7-20-2013

An investment appraisal of ocean engineering projects - the case of diving support vessel

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A research paper submitted to the World Maritime University in partial Fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE

In

INTERNATIONAL TRANSPORT AND LOGISTICS

2013

DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is 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.

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Professor Gang ZHAO

Shanghai Maritime University

ACKNOWLEDGEMENT

Firstly I would like to express my deepest thankfulness to Professor Shuo Ma, who gave me the opportunity to be with those outstanding professors, scholars and classmates and to study in this ITL project. Meanwhile, I would like to thank two nice and kind ladies, Ms. Jiang Zhengfei and Ms. Hu Fangfang, who helped me a lot during this program.

I also would like to express my gratitude to Professor Gang Zhao, who had given me many help, support and guide during the dissertation writing stage. Prof. Zhao had given me a lot of help regarding what would be a good topic, how to structure the paper and how to write a good paper. This paper could not have been finished without his patience and knowledge.

Thirdly, I would like to thank all the professors who had taught me useful information and showed me a wonderful world of transportation and logistics. Their knowledge, patience, passion and professionalism had impressed me deeply. I have learned many things from them and academic knowledge is just one of them. I would especially express my gratitude to Associate Professor Pierre Cariou who had showed me a world of finance and given me important information during the paper writing.

Finally, I would like to thank my dear classmates who had given me a wonderful time in Shanghai during the study. I would never be able to finish this program without their company and support.

ABSTRACT

With the development of technology and onshore oil field exhaustion, ocean engineering industry started from 1950s and has spread all over the world. Since 2008, due to the depression of shipping market, more and more attentions are paid to ocean engineering industry and many companies are investing in building new ocean engineering projects. However, many investment decisions were made blindly and hastily. Those hasty decisions would only put more pressure on this overheated industry.

In order to help companies make rational and scientific decisions, the economic appraisal of investment in ocean engineering project is analyzed in this paper. The features of ocean engineering project economic appraisal, evaluation indexes and standards, and factors that may influence investment in ocean engineering project are demonstrated and the method for evaluation is probed. A case study for diving support vessel (DSV) was used to test the effect of the method. Net present value (NPV), internal rate of return (IRR), return on investment (ROI) and discounted payback period (PBP) were chosen as economic indicators. And dayrate, vessel price, bunker price and discount rate were chosen as the influencing factor to analyze the risk since they represent the risks in market situation, fixed cost, variable cost and financial status separately.

With the help of Excel software, the evaluation result and risk analysis of the case study were obtained. The result has shown that NPV is positive, IRR is bigger than the company's required IRR, discounted PBP is 9 years and ROI is more than 10%. It means that this investment is economically feasible. Dayrate of the equipment was found to be the most sensitive influencing factor and has the most significant impact on the economic indicators for evaluation. Vessel price is relatively sensitive factor.

Bunker price and discount rate were not sensitive factor compared to dayrate or vessel price.

The case study proved that NPV, IRR, discounted PBP and ROI were useful economic indicators and dayrate, vessel price, bunker price and discount rate could be effective influencing factors. However, more researches needed to be done and more methods needed to be investigated in order to find the optimal indexes and method for ocean engineering project economic appraisal.

Keywords: ocean engineering project, economic evaluation, DSV

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LIST OF ABBREVIATIONS

CERA	Cambridge Energy Research Associates
OECD	Organization for Economic Cooperation and Development
E&P	Exploration and Production
OSV	Offshore Supply Vessel
AHTSV	Anchor Handling Towing Supply Vessel
DSV	Diving Support Vessel
PSV	Platform Supply Vessel
FPSO	Floating Production, Storage and Offloading Unit
ROV	Remotely Operated Vehicle
DP	Dynamic Positioning

NPV	Net Present Value
IRR	Internal Rate of Return
RFR	Required Freight Rate
PBP	Payback Period
CPT	Cost Per Ton
AAC	Average Annual Cost
ROI	Return On Investment
LIBOR	London Interbank Offer Rate
EBIT	Profit After Depreciation and Before Taxation and Interests
ROR	Rate Of Return
IPO	Initial Public Offer
BOE	Barrel Of Equivalent
CNPC	China National Petroleum Corporation
CNOOC	China National Offshore Oil Corporation
FCSTT	Floating Container Storage and Transshipment Terminal
TERA	Techno-economic, Environmental and Risk Analysis
AHP	Analytic Hierarchy Process
KPCA	Kernel Principal Component Analysis
DCF	Discounted Cash Flow
PV	Present Value
WACC	Weighted Average Cost of Capital
MGO	Marine Gas Oil

Chapter 1 Introduction

With the increase of demand for energy from all over the world and the development of modern techniques and equipments, the ocean engineering industry has stepped into the global energy picture and drawn more and more attention from governments, shipyards, ship owners and investment companies. Although more and more new energy sources are being discovered, oil and gas will still be the main energy source for a very long time in the future. Now, the exploration rate for land oil and gas resource is more than 70%, while the number for offshore oil and gas resource is only about 30%. So there is a huge exploration potential waiting for us in the sea. According to Cambridge Energy Research Associates, in the year of 2009, offshore oil production is about one third of the global oil production. And the number will be up to 35% in the year of 2020 according to the same institute. Meanwhile, during 2011-2015, global oil demand is expected to grow on average 1.2% per year, with this demand entirely driven by non-OECD countries, particularly China. China is going through a booming time of its development, which calls for huge demand of oil and gas as energy source and industry material. And Chinese government also sees the significance of energy industry. In October of 2011, in Chinese government report about nurturing and developing strategic emerging industry, ocean engineering industry has been pointed out specifically. It means that more and more parties have seen opportunity and challenge in this emerging industry compared with traditional shipping industry.

