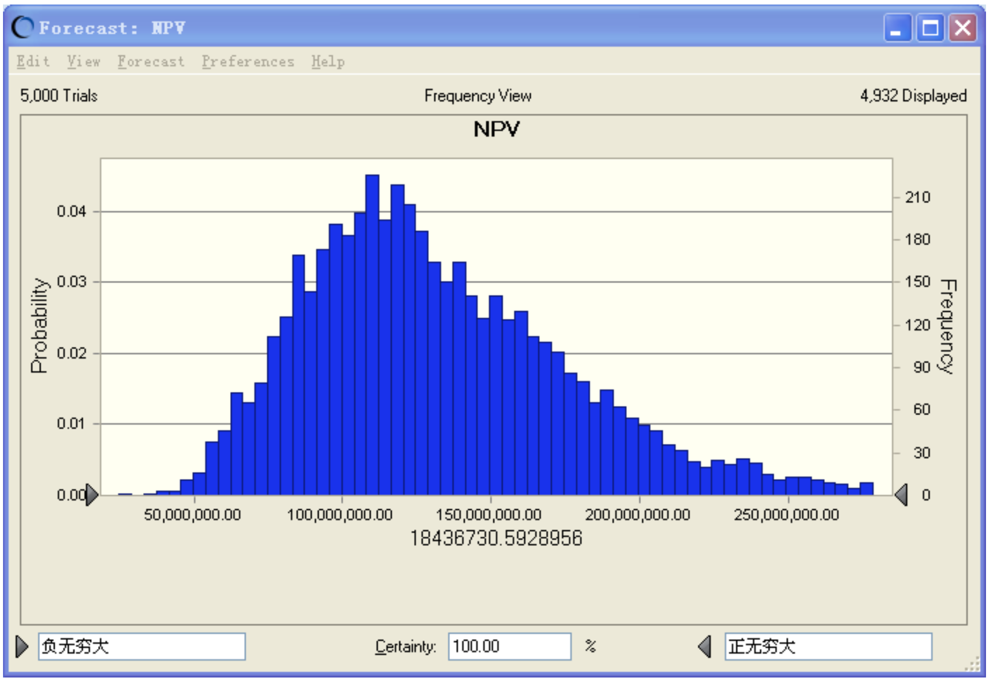

Figure 7 Sampling Distribution of the Value of the Underlying Asset

And simulation results are also included in the following chart.

Statistic	Forecast values
Trials	5,000
Base Case	18,436,730.59
Mean	134,461,884.94
Median	125,093,394.17
Mode	---
Standard Deviation	51,269,016.93
Variance	2,628,512,097,418,090.00
Skewness	1.97
Kurtosis	14.77
Coeff. of Variation	0.3813
Minimum	24,907,750.27
Maximum	739,661,115.97
Mean Std. Error	725,053.39

Figure 8 The Simulation Results of Forecast Values

According to the simulation results that ANPV is 134,461,884.94 and
δ is 51,269,016.93,
it is calculated that

Full-stage volatility：$$\sigma^* = \frac{\delta}{|ANPV|} = 0.38129$$

Annual volatility: $$\sigma = \frac{\sigma^*}{\sqrt{n}} = 0.09845$$

The value of underlying asset is \$134.462 million and the volatility is 9.845%.

According to the above results, we can get the option expiration time, the execution price *X*, the risk-free interest rate *r*, the underlying asset value *S* and its volatility *σ*.

For the optional order in Japan:

The Option Expiration Time *T*	The Execution Price *X*	The Risk-free Interest Rate *r*	The Value of Underlying Asset *S*	The Volatility of Asset *σ*
0.25	\$164 million	2.38%	\$134.462 million	9.845%

Table 8 The Parameter Value of Pricing Model of Optional Order in Japan

$$d_1 = \left[\ln(\frac{S}{X}) + (r + \frac{\sigma^2}{2})T \right] / \sigma\sqrt{T} = -0.3888$$

$$d_2 = d_1 - \sigma\sqrt{T} = -0.3937$$

$$V(S,t) = \left| SN(d_1) - N(d_2)Xe^{-r} \right| = \$10.0047 million$$

For the optional order in China:

The Option Expiration Time T	The Execution Price X	The Risk-free Interest Rate r	The Value of Underlying Asset S	The Volatility of Asset σ
0.5	\$104 million	2.38%	\$134.462 million	9.845%

Table 9 The Parameter Value of Pricing Model of Optional Order in China

$$d_1 = \left[\ln(\frac{S}{X}) + (r + \frac{\sigma^2}{2})T \right] / \sigma\sqrt{T} = 0.3896$$

$$d_2 = d_1 - \sigma\sqrt{T} = 0.32$$

$$V(S,t) = \left| SN(d_1) - N(d_2)Xe^{-r} \right| = \$24.1051 million$$

5.5. Results Analysis and Conclusion

The value of underlying asset S remains high. On the one hand, it reflects that at present these vessels are valuable in their routes. The container vessels, especially these small ones, have good market performance. On the other hand, these small vessels have promising future with low volatility of assets. Now that the whole shipping market is at a low level, so compared to other vessels, comparatively making some investment decision in small container vessels would be a good choice.

