

Real Option Analysis on Ship Investment Valuation

Chi-Yeol Kim[†] · Dong-Keun Ryoo* · Jae-Kwan Kim**

[†] Graduate school of Korea Maritime University, Busan 606-791, Korea

* Associate Professor, Division of Shipping Management, Korea Maritime University, Busan 606-791, Korea

** Graduate school of Korea Maritime University, Busan 606-791, Korea

Abstract : *Recent collapse of shipping market right after unprecedented surge clearly demonstrates that shipping industry is extremely risky. Due to the volatile movements of the freight rates, investors tend to ask higher rate of return; higher required return reduces the total net present value of the investment project. For several decades, the Discounted Cash Flow(DCF hereafter) analysis has been the most frequently used valuation technique. However, the main problem of the DCF analysis is its assumption that the discount rate would stay the same during the project life. In other words, it usually does not address the decisions that managers have after a project has been accepted. The purpose of this study is investigate a new valuation method of investment: the Real Option Analysis(ROA hereafter) on ship investment. By replacing the existing valuation methods with the new one, the research will present a new perspective on investment with uncertainty. While uncertainty increases risk of investment and consequently discounts the value of it in the traditional feasibility analysis, in the ROA, a new valuation method which will be addressed in the research, uncertainty means some additional value of flexibility so that the tool can help investors produce more accurate decisions. Contrary to the DCF analysis, the ROA takes managerial flexibilities into account. In reality, capital budgeting and project management is typically dynamic, rather than static in nature. The ROA finds and assesses the values of managerial flexibilities or real options in the investments. The main structures of the research will be as follows: (1) overview of the ship investment project, (2) evaluation of the project by the Net Present Value analysis, (3) evaluation of the same project by the Real Option Analysis, (4) comparison of the two techniques.*

Key words : *Real Option Analysis, Discounted Cash Flow, Ship Investment, Managerial Flexibility, Uncertainty*

1. Overview of the research

Few industries are as international or dynamic as shipping.¹⁾ Freight rates in shipping markets have fluctuated significantly. For instance, the Baltic Dry Index, an index covering freight rates in dry bulk shipping soared up to above 11,000 points in November 2007. The index, however, now indicates mid-2000s: a dramatic reduction of about 80%. Among a number of risks in the shipping industry, these explosive movements of freight markets have made ships regarded as very risky assets. Due to the volatile movements of freights rates, investors tend to ask higher rate of return.

For these reasons, innumerable shipping investment plans have been rejected because of their negative net present value; later, it has been demonstrated that the projects would make tremendous profits if they had been accepted.

The purpose of this research is to investigate a new valuation method of ship investment. By replacing the existing valuation methods with the new one, the research will present a new perspective on investment with uncertainty.

While uncertainty increases risk of investment and consequently discounts the value of it in the traditional feasibility analysis, in the Real Option Analysis(the ROA hereafter), a new valuation method which will be addressed in this study, uncertainty means some additional value of flexibility so that the tool can help investors produce more accurate decisions.

Contrary to the DCF analysis, the ROA takes managerial flexibilities into account. In reality, capital budgeting and project management is typically dynamic, rather than static in nature. There are numerous contingencies during the project's life. The ROA finds and assesses the values of managerial flexibilities or real options in the investments. It borrows its basic principles from the financial option pricing models.

The main structure of the paper will be as follows: (1) overview of the ship investment project, (2) evaluation of the project by the DCF(NPV) analysis, (3) evaluation of the same project by the ROA, and (4) comparison of the two results.

[†] Corresponding Author : Chi-Yeol Kim, bravoxo@kita.net, 02-6000-5456

* Dong-Keun Ryoo, dkryoo@hhu.ac.kr 051-410-5126

** jaekkim@hanjinsm.net 051-460-8220

1) C.Th. Grammenos, e.m. Xilas(2004)

2. Theoretical backgrounds

Academical studies on real option had been carried out since early 1980s. Hayes(1980), Abernathy(1980), and Garvin(1982) pointed out that the DCF valuation neglected the value of strategic flexibility and proposed the need of new method.