1.1 Backgrounds

Like probably everyone would know the global shipping market has reached its peak in 2007 due to world economy development and increased demands for logistics, however, it hits the low end afterwards and keeps running low since then. The Baltic Dry Index has dropped from 8223 in 2007 to 623 in 2008 and until now, it has not been recovered yet (see Fig 1.). The lowest Baltic Dry cargo Index in 2011 is even lower than the index in 2009 when the market was crashed by economic crisis. The worldwide economy depression, over-built vessels and increased running cost have worked together to depress the shipping market. Besides of the economic crisis, the pre-crisis peak had inspired many companies building vessels which come to the market now, the over-supplied transportation compared to the shrunk market, had made things worse. At the same time, international petroleum price has been increased, the stricter requirements from life protection, environmental protection and other regulation have increased the overheads in every shipping company. Therefore, the continuation running in shipping market would make a huge loss, while if the company stopped running, it will lose its customers and market share. The situation has forced some shipping companies to change their businesses into other fields.

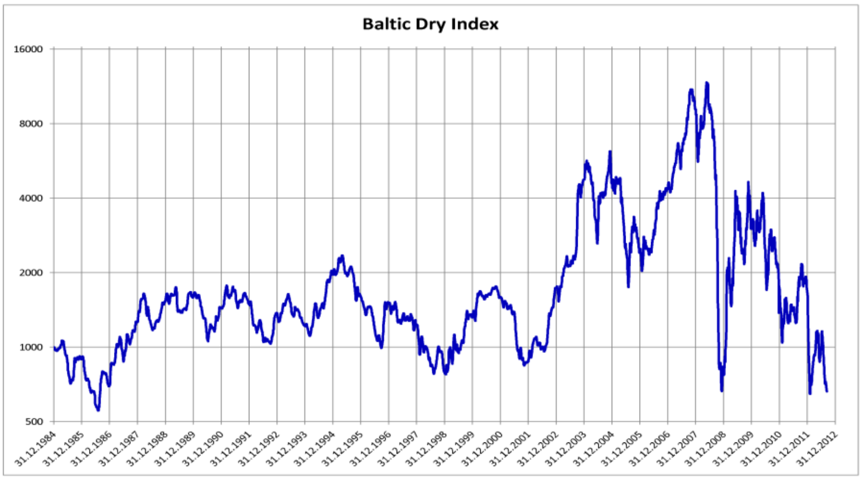

Figure 1. Baltic Dry Index from December, 1984 to December, 2012

With the shipping market going down, there is another market is rising up. The need for energy, the dry out of onshore oil field and the development of technology have grown in recent years. All of them have raised the question about exploring oil and gas in the ocean. Most of the proven offshore oil and gas reserves are contained in continental shelf and seabed of deeper than 3000 meters. The offshore energy reserve would be more than 100 times of the onshore energy reserve. In the future, the potential for oil and gas production increase would come from the offshore field. Offshore exploration and production (E&P) started in the U.S. Gulf of Mexico (GOM) in 1947, and expanded rapidly to the North Sea, Brazil, West Africa, the Persian Gulf and Southeast Asia. China and India are important emerging markets. Over the past decade, about 3500 offshore wells were drilled each year. Currently, offshore oil is produced in 30 countries. Qin et al. (2012) held that the only not so bad market in world vessels in 2012 is the marine engineering market. In the year of 2011, the marine engineering market has received a large amount of orders. The order book has increased by 300.3% compared to last year. Most of the orders are deep water platforms that have a work depth of 350 ft. And platform supply vessel and offshore support vessel have got the biggest increase in order books. The average annual investment for offshore oil and gas exploration and production would be up to 50 billions US dollar in the coming five to ten years.

Offshore supply vessels (OSVs) can be simply defined as the vessels that participate in the offshore energy exploration and production. They are known as the “workforce” of the offshore oil and gas exploration industry. OSVs include accommodation vessel, anchor handling towing supply vessel (AHTSV), diving support vessel (DSV), drilling vessel, platform supply vessel (PSV) and floating production, storage and offloading unit (FPSO). They are designed for moving personnel to, from, and between offshore installations and rigs; delivering supplies, equipment, fuel, water, and food; towing rigs and placing and retrieving rig anchors; and supporting offshore construction projects. The first specialized ocean supply vessel was built in 1955 in USA with small horsepower, short length and limited towing gears. In the middle and late 1960’s, with the development of oil and gas exploration in North Sea in Europe, this kind of vessel could not fulfill the requirement for working in a bad sea situation, the anchor handling towing supply vessel (AHTSV) has come to the picture with the ability of anchor handling and towage. With the market development, the ocean engineering fleet is growing rapidly. If calculated by the number of the vessels, the present new projects in OSV business have accounted for 9% of the global new project, which has not included the number of wind turbine installation vessels, heavy lift vessels, seismic vessels and other kinds. In 2012, OSV had 292 orders, in which PSV was the most demanded with 140 new orders. The following are AHTSV with 56 orders, then crew/fast supply vessel with 26 orders and multiple supply vessel with 24 orders. Meanwhile, the structural changes are also happening in the OSV market.

The AHTSV less than 12500BHP barely had new orders and PSV with more than 2000 DWT is more popular.