The option expiration time T is very short. Unlike other optional orders, these two options require quick reactions for investment makers, which is due to that the value of options is not as valuable as the underlying asset. The shorter expiration time always means that the lower value of optional orders.

The risk-free interest rate and the volatility of asset still remain a bad level, which reveal that the performance of whole economy is not so optimistic and the shipping market which base on the vessels and transactions still go through a long recovery period.

The value of optional orders is comparatively low. According to the formula of European options, it is calculated that these optional orders only worth small percent of the total value and it is likely that the loss outweighs the gain. which can be regarded as an unnecessary and unreasonable investment decision if the ship company choose to exercise these optional orders.

After considering all the factors, the decision makers of Wan Hai Lines are likely to abandon these optional orders.

The simulation results coincide with real fact. From the latest news of TradeWinds, the relevant people take in charge of the Wan Hai Lines have already abandoned these optional orders in JMU and Huangpu Wenchong Shipyard. Here are two following relevant announcements of abandoning optional orders for Wan Hai Lines.

SEQ_NO	1	Date of announcement	2019/02/18	Time of announcement	19:03
Subject	Supplementary announcement for acquisition of 4 2038-TEU vessels as of November 12,2018 on behalf of Wan Hai Lines(Singapore) PTE.LTD.				
Date of events	2019/02/18	To which item it meets	paragraph 20		
Statement	1.Name and nature of the subject matter (e.g.land located at Sublot XX, Lot XX, North District, Taichung City): N/A 2.Date of the occurrence of the event: 2019/02/18 3.Transaction volume (e.g.XX square meters, equivalent to XX p'ing), unit price, total transaction price: N/A 4.Counterparty to the trade and its relationship with the company (if the trading counterpart is a natural person and is not an actual related party of the Company, the name of the trading counterpart is not required to be disclosed): N/A …… 27.The appraisal price conducted in accordance with the Article 16 of the "Regulations Governing the Acquisition and Disposal of Assets by Public Companies":N/A 28.Where the above appraisal price is lower than the transaction price, the appraisal price conducted in accordance with the Article 17 of the "Regulations Governing the Acquisition and Disposal of Assets by Public Companies": N/A **29.Any other matters that need to be specified:** **The company determined to release the optional clause of adding additional order of 4 full-container vessels under same transaction terms**					

Figure 9 The Supplementary announcement for acquisition of 4 2038-TEU vessels as of November 12,2018 on behalf of Wan Hai Lines(Singapore) PTE.LTD.

<table>
<tr><td>SEQ_NO</td><td>2</td><td>Date of announcement</td><td>2019/05/09</td><td>Time of announcement</td><td>17:30</td></tr>
<tr><td>Subject</td><td colspan="5">Supplementary announcement for acquisition of 4 3060-TEU vessels as of November 12,2018 on behalf of Wan Hai Lines(Singapore) PTE.LTD.</td></tr>
<tr><td>Date of events</td><td colspan="2">2019/05/09</td><td colspan="2">To which item it meets</td><td>paragraph 20</td></tr>
<tr><td>Statement</td><td colspan="5">1.Name and nature of the subject matter (e.g.land located at Sublot XX, Lot XX, North District, Taichung City): N/A
2.Date of the occurrence of the event: 2019/02/18
3.Transaction volume (e.g.XX square meters, equivalent to XX p'ing), unit price, total transaction price: N/A
4.Counterparty to the trade and its relationship with the company (if the trading counterpart is a natural person and is not an actual related party of the Company, the name of the trading counterpart is not required to be disclosed): N/A
……
27.The appraisal price conducted in accordance with the Article 16 of the ”Regulations Governing the Acquisition and Disposal of Assets by Public Companies”:N/A
28.Where the above appraisal price is lower than the transaction price, the appraisal price conducted in accordance with the Article 17 of the ”Regulations Governing the Acquisition and Disposal of Assets by Public Companies”: N/A
29.Any other matters that need to be specified:
The company determined to release the optional clause of adding additional order of 4 full-container vessels under same transaction terms</td></tr>
</table>

Figure 10 The Supplementary announcement for acquisition of 4 3060-TEU vessels as of November 12,2018 on behalf of Wan Hai Lines(Singapore) PTE.LTD.

Also, the relevant president said, “The container ship market is still unhealthy. The market has not yet developed enough to cover the cost of new shipbuilding and the cost of financing. The companies that invested in feeder container ships in the past 10 years have not made any money. The ships being invested are good ships, but the ship leasing market has not improved, just because of the oversupply of ships.”

In fact, their decisions are closely relevant to the company’s strategy, so there is no wonder about what Wan Hai Lines did. Wan Hai Lines is flexible in its management and with customer-oriented, it is adapted to the needs of the development of the shipping market, which can timely and predictively adjust the company’s strategy. In addition, Wan Hai Lines has the characteristics of small ship tonnage and high storage capacity. Therefore, ships on most routes of Wan Hai Lines, especially on Southeast Asia, are basically in full load at most time, even when the shipping industry is in recession or off-season, its storage capacity is as high as 85%. Because of these above reasons, the company strategy of Wan Hai Lines is comparatively more quickly and flexible than most companies, and they could choose to exercise or abandon these optional orders easily according to the variation of ship market.