Myers(1984), who coined the word 'Real Options', demonstrated four major limits of the DCF. He criticized that the DCF failed to link "Today's investments" to "Tomorrow's opportunities" and compared the ROA to "Bridging the gap between financial theory and corporate strategy"

Mcdonald and Siegel(1986), Majd and Pindyck(1987) presented the model to evaluate the options to defer. Trigeorgis and Mason(1987) demonstrated the merits of applying the decision tree analysis, one of real option pricing models, to real investments. Myers and Majd(1990) developed the model for assessing abandonment value using option pricing theory. Dixit and Pindyck(1995) asserted the need to apply financial option pricing models to investment valuations. Copeland and Antikarov(2001) insisted that the binomial option pricing model is more apt for corporate finance practices than the Black-Scholes Model.

In the fields of shipping, port, and logistics, Tvedt(1997) calculated the value of VLCCs using real option analysis. Bendall(2003) applied real option approach to investment strategy of liner shipping. Sodal(2004) assessed the value of switching options for combination carriers. Pireira(2006) analyzed the optimal development timing for an international airport.

3. Real option approach to investment under uncertainty

3.1 Limits of the existing methods

The DCF analysis, up to now, has been the most frequently used investment valuation technique. It was found, in a research, that an average of 86% of 424 large firms used the NPV analysis, the representing method of the DCF, in 1978 increasing from 19% in nearly two decades ago.²⁾ This is because the concept of the NPV is exactly apt for the principle of corporate finance: maximizing shareholders' wealth.³⁾ It implies that shareholders' wealth will increase or

decrease as much as the calculated result.

However, the DCF analysis has several drawbacks from internal or external factors.

First, it fails to reflect the managerial flexibility in investment. Decision makers have to depend on the expected future cashflows and discount rate at the time of valuation and assume that it will be constant through the project duration.

Second, the DCF is not suitable for investment under uncertainty: with unpredictable cashflows and high risks. That is, setting the appropriate discount rate is very difficult task because the discount rate is the only parameter that reflects uncertainties. The DCF, thus, tends to conservatively depreciate the project as volatility becomes high, i.e. it makes the discount rate up.

3.2 Introduction of real option

1) General concepts

In corporate finance, real option analysis(ROA) applies put option or call option valuation techniques to capital budgeting decisions. In other words, to be more faithful to the definition of financial option, real option is the right, but not the obligation, to take an action(e.g., deferring, expanding, contracting, or abandoning) at a predetermined cost for a predetermined period of time.⁴⁾

Table 1 Comparison between real options and financial options

Real Options	Parameter	Financial Options
Expected NPV of Cashflows	S(+*)	Value of the Underlying Asset
Investment Cost	X(-*)	Exercise Price
Time to expire	T(+)	Time to expiration
Uncertainty about the NPV	$\sigma(+)$	Standard Deviation of the Underlying Asset
Risk-Free Rate	$r_f^{(+)}$	Risk-Free Rate
Other Costs of opportunities	D(-)	Dividends

*'+ ' means positive; '- ' means negative, and they are all in case of call option

** Copeland and Antikarov(2001)

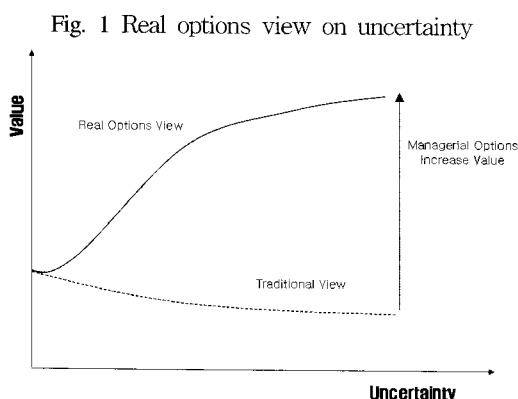
One of the significant properties of the ROA is its 180-degree attitude to uncertainty. Contrary to the traditional DCF, which depreciate the value of the investment as much

2) T. Copeland, V. Antikarov(2003)

3) S. A. Ross, R. W. Westerfield, B. D. Jordan(2003)

4) op. cit.

as volatility increase, the ROA tries to find and evaluate managerial flexibility, i.e. embedded option, in the project. The figure below represents the two viewpoints.