This change in the demand can be easily explained by the developing trend of ocean engineering industry towards deepwater offshore exploration and production. Deepwater (3000 m) drilling activity has grown over the past 15years. Now many market participants are focusing on the more lucrative deepwater segment. Despite the fact that deepwater drilling makes up a relatively small proportion (about 20%) of the number of offshore wells drilled, the deepwater market accounts for approximately two-thirds of market revenue. By the late 1990s, drilling technology had advanced to allow exploration in ultra-deepwaters, but few rigs were capable of drilling in water depths greater than 1500 ft. Contractors responded by upgrading existing rigs and ordering a limited number of floaters, the first of which were delivered in 1998. In recent years, regardless of the oil price fluctuation, the trend of offshore oil exploration and production towards deepwater had never changed. From the number between 1994 and 2009, deepsea oil production has been spiked since 2004. In the year of 2005, deepsea oil production was three million barrels per day and the number will be up to 6.7 million barrels per day in 2010. And after 2010, all the increase of offshore oil production will come from deepwater production. Although the exploration and production cost of deepwater offshore oil field is higher than shallow water offshore oil field, the exploration cost per unit is not so high because the average reserves and average daily production of deepwater oil field would be obviously higher than shallow water offshore oil field. In fact, the oil exploration costs for deepwater oil field and the cost for shallow water oil field are getting closer and closer. Since 1998, the cost for deepwater oil exploration per barrel has dropped from 6 USD to 4 USD in ten years. According to Cambridge Energy Research Associates (CERA), when the oil price fluctuates between 55 USD to 85 USD per barrel, deepwater oil project would have profit. And according to Douglas-Westwood, as long as the crude oil price fluctuates between 35 USD to 65 USD per barrel, deepwater oil project would produce economic benefit. And many authorities have forecasted that the possibility of crude oil price being more than 100 USD per barrel in 2013 is very high. KennedyMarr's offshore industry monthly report has also showed that in 2013, the Brent oil price moved between 107.5 USD and 111.6 USD in March, and averaged 110 USD over the last twelve months.

The expanding of offshore deepwater oil field certainly leads to the growth and booming of OSV market. According to Tiderwater, in the first quarter of 2009, the dayrate for shallow water fleet would be averagely 12.9 thousands USD per day, while this number is 27.6 thousands USD per day for deepwater fleet, more than two times the number for shallow water. This phenomenon has suggested that deepwater offshore projects had a huge growing potential. And Zhao (2013) also had mentioned that ultra-deepwater drilling ship and other OSV which serves mainly in deepwater offshore projects are in great demand.

With more focus are put on to the development of deepwater offshore oil field, simple and small powered AHTSV could not fulfill the requirement of ocean engineering industry. Therefore, diving support vessel (DSV) was designed to help the work in deepwater in both the search and rescue department and ocean engineering department. Commercial Diving Support Vessels emerged during the 1960s and 1970s. Most of the vessels currently in the North Sea have been built in the 1980s. The key components of the diving support vessel are:

(1) Dynamic Positioning (DP) - Controlled by a computer with input from position reference systems, it will maintain the ships position over a dive site by using

multi-directional thrusters, other sensors would compensate for swell, tide and prevailing wind.

(2) Saturation diving system - For diving operations below 50m, a mixture of helium and oxygen (heliox) is required to eliminate the narcotic effect of nitrogen under pressure. A saturation system would be installed within the ship. A diving bell would transport the divers between the saturation system and the work site. The support system for the saturation system usually includes a Remotely Operated Vehicle (ROV) and heavy lifting equipment.

Driven by high oil prices since 2004, the market for subsea developments in the North Sea has grown significantly. This has led to a scarcity of Diving Support Vessels and had driven the price up. In the Middle East, Zamil has been working on converting PSVs into specialized DSVs, due to their belief that diving and subsea support segment would be a growth opportunity for its development in the future. With the change from shallow water offshore oil field to deepwater offshore oil field, the DSV can be expected to be more and more important in the offshore oil field exploration.

1.2 Literature Review

1.2.1 Ocean engineering industry and OSV

Many researches have been done to study the problem that rose in the ocean engineering industry and OSV market. Antonsen (2009) had studied the relationship between culture and safety on offshore supply vessels and discovered a great deal of friction between aspects of culture and aspects of structure. In particular, there appears to be incompatibilities between the occupational culture on the vessels and the rule-based safety management approaches of the petroleum industry. Wang and Li (2012) had studied the electrical design of diving support vessels. Zeng(2007) had forecasted and analyzed the development of offshore specialized vessels. Zhou et al. (2011) had introduced the design and function of multi-purpose diving support vessel, for example, saturation diving, dynamical positioning, ROV remote detecting and heavy load lifting at sea. Fagerholt and Lindstad (2000) studied supply operations in the Norwegian Sea, and presented an integer programming model based on a priori generation of voyages. Hoff et al. (2010) presented a literature survey covering fleet composition and routing problems in both road-based and maritime transportation. Aas et al. (2009) discussed the role of supply vessels in the offshore logistics chain and tried to find the optimal supply vessel design that can serve their duties better. The routing problem arising in the service of offshore installations was studied by Gribkovskaia et al. (2008). The authors considered a single vehicle pickup and delivery problem with limited customers and limited storage capacity on the installations. Halvorsen-Weare et al. (2012) had helped the company Statoil to determine the optimal fleet composition of offshore supply vessels and their corresponding weekly voyages and schedules.

1.2.2 Investment appraisal review

There are many papers that related to the investment appraisal of a marine project or other industrial project, however in this paper, we will focus on the economic evaluation since this might be the most important problem that needs to be solved in today's depression.