Compared to the traditional methods like NPV, real option method has its unique advantage in analyzing these cases. The high degree of uncertainty in the shipping market and the flexible management strategy of shipping companies are of great value to investors, and traditional investment decision making methods cannot take this value into account, which is unreasonable. In this paper, the simulation results luckily coincide with the real fact and prove that real option method is a feasible and reliable way in evaluating the value of optional orders. The real option method can find a better solution for the evaluation of ship investment projects, and can better reflect its value, which can provide a more comprehensive and objective reference for the ship company or shipowner in order to make a wise and reasonable investment decision.

Chapter 6 Summary and Prospect

6.1. Summary

This paper analyzes the application of real options in the shipping industry. Starting from the uncertainty of ship investment, it is considered that the traditional ship investment decision-making method can't make effective decisions. Therefore, the introduction of the real option method is of great significance. Then, with the latest optional order case of Wan Hai Lines, the main process of this article is identifying options, selecting pricing models, building models, and drawing the conclusion.

The chapter three talks about the many aspects of real option analysis and makes the comparation between traditional method like NPV and real option in a small case, which paves the way for later analysis of real case. The chapter four makes a detailed introduction of two optional order with large amount of investment, furthermore, it discusses the apparent characteristics and influencing factor of optional orders to better understand the essentials. The next chapter five lays great emphasis on the model to make further analysis. With the aid of Crystal Ball software, I have established an option pricing model by deriving the distribution of shipping prices and obtained the target asset value and its volatility by performing Monte Carlo simulation. Through the B-S option pricing model, the value of the real option included in the contract is calculated and the pricing results is analyzed, which points out that these optional orders are greatly likely not to be exercised. On the one hand, these optional orders are not of very importance in the estimation of value. On the other hand, Wan Hai Lines is easy to tackle these orders in order to adapt to their flexible and varied company strategy.

This paper takes the example of two recent vessel optional orders from Wan Hai Lines as the main analysis object. I have confirmed that my analysis result coincides with the actual situation, which will provide a reference for some ship companies who are in the face with similar optional orders.

There is no doubt that there are some present problems in my model and analysis. One thing is the rent level and volume involved in the article have relatively large fluctuations and lag in practice so using them enter real option pricing may cause errors. In addition, the key factors like discount rate are difficult to estimate and determine. Because in fact the cash flow in the far future is often much more risky than the cash flow in the near term, the discount rate should be adjusted appropriately according to the factors like the risk of maturity. Apart from that, the current shipping market is not all fully competitive in the reality and competition between shipping oligarchs has an important impact on their investment decision-making. So it would be a good improvement if the Game theory can be fully and well adopted in the analysis of optional orders.

6.2. Prospect

In the actual investment decision, there will be a more complicated investment environment in the real situation, even if the simple real option is fully met in the application. Model assumptions are also difficult. Therefore, the future research direction is mainly how to translate theoretical research into practical applications. In a word, we should better apply the theory into practice with a more precise and reliable model. And as for the prospect, I think some aspects should be improved in the future.

(1) The high risk of the shipping market determines that investors need to carry out a long-term strategic regulation when investing in ships. The phased and multiple options of a ship's investment project will form a compound option. In view of the volatility of the shipping market and the uncertainty of information, investors must firstly consider the timing of entering the market when investing in a route or a single

ship. Then, after the ship is completed and put into operation, based on market conditions, they need to consider further decisions, such as expanding the scale of operations by additional investment or chartering vessels when market conditions are favorable. The ship investment project is faced with an extremely complicated environment, and the shipping company or shipowner faces many choices in the investment process, such as choosing which ship type to invest in, choosing to charter a ship or buying a ship, buying a new ship or a second-hand ship, and choosing a charter ship or a model of its own operation. These flexible investment decisions constitute composite real options, and how to price the underlying assets when they are not tradable, further researches are needed.

(2) Considering the non-exclusivity of the introduced option, the real option pricing theory and the game theory are combined to evaluate and analyze the real option value contained in the project. The current shipping market is not completely competitive, with the pattern of oligopoly having basically taken shape. The investment decisions of ship investment projects under the game between decision makers of some oligarchy shipping companies are also one of the problems that need to be solved in the future, which has to do with the option pricing under the game when the underlying assets are not tradable, such as using game theory to analyze the interaction between investors and combining real options and game theory to analyze the investment strategies under different competitive landscapes.

(3) In the case that the underlying asset is not tradable and the fluctuation of the value of the investment project of the ship is unknown, the decomposition method adopted in this paper will price the real option, and only decompose the value of the project into an exogenous variable of the shipping freights, assuming that other variables remain unchanged or changed according to the proportion of shipping price, and there is still a certain difference with the actual investment situation of the project, which needs to be further deepened in the future researches, and makes the setting and assumption of parameters be closer to reality, and the research be more practical.

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