Amram and Kulatilaka(1999)

2) Taxonomy of Real Options

Real options are classified by the type of flexibility that they offer.

Table 2 Types of real options

Terminology	Right Type	Option Type
Deferral Option	right to delay the start of a project	American Call
Option to Abandon	right to abandon a project for	American Put
Option to Contract	right to sell a fraction of project	American Put
Option to Expand	right to scale up the project	American Call
Switching option	right to switch between two models	Combination of American Call and Put

Copeland and Antikarov(2001)

In addition, there are also compound options, i.e. options on options and rainbow options on investment with multiple sources of uncertainty.

4. Empirical study

4.1 Ship Investment Overview

To illustrate the ROA of ship investment, a fleet investment will be reviewed in this section.

1) Deal Specification

A shipping company is considering fleet expansion for future operation. The plan consists of 3-ULCS(Ultra Large Container Ship, 60,000dwt Class) purchase and 2-ULCS-option to purchase. Each vessel has 25 durable years including the

building period. The first vessel will be delivered after 3 years from now on, and next delivery will take 1 year after each delivery.

The liner has an option purchase 1 or 2 more vessel of the same class until the delivery of the third ship. i.e. in 5 years. The shipbuilder gives the investor a favor of limiting the maximum price of each vessel to the current level.

2) Financing conditions

The carrier can borrow 80% of the vessel price from banks and the interest rates for the lending is 6.5% of the outstanding balance.

3) Invest and payback plan

The capital, 20% of the vessel price, will be invested separately: a quarter at the beginning, a quarter at the year 1, and the rest at the year 3.

The principle will be paid back by 7.5% of the total lending after delivery and the rest of the outstanding balance will be cleared after 11 years from delivery.

4.2 Investment valuation by NPV

To assess the net present value of the project, cashflow analysis should be done first. Cashflows of the investment consist of cash inflows and cash outflows. In this investment, there are only one cash inflow: freight income. Cash outflows are cargo handling variable costs, operation variable costs, operation fixed costs, administration costs, taxes, interests, payback of the principal, and other sales and purchase costs.

1) Cash inflows

Each vessel has freight incomes during the life. Incomes depend on market conditions that are three cases: the best, moderate, and the worst. In the best case, revenue per TEU is USD 1,500 with loading factor of 80%; in the moderate case, revenue per TEU is USD 1,300 with loading factor of 70%; and, in the worst case, revenue per TEU is USD 1,100 with loading factor of 60%.

2) Cash outflows

(1) Cargo handling variable costs

① Charging and discharging

This is the result of multiplication of the unit price, rounds of voyage, loading factor. It is assumed that the cost will increase by 1% a year.

② Delivery

This is also the result of multiplication of the unit price, rounds of voyage, loading factor. It is assumed that the cost

will increase by 1% a year.

③ Agent fees

This is the predetermined portion of annual freight incomes. The liner gives its agent 2% of the income.

(2) Operation variable costs

① Port Charges

This is the multiplication of the annual average port charges and the number of voyages.

② Fuel costs

This the function of the fuel price per ton, daily consumption, and the number of operating days.

(3) Operation fixed costs

① Manning

This is the multiplication of the number of crews and annual average costs of crewing. This cost is assumed to increase by 3% a year.

② Maintenance

This is the average annual costs for maintenance of the hull and its equipment. This is assumed to increase by 1% a year.

(4) Administration

This is 4.5% of annual average freight incomes.

(5) Taxes

Thanks to the tonnage tax system, it is fixed at the level of USD 36,000 per year, regardless of the earning before interest and taxes.

(6) Capital costs

For debt, its interest rate is 6.5% and for capital, the required rate of return is 15%.

(7) Other costs

In this part, there are brokerage, and other commissions.