In their paper, Chu and Xie (2003) had built up a mathematics model of technical and economical evaluation for LNG ship with Visual Basic language, developed a ship form evaluation software and gave the result of evaluation based on single-ship operation. In their analysis, the economic indexes such as net present value (NPV), internal return rate (IRR), required freight rate (RFR) and payback period (PBP) were chosen as the basic data and a sensitivity analysis was used to check the influence of vessel's price, fuel cost, freight rate, port cost and other factors. Baird and Rother (2013) had evaluated the floating container storage and transshipment terminal (FCSTT) from technical and economic perspectives. They outlined design options for a FCSTT including analysis of crane preferences. Based on assumed costs, traffic flows and revenues, the capital and operating costs for the FCSTT were estimated and cash flows were calculated. Doulgeris et al. (2012) had developed the method called Techno-economic, Environmental and Risk Analysis (TERA) computational method to evaluate the marine propulsion systems. The method comprises several numerical models which simulate the life cycle operation of marine gas turbines installed on marine vessels. Those modules include: ship module; propeller module; gas turbine module; weather module; hull fouling module; journey module; emissions module; turbine blade creep module; and life cycle cost and risk analysis module. This method is an integrated virtual marine vessel operating environment that allows the calculation of engine performance and exhaust emissions. The economic model predicts net present cost over the operating life of the vessel using stochastic analysis of the earning capacity of the ship powered by the chosen prime mover. The TERA simulation of a 25 MW marine gas turbine powering a RoPax fast ferry in an integrated full electric propulsion system is presented as an illustration of the method. Zhang et al. (2006) had carried out the technical and economic evaluation on 250TEU open container ship. The authors have used the software developed with Visual C++ language to tackle the problem. The software considered ship price, operation and used average annual cost, PBP, RFR, NPV as the economic indexes. The result had given the optimal scheme and the sensitivity analysis had shown that operating cost had the biggest influence on NPV, followed by ship price and unit fuel cost. Chen (2012) had set up a reasoning method and decision making model of economic evaluation of ship form based on gray relational analysis. The author took NPV, IRR, PBP, RFR and cost per ton (CPT) as economic indexes and used gray relational coefficient and weight calculated by analytic hierarchy process (AHP) to choose the optimal vessel form. Frankel & Stochastic (1992) used AHP method to make decisions on vessel design and vessel project management. All kinds of subjective and objective factors were considered to analyze the risk of subjective decision. Zhang et al. (2006) built up the multi-goal fuzzy decision model for choosing vessel form according to fuzzy pattern recognition theory. Entropy of information and personal preference were used to decide the weight of every vessel form scheme. Sang et al. (2002) used improved AHP method to help make decision on multi-goal vessel form scheme. Yang & Li (2008) used kernel principal component analysis method (KPCA) to find the optimal scheme for inland water dry bulk transportation vessel form and the method had been proved to be effective and practical. Li (2010) used the improved stepped-up chaos optimization algorithm in ship form decision demonstration and this method had been proved to be simple, practical, reliable, effective and accurate. Liu & Su (2009) built up multi-criteria comprehensive benefit measurement model for Yangtze River bulk cargo transportation organization mode and used AHP method to carry out the multi-variant multi-criteria tech-economic performance optimization and ship type investigation. Zhang et al. (2006) applied the fuzzy comprehensive appraising method in the technical and economic evaluation for design of the coastal oil products tanker. The authors chose ship NPV, average annual cost (AAC), RFR, IRR and PBP as economic indexes and found the optimal ship form scheme. Li and Song (2012) had done the economic evaluation for iron ore ship type coming from Brazil. And they chose to use ship price, RFR, NPV and total price as economic indexes and a sensitivity analysis was given in the end to analyze the risk.

1.3 The Framework and Content

The main goal of this paper is to discuss the economic appraisal of ocean engineering project, especially OSV. The discussion started with a brief introduction of ocean engineering project's history, development and status, followed by a introduction of investment appraisal, then a discussion about economic appraisal methodology. A case study would be performed to test if this methodology is reliable and effective. In the end, a conclusion and recommendation would be given. In order to illustrate the problem clearly, this paper would follow the following sequence: background of the question---description of the question---method to evaluate---application of the method in reality---conclusion.

In chapter one, a background of rising ocean engineering market and different kinds of specialized OSV was introduced. The trend of moving offshore oil field to deepwater was well noted and the resulting specialized OSV---DSV was presented. Afterwards, a literature review about previous studies on ocean engineering market and OSV was given. And the introduction about former researches on investment appraisal, especially economic evaluation, was delivered to give a general idea about this field. At last, a framework of the dissertation would be presented.

In chapter two, investment appraisal of ocean engineering project would be introduced. First of all, the features of economic evaluation of ocean engineering project would be referred to. Then the indexes and standards that can be used to evaluate the economic investment feasibility would be recommended. Lastly, the influencing factors and risks would be described.

In chapter three, detailed economic appraisal methodology would be pictured. First of all, what would be useful data and how to get them would be introduced. Secondly, economic evaluation methodology would be decided based on previous researches and data availability. At last, the method that could be used to evaluate risks would be described.

In chapter four, a case study about economic appraisal of DSV for a particular company would be executed. The background of the company, the timing of purchasing one DSV and the DSV's specifications would be introduced. Afterwards, a description about how the data was collected and how to apply them into the method mentioned in chapter three would be given. And the result and risk would be analyzed subsequently.

In chapter five, a summary and conclusion based on this paper's investigation was presented and author's recommendation about future researches on economic appraisal of ocean engineering project would be given.

Chapter 2 Investment appraisal of ocean engineering project

Although there are many researches that have been done to study the economic evaluation of marine project, most of them focused on more conventional vessel types, for example, container ship, bulk cargo vessel, very few of them had tried to study the evaluation of ocean engineering project, not to mention OSV. Hereby, we tried to investigate the features, indexes, standards, risks and influencing factors of economical evaluation of ocean engineering project.

2.1 Features of investment appraisal of ocean engineering project

2.1.1 Features of ocean engineering project investment

Compared with onshore engineering projects, ocean engineering projects has longer manufacturing cycle, bigger risk, more specialized design, bigger investment, higher payback, bigger growth potential and higher technical requirement. All the characters of ocean engineering project had made the investment in ocean engineering project different from the investment in onshore engineering project.

Ocean engineering project investment is one of the investment types of shipping companies, it has some common features of general investment, but also has some specialties that are unique for ocean engineering. The primary features are:

(1) The amount of investment is relatively huge. Nowadays, newbuilding ships appear to be bigger and bigger and the shipbuilding cost also becomes higher and higher. For example, in April 2013, Fafnir Offshore of Iceland has ordered an Ice Class B PSV of Havyard 832L WE design from Bergen Group, which cost 57 million USD. Meanwhile, one newbuild 350 ft jack-up rig would cost 210 million USD and one newbuild 10000ft+ drillship would cost 655 million USD in March 2013. In order to have sufficient equipment for exploration and production, ocean engineering company needs a big amount of capital to invest in rigs, vessels and other corollary equipments.

(2) The payback period would be relatively long. Due to the high technique, longer manufacturing cycle and specialized design, the manufacture of ocean engineering project would take longer time than ordinary project. And the time from design, ordering, fabrication, delivery, working until payback would take more than ten years, if not longer.

(3) Technical progress would have a great influence on the return of investment. Because of the highly specialized design and high technical requirement, the manufacture, employment, deployment, maintenance and life cycle would be heavily affected by the technical situation of contemporary society. The higher technique being used, the longer life cycle and wider deployment range the equipment will usually have. At present, the vessels without DP system are not popular in the OSV market since many deepwater programs are demanding this system to make the vessel stable in the open sea.

(4) High risks and high uncertainties. Since ocean engineering project and its ability of making profits would be affected greatly by international trade, international relationship and price of petroleum, the investment in this business would carry more risks than onshore project. Emergency among countries would have an unexpected and immediate effect on the function and running of ocean engineering project and therefore, the payback of the investment. Besides, the foreign exchange rate change would also have a huge effect on the investment project since many companies are using the currency other than their own national currency to settle accounts, such as US dollar and Euro. Meanwhile, since ocean engineering project has long payback period, it is more vulnerable to the unexpected change of market. In addition, the reliability on technical development made ocean engineering project more sensitive to technology evolution. A more advanced technique might obsolete old technique and old equipment. Therefore, investment in ocean engineering project would carry more risks and more uncertainties.

2.1.2 Features of economic evaluation of ocean engineering project

Due to the difference of ocean engineering project investment from other project, the economic evaluation of ocean engineering project has its own characters. The characters are summarized as follows:

(1) The evaluation should be careful and thorough. Since the investment in ocean engineering project carries properties like high risks, high uncertainties, high technical demand and big capital requirement, the economic evaluation in advance must be done with careful thinking and thorough consideration of the whole picture. The more effective indexes are chosen, the bigger picture would be revealed and the more accurate information would be obtained. In order to get an overall view of what

result this investment would bring, more indexes should be evaluated from different aspects.

(2) The evaluation should consider investment's long term return. Owing to the relatively longer manufacturing time and payback period, the evaluation should not be confined to short term observation. In order to get the maximum profit, the evaluation should not just consider the manufacturing market and spot rate at that time, but also should take the forecast of international trade, international relations, oil and gas market, equipments' spot rate in two, five and ten years into account. Now the depression of shipping market was largely due to the overbuilt of vessels before 2008 which was the result of not considering the long term result.

(3) In the evaluation of investment, the market change should be given some consideration and certain room should be kept in the calculation for the possible change in the future. For example, instead of using normal 12% as IRR, 15% or even 18% can be used as the benchmark for IRR. In this way, the possible future downtime, idle time induced by technical progress, foreign exchange rate change and other unexpected loss to the profit would not make a significant damage or change of the evaluation result.

(4) Technical factors should better be considered in the economic evaluation. Some high technique might cost a fortune, but they are commonly utilized and will be used in a very long time, when investment of this kind of technique are to be evaluated, certain attention should be given. Meanwhile, when some other equipment is to be built, but with low technical standards which can be obsolete in near future, investment into this equipment should be evaluated very carefully. Only when the profit will be certain to get when the equipment is delivered, this device is worth investing into.

2.2 Investment appraisal indexes and standards

The ultimate goal and mission of a company is to make profit, which is the same case regarding ocean engineering investment company. Therefore, the appraisal of investment in ocean engineering project would contain two parts, qualitative analysis and quantitative analysis. Qualitative analysis would be determining if this project is worth investing at first place. The evaluation indicator would include but not limited to the following: the market situation, the utilization rate, feedback from users, technical advancement. And quantitative analysis would be detailed analysis for the project with mainly economic traits involved. Economic indicators can be: NPV, IRR, PBP, AAC and so on.

2.2.1 Qualitative analysis

If the market of certain ocean engineering project is in its period of rising and still has a great potential to grow in the future, then this project will probably have high spot rate or charter rate when it is delivered and the investment in this project will get pay back. On the contrary, if the project belongs to a declining market and a new technique has already shown some signs of replacing the old technique, then this project is not suitable to be invested on.

If the utilization rate of this ocean engineering project is high, which means that it is in great demand and it is possible that it is still in demand when the project is delivered, in this case, the investment can be proved to enter the quantitative analysis stage. But if the utilization is particularly low, it means that this project is in very low demand and is oversupplied. In the second case, the investment in this project can be held and further analysis would be only necessary when new information is given.

As an investment company, the feedback from customers is very important. And by contacting and communicating with customers and end users, investment company should be able to have a general idea about what is needed in the market and what is the rising market. Therefore, decision on investment can be made wisely and the needed project can go to the next stage of evaluation.