3) Weighted Average Cost of Capital

To calculate the company's cost of capital, capital structure analysis should be done first. This project, if apart from other cashflows of the company, has 20% of equity and 80% of debt. In this investment, as mentioned before, the tax effect of the debt can be ignored thanks to the tonnage tax system. As a result, the WACC of the project is 8.20%.

4) Summary

The NPV is USD 983,229,274 in the best case; USD 194,184,049 in the moderate case; and USD -431,100,595 in

the worst case.

4.3 Investment valuation by the real option analysis

1) Four-step process for valuing real options⁵⁾

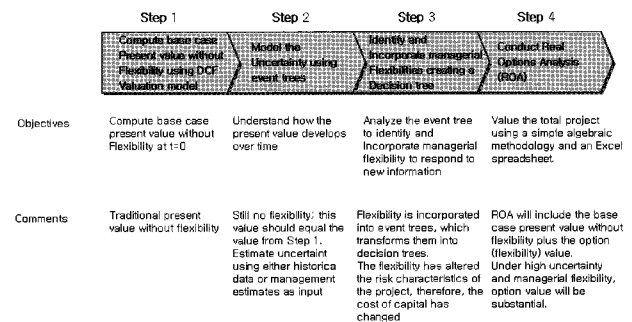
The first step is to calculate the net present value of the project using traditional methods. The result, without saying, has no value of flexibility.

The second step is to build an event tree of the project. The tree visually and systematically shows the uncertainty that drives the volatility of the underlying asset during the project life. In this paper, the consolidated approach to uncertainty, which assumes that the multiple uncertainties can be combined, is used.

The third step is turning the event tree into a decision tree by putting management decisions into the nodes. While the event tree shows the possible values of the underlying asset may go through, the decision tree does the payoffs from optimal decisions.

The fourth step is to conduct the real option analysis and to value the total project. The result is combined values of the net present value without flexibility and the payoffs of the real option in the project.

Fig. 2 The four-step process of valuing real options



2) Types of option calculator

There are three kinds of option calculator: the partial differential equation(PDE), the dynamic programming, and the simulations. However, it does not matter which method to be used if the model can accurately reflect every business contingency in the project; if it can, all the results from the three equations are same.⁶⁾

The PDE approach uses a partial differential equation and boundary conditions to mathematically express the option value and its dynamics. It is based on the Black-Scholes equation for the European call option without dividend.

5) op. cit.

6) M. Amram, N. Kulatilaka(1999)

The Dynamic programming rolls out every possible values of the underlying asset(rolling forward process), and then, finds optimal decisions in the future by tracking back from the final nodes of the decision tree(recursive backward iteration).

The simulation models rolls out a huge number of possible paths of evolution of the underlying asset to the maturity of the options. The option value is expressed by averaging the payoffs discounted to the present.

3) Real option analysis of the fleet investment

In this paper, the Binomial Option Pricing Model will be used as an option calculator. Considering the feature of this investment i.e. exercising before maturity, option pricing model for american one is more suitable than others, and the binomial model has more flexibility in its application.

(1) Parameters

Before valuing the options, several parameters should be proposed. The parameters are the volatility, the upward movement and downward movements of the underlying asset, and risk-free rate.

① Volatility of the underlying Asset

In this paper, the standard deviation of the Howe Robinson Container Index from January 2000 to April 2008 is used as the volatility(σ) of the underlying asset. Its volatility is 423.3, or 37.34% of the average.

② Upward and downward movement of the underlying Asset

Cox, Ross, and Rubinstein(1979) proposed the value of the upward(u) and downward(d) movement of the underlying asset to match the volatility of it. The solution they proposed is

$$u = e^{\sigma\sqrt{\Delta t}}, \quad d = e^{-\sigma\sqrt{\Delta t}} \tag{1}$$

③ Risk-free rate

In this paper, the average interest rate of the government bond with 3-year maturity for the last ten years is used as the risk-free rate.