With technology development, if an ocean engineering project is using a new, advanced and reliable technique, then it is very likely that it will be in urgent need when it is delivered. And investment project like this should be passed to the quantitative analysis. But if a project employed some old-fashioned and outdated technique, then the chance the equipment would be employed after delivery would be very low and investment in this project might not get payback.

2.2.2 Quantitative analysis

Before 1970, the appraisal of an investment project used rate of return on investment (ROI) and static PBP to be the indicators. After 1970, with more realization of time value, dynamic analysis was invented and indexes such as NPV and discounted PBP were employed. Currently, in vessel's investment project, breakeven point method, sensitivity analysis method and probability analysis method are used to evaluate the risks. Breakeven point method focuses on the profit and loss range of vessel's shipping volume, freight rate and operating cost and investigates the risks under different uncertain factors. Sensitivity analysis adopts IRR as main indexes, and tests the influence of ship price and capital cost on IRR. Probability analysis and decision tree method are also often used in decision making.

To better evaluate the ocean engineering project, economic indexes such as: NPV, IRR, PBP and ROI can be employed and sensitivity analysis could be used to assess risks.

In order to make sure that the company makes profit from the project, net present value (NPV) should be more than zero. Money has a time value as an amount of money held now worth more than an equal amount to be held in the future. This is particularly true when inflation significantly reduces the value of money over time. NPV is the sum of net cash flows discounted by discount rate. Only when NPV is positive, the investment project is worth investing. It means that the capital invested generates more returns than investing the same amount in a bank account with an interest rate equal to bank interest rate. If NPV is not positive, then this investment would generate just the same or even less return compared with putting the money in a bank. The company would earn the same or less money with carrying more risks. In this case, the investment is not economically feasible for a company. The main advantage of NPV is that it considers money's time value and the main disadvantage is that the selection of discount rate is always a problem. Normally, the London interbank offer rate (LIBOR) is used as the selected rate. And another disadvantage of NPV is that it can be only used to compare projects with similar size and risk.

The internal rate of return (IRR) is deprived from NPV. IRR is the discount rate for which NPV is equal to 0. An investment is eligible if the IRR exceeds the interest rate of return the company can expect from another investment. The advantages of IRR are that it is closely related to NPV and easy to communicate as expressed in %. However, there are situations that NPV and IRR rankings conflict with each other for some discounted rates. In those cases, normally, NPV will give more information and is a more powerful tool.

Payback period (PBP) is the time required for the return on an investment to repay the sum of the original investment. It is easy to calculate and useful in measuring capital rationing situations. It can also avoid long term forecasting. However, PBP does not consider the cash flows arising after pay back time. And it lacks an arbitrary cut-off point on what is the optimal payback time. This cut-off point can only be decided by individual company and no general rules to follow. It is generally agreed that this index for investment calculation should not be used in isolation and NPV and IRR can be useful companion. In reality, normally discounted PBP is used which considered the time value of money.

ROI is one of measurement for the return on capital employed. The return on capital employed is the ratio of the accounting profit generated from an investment to the required capital outlay. The accounting profit is generally taken as the profit after depreciation and before taxation and interests (EBIT). The required capital outlay can either be the initial capital employed (Return on investment- ROI) or to the average capital employed (Rate of Return- ROR). ROI is easy to be understood and to be communicated as expressed as %. However, ROI needs an arbitrary benchmark and it does not consider the time value of money. PBP and ROI are usually used in conjunction, but after 1970's, inflation has called for the use of alternative tools that take into account the time value of money.

2.3 Influencing factors and risks

2.3.1 Influencing factors

Due to the features of ocean engineering project investment, it can be affected by many factors. The main influencing factors are: capital cost, financing cost, cash flow, ownership, market forecast and technical development.

(1) Capital cost. The price of manufacturing certain project is important when a decision has to be made. If two projects will make similar returns, then the less the

capital cost is, the better investment is. Especially in today's market, every company has to face the problem of capital shortage.

(2) Financing cost. It is also known as cost of finances. It is the cost of the interest and other charges involved in the borrowing of money to build or purchase equipment. Since ocean engineering project normally involved millions of US dollars, it is quite common that companies would use ways like initial public offerings (IPO), bond financing, bank loans, government loan and internal financing. The mode and timing of financing would have an influence on the economic evaluation of investment.

(3) Cash flow. There are two important indicators that will suggest the operation status, profit and cash flow. In reality, sometimes the equipment's price almost equals to the capital cost plus the financing cost, in this case, cash flow will be the determining factor.

(4) Ownership. Due to the different financing modes, the ownership of the ocean engineering project can be different. Because of the unpredictability of the market, the price of the equipment can be changed dramatically at any time. So the accurate assessment of the market and the company's situation would help to make the right decision on ownership, which will affect the result of the investment.

(5) Market forecast. Although the market of ocean engineering is unpredictable, it is still possible for a company to use market data to deduce some opinions about the market's future. The forecast of market would influence heavily the investment decision. A rising market would definitely be a positive sign for certain investment.

(6) Technical development. Ocean engineering project investment relies heavily on high technique. Therefore, the development of technique in ocean engineering

industry would influence greatly the investment. Some modern and advanced technique would certainly make the related investment a success, however, outdated technique would make the investment less attractive and carry a big risk of being not able to get payback.

2.3.2 Risk analysis

Risk is the potential that a chosen action or activity will lead to a loss. For the ocean engineering project investment, risks can come from everywhere due to the big capital occupation, long payback time and unexpected market change. The main risk that will affect the investment would be as following:

(1) The great volatility of oil price. Oil price has a big impact on the cost of ocean engineering project exploration and production. Although thanks to technology development, the production cost of offshore oil has been down to 4-6 USD per barrel of oil equivalent (BOE) and offshore oil exploration and production will make a profit as long as the oil price is about 60 USD per barrel, oil price's hover in the low price will severely affect the pace of new orders' delivery. And low oil price will make the demand of ocean engineering facilities stay lower than expectation.

(2) Internal or national digestion of the orders. For the moment, more than 80% of the global ocean engineering equipment orders came from national oil companies. More and more countries came to realize that the significance of import substitution rate or so-called "localization rate of parts and components". It means that to replace foreign imports with domestic production. For example, the big order for ocean engineering project from Petrobras has very clear requirement for import substitution rate, which is 50% at the first stage and will be increased gradually. Korean and Singapore shipyards started investing in or taking over local Brazilian shipyards, while nothing has been heard from Chinese shipyards. On the other hand, three big

oil companies have started investing in their own ocean engineering equipments manufacturing base, for example, Qingdao base of China National Petroleum Corporation (CNPC) and China National Offshore Oil Corporation (CNOOC). And their further orders would be more awarded to their own affiliated companies.

(3) Overcapacity came from the overheating construction of ocean engineering projects. When shipping market and shipbuilding industry experienced a big depression, many shipbuilding and shipping companies started investing in ocean engineering project and wanted to use ocean engineering industry as their refuge. Meanwhile, heavy machinery firms and downstream ocean engineering service companies also started to step into this field. In fact, ocean engineering industry carries high risk, big capital requirement, high technique and accumulated experiences. Without sophisticated research and design capability and long term experiences, entering this industry blindly will only produce oversupplied capacity in the lower-end of the market. The whole level of this industry will not be raised in this way.

(4) The fragility of spot rate or charter rate of rigs, vessels or other equipments. Rate of rigs, vessels and other equipments can be changed dramatically and unexpectedly, especially spot rate. Even the charter rate is more stable in a short term, it is not stable for a long term. After completing every charter party, the rig or the vessel needs to find a new charter party to work in. And in depressing market, charter parties will not be so easy to be found, therefore, the income or the profit of ocean engineering project will be vulnerable.

Chapter 3 Economic appraisal methodology

3.1 Economic evaluation methodology

To better evaluate the economic feasibility of an investment, cash flow and profit should be considered at the same time since they both are very important indicators for the operation of a project or a company. For evaluating cash flow and profit, several economic indicators would be used to evaluate economically the ocean engineering project investment feasibility. The author would employ NPV, IRR, discounted PBP and ROI in the economic evaluation. ROI does not consider the time value of the money and they are commonly used in the past, while NPV and IRR are more commonly used in recent years and they take the time value of money into account. A general and comprehensive picture is expected to be drawn after the analysis.

(1) Net present value (NPV)

NPV is a central tool in discounted cash flow (DCF) analysis and is a standard method for using the time value of money to appraise long-term projects. NPV compares the present value of money today to the present value of money in the future and it considers inflation and returns. Each cash inflow/outflow is discounted back to its present value (PV). Afterwards, all the PVs are summed. Therefore NPV is the sum of all terms. PV is calculated by the following formula,

$$\frac{R_t}{(1+i)^t}$$

where

t- time of the cash flow

i- the discount rate

R_t- the net cash flow i.e. cash inflow – cash outflow at time t.

The discount rate is the rate of return that could be earned on an investment in the financial markets with similar risk. It normally used LIBOR or weighted average cost of capital (WACC) determined by each firm.

Given the (period, cash flow) pairs (t,R_t) where N is the total number of project life, the net present value NPV is given by:

$$\mathrm{NPV}(i,N) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t}$$

In this formula, the usual initial investments during the first year R_0 are summed up as a negative cash flow.

NPV is an indicator of what value an investment or project adds to the firm. With a particular project, if R_t is positive, the project is in the status of positive cash inflow at the year t and may be accepted. If R_t is a negative value, the project is subtracting value from the firm and should be rejected. Regarding projects comparison, if there is a choice between two mutually exclusive alternatives, the one yielding the higher NPV should be selected, theoretically. And when NPV equals to zero, the project adds no monetary value to the company and decision should be based on other criteria such as strategic positioning.

(2) Internal rate of return (IRR)

IRR is the discount rate at which the present value of all future cash flow is equal to the initial investment. The term *internal* refers to the fact that its calculation does not incorporate environmental factors such as interest rate or inflation. IRR is commonly used in evaluating the desirability of investment or projects. The higher a project's IRR is, the more desirable it is to undertake the project. Because IRR is a rate quantity, it is an indicator of the efficiency, quality or yield of an investment. On the contrary, NPV is an indicator of the value or magnitude of in investment.

An investment is considered acceptable if its IRR is greater than an established minimum acceptable rate of return which is different in every company. When NPV is zero, the discount rate is IRR. Given the (period, cash flow) pairs (n, C_n) where n is a positive integer, the IRR is given by r in:

$$\mathrm{NPV} = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n} = 0$$

As an investment decision tool, the calculated IRR should not be used to compare mutually exclusive projects, but only to decide whether a single project is worth investing in.

(3) Payback period (PBP)

Normally, PBP is not considered a useful tool for investment evaluation when it is used alone. PBP does not specify any required comparison to other investments. It is preferably used together with NPV and IRR. PBP can also be defined as the quotient of amount to be invested over estimated annual net cash flow. Hereby, we adopt discounted PBP into consideration. Discounted PBP is the number of years after the initial investment at which the first positive value of cumulative cash flow occurs.

When calculating the discounted PBP, normally it is the year number that first positive NPV happens. It can only give the general idea about how long it would take to get the initial investment back.