(2) Marketed asset disclaimer⁷⁾

The binomial option pricing model uses the replicating portfolio approach or the twin security approach. To value the option price, it artificially makes the replicating portfolio consisting of Δ units of underlying asset and options. In financial options, it is possible to find the twin security

whose payoffs are perfectly correlated with the underlying asset, however, in real option it is almost impossible. Copeland and Antikarov (2003) asserts that the net present value of the project without flexibility is the best unbiased estimate of the market value of the project were it a traded asset

(3) Structuring the Binomial Tree

By rolling forward process, the binomial tree of the project is as shown below

Table 3 Movements of the underlying asset

(unit : USD 1,000)

Year	0	1	2	...	5	6
	S_0	uS_0	u^2S_0	...	u^5S_0	u^6S_0
	194,184	282,084	409,774	...	1,256,150	1,824,765
				...	d^5S_0	d^5uS_0
				...	30,018	43,607
				...		d^6S_0
				...		20,664

(4) Option to abandon

During the project life, the carrier has an option to abandon the project if market conditions are not favorable. If they decide to dispose the vessels, the management can get 40% of the fleet price($I * 0.4$).

This is a typical american put option. The exercise price of the option is 40% of the fleet price. If $d^{6-i}u^iP$ denotes the values of the options at nodes of the binomial tree at year 6, the option prices are

$$Max[0, I \times 0.4 - d^{6-i}u^iS_0] \tag{2}$$

($i = 0, 1, 2, 3, 4, 5, 6$)

By recursive backward iteration, the values of the options at nodes at year t are

$$Max[(p \times d^{t-i}u^{i+1}P + (1-p)d^{t-i+1}u^iP)e^{-rt}, I \times 0.4 - d^{t-i}u^iS_0] \tag{3}$$

($i = 0, 1, 2, 3, 4, 5, \quad t = 0, 1, 2, 3, 4, 5, \quad t \geq i$)

(5) Option to shrink

During the project life, the carrier has options to contract the project if market conditions are not favorable. If the option to abandon 1 vessel is exercised, the value of the project will decrease by a third and there will be some cash inflow by the amount of 40% of the vessel price; if the option to abandon 2 vessels is exercised, the value of the

7) op. cit.

project will decrease by two thirds and there will be some cash inflow by the amount of 40% of the two-vessel price. The option to shrink is a kind of american put option with the exercise price of $d^{t-i}u^i S_0 \times \frac{2}{3} + I \times \frac{1}{3} \times 0.4$. (in the case of abandoning 1 vessel)

The values of options at the nodes of the binomial tree when t=6 are

$$Max[0, d^{6-i}u^i S_0 \times \frac{2}{3} + I \times \frac{1}{3} \times 0.4 - d^{6-i}u^i S_0] \quad (4)$$

$(i = 0, 1, 2, 3, 4, 5, 6)$

And the values of options at the other nodes are

$$Max[(p \times d^{t-i}u^{i+1}P + (1-p)d^{t-i+1}u^iP)e^{-rt}, \frac{1}{3}(I \times 0.4 - d^{t-i}u^i S_0)] \quad (5)$$

$(i = 0, 1, 2, 3, 4, 5, t = 0, 1, 2, 3, 4, 5, t \geq i)$

(6) Option to expand

The options to expand are inherent in the project. The management can decide purchase 1 or 2 more vessels when market conditions are favorable. If the option to purchase 1 more vessel is exercised, the value of project will be increase by 20% for the price of one vessel; if the option to purchase 2 more vessel is exercised, the value of the project will be increase by 40% for the price of two vessels. The option to expand is a kind of american call option with exercise price of $d^{t-i}u^i S_0 \times \frac{6}{5} - I \times \frac{1}{3}$ (in the case of purchasing 1 more vessel).

The values of options at the nodes of the binomial tree when t=6 are

$$Max[0, d^{6-i}u^i S_0 \times \frac{6}{5} - I \times \frac{1}{3} - d^{6-i}u^i S_0] \quad (6)$$

$(i = 0, 1, 2, 3, 4, 5, 6)$

And the values of options at the other nodes are

$$Max[(p \times d^{t-i}u^{i+1}C + (1-p)d^{t-i+1}u^iC)e^{-rt}, d^{t-i}u^i S_0 \times \frac{1}{5} - I \times \frac{1}{3}] \quad (7)$$

$(i = 0, 1, 2, 3, 4, 5, t = 0, 1, 2, 3, 4, 5, t \geq i)$

(7) Combination option

In business practice, it is more possible to assume that a project allows any of simple options, such as options to abandon, options to shrink, and options to expand to be exercised at each node of the binomial tree. In this project there are up to five simple real options: an option to abandon the project, an option to shrink(1 vessel), an option to shrink(2 vessels), an option to expand(1 more vessel), an

option to expand(2 more vessels). The movements of the underlying asset remains the same as before, and the option values at the nodes when t=6 is,

$$Max[0, I \times 0.4 - d^{6-i}u^i S_0, d^{6-i}u^i S_0 \times \frac{2}{3} + I \times \frac{1}{3} \times 0.4 - d^{6-i}u^i S_0, d^{6-i}u^i S_0 \times \frac{1}{3} + I \times \frac{2}{3} \times 0.4 - d^{6-i}u^i S_0, d^{6-i}u^i S_0 \times \frac{6}{5} - I \times \frac{1}{3} - d^{6-i}u^i S_0, d^{6-i}u^i S_0 \times \frac{7}{5} - I \times \frac{2}{3} - d^{6-i}u^i S_0] \quad (8)$$

$(i = 0, 1, 2, 3, 4, 5, 6)$

And the values of options at the other nodes are

$$Max[(p \times d^{t-i}u^i P + (1-p)d^{t-i+1}u^i P)e^{-rt}, I \times 0.4 - d^{t-i}u^i S_0, d^{t-i}u^i S_0 \times \frac{2}{3} + I \times \frac{1}{3} \times 0.4 - d^{t-i}u^i S_0, d^{t-i}u^i S_0 \times \frac{1}{3} + I \times \frac{2}{3} \times 0.4 - d^{t-i}u^i S_0, d^{t-i}u^i S_0 \times \frac{6}{5} - I \times \frac{1}{3} - d^{t-i}u^i S_0, d^{t-i}u^i S_0 \times \frac{7}{5} + I \times \frac{2}{3} - d^{t-i}u^i S_0] \quad (9)$$

$(i = 0, 1, 2, 3, 4, 5, t = 0, 1, 2, 3, 4, 5, t \geq i)$

(8) Summary

Table 4 Values of options

(unit : USD 1,000)

NPV(A)	Option Value(B)	Total(A+B)	
194,185	Abandon the Project	34,332	228,517
	Abandon 1 Vessel	11,444	205,629
	Abandon 2 Vessels	22,888	217,073
	Purchase 1 more Vessel	3,502	197,687
	Purchase 1 more Vessels	7,005	201,190
	Combination	41,337	235,522

5. Conclusion

5.1 Summary and Implications of Study

In this paper, a new viewpoint to capital investment has been presented. The ROA not only captures new business opportunities incorporated in the investment, but mathematically calculates the value of managerial flexibility. Through the existing DCF methods, that additional value cannot be reflected. Moreover, considering very explosive movements of the shipping market, it is not appropriate for investors to assume that important variables, such as freight incomes or operating costs, will not deviate from the

expected cashflows.

The ultimate purpose of the ROA is not how to calculate the value of the option inherent in the investment, but how to gain insight into the investments, that is, a new way of looking at uncertainty adverse to traditional manners. Harmonized with the NPV, the ROA can give investors more accurate information and prevent them from abandoning the investments with huge potentials.

5.2 Limits of the study

The ROA has been discussed as the alternate valuation method to the traditional DCF. It, however, also has some shortcomings.

First, even though it can capture managerial flexibility in the investment that the DCF fails to, its starting point is still the NPV. Second, in the ROA, it is still a tough job to estimate the cashflows, especially cash inflows, of the project. Cash outflows are also variable, but historical data in shipping industry imply that the change of cash inflows is much more volatile than that of cash outflows.

Third, in this paper, setting the exercise prices of each option is more or less artificial.

Last, but not least, there is the matter of volatility of the underlying asset. This is the most arguable matter in the ROA like the discount rate in the DCF.

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