(4) Return on investment (ROI)

As a performance indicator, ROI is used to measure the efficiency of an investment or to compare the efficiencies of several different investments by comparing the return on money with capital outlay. It is one way of measuring profits in relation to capital invested. ROI provide a snapshot of profitability and it was agreed very useful by 77% interviewee in a survey of nearly 200 senior market managers.

The return on investment can be calculated as:

$$ROI = (EBIT\ p.a/Initial\ Capital\ Employed) \times 100$$

EBIT is the profit after depreciation and before taxation and interests. It can also be net profit instead.

PBP and ROI are usually used in conjunction to better work as indicators. However, the effect of inflation can only be shown by the use of NPV and IRR.

3.2 Data collection

In order to calculate NPV, IRR, PBP and ROI, certain economic data have to be obtained. Those economic data includes: project life span, initial capital expenditure, discount rate, day rate, working days per year (expected), earnings per year, fixed operating cost, variable operating cost, net cash flow, depreciation and bunker price.

Project life span, initial capital expenditure, expected time charter rate, expected working days per year, fixed operating cost, variable operating cost and depreciation can be found in similar equipment operating company's annual report, financial report or proposals for similar projects. Besides, these information can be acquired by talking to manager who knew similar projects or the industry well.

For discount rate, both (LIBOR + risk margin) and the interest rate of the loan can be employed here. And the latter would be a better choice compared to the former one since it contains both the interbank offer rate and the actual risk margin.

Bunker price can be found from certain website that offers the price of IFO180, IFO380, MDO and MGO for the main port globally.

Earnings per year and net cash flow for every year can be calculated from the data obtained above according to accounting and financial principle.

3.3 Risk analysis methodology

There are mainly three methods to analyze the risk that an investment might bring, which are break-even analysis, probability analysis and sensitivity analysis.

(1) Break-even analysis

Break-even analysis analyzed the workload volume of the equipment when break-even point is met during the operation of the equipment. The calculation formula is

$$Q_E = \frac{F}{p - v}$$

Q_E: Equipment's annual workload volume when break even

F: Annual fixed operating cost

V: Variable operating cost

P: Day rate

The utilization of equipment's operation ability can be calculated as:

$$E^* = \frac{Q_E}{Q_C}$$

E*: The utilization of equipment's operation ability

Qc: The maximum quota of operation ability

E* reflected the risk resistance capacity of the investment project. The smaller E* is, the stronger capacity the project will have to adjust to the market change, the bigger risk resistance capacity the project has.

(2) Probability analysis

Probability analysis is a way that employs probability to study the influences on project investment decision of all different kinds of factors and risk factors. Normally, the cumulative probability of NPV when NPV is positive and zero is used as the indicator for risks. The bigger the cumulative probability is, the smaller the investment risk is.

Due to different probability distribution patterns, probability analysis can use normal distribution image method or decision tree method. The former will resort to normal distribution theory and the latter would seek help from drawing a decision tree.

(3) Sensitivity analysis.

In all three methods, sensitivity analysis is the most popular and effective method. Sensitivity analysis is the study of how the uncertainty in the output of a mathematical model or system (numerical or otherwise) can be apportioned to different sources of uncertainty in its inputs. In investment appraisal, sensitivity analysis is the study of the degree of variability of project's economic effect evaluation indexes caused by the change of one or more uncertain factors. In an investment, the investors need to know which factors would affect the development of the project, how big this effect will be and the biggest variable range of factors if the anticipated profit is met. And sensitivity analysis could answer those questions. The factors that have a bigger influence on profit would carry a higher degree of sensitivity and the factors that have a small influence on profit would carry a low one. The high sensitive factors are crucial to investment evaluation and risk control since they have a relatively significant influence on operation and profit. At present, most of the project risk evaluation relies on sensitivity analysis in China and in one of the outlines of project evaluation released by Chinese National Development and Reform Commission, sensitivity analysis was required specifically. Meanwhile, in the Economic Evaluation Methods and Indexes for Construction Project published by Chinese State Development Planning Commission, sensitivity analysis was stipulated as the main method for uncertainty analysis. The major influencing factors includes: unit price, unit variable cost, sales volume, fixed cost, initial investment and so on.

Sensitivity analysis would be used as the method to analyze risks in the economic evaluation of ocean engineering project since it is well recognized and proven to be effective.

There are many different ways to complete sensitivity analysis, but most procedures adhere to the following outline:

(1) Quantify the uncertainty in each input (e.g. ranges, probability distributions).

(2) Identify the model output to be analyzed (the target of interest should ideally have a direct relation to the problem tackled by the model).

(3) Run the model a number of times using some design of experiments, dictated by the method of choice and the input uncertainty.

(4) Using the resulting model outputs, calculate the sensitivity measures of interest.

In our economic evaluation risk analysis, the sensitivity coefficient equals to the induced change of economic indicator over the change in specific factor. By rule, the variable range of influencing factor would be positive and negative 20%, 10% and 5%.

In order to find the most sensitive influencing factor, the sensitivity coefficient of every factor under the same variable range should be compared. The bigger the sensitivity coefficient is, the more sensitive the factor is. In other words, the same percentage change in this factor would induce bigger change in economic indicators.

In ocean engineering project, the author would choose initial vessel price, bunker price, day rate for ocean engineering operation and discount rate four factors to analyze the risk of this investment since they represent separately the effect from the fixed cost, variable cost, market situation and financial status.

Chapter 4 Case study---DSV

4.1 Background of the case

Company A was established on September 1974. It's an institution responsible for its own losses and profits and meanwhile it undertakes the governmental non-profit functions of property salvage, wreck removal, oil spill recovery and etc. in North China Sea. It also is the largest marine salvage and ocean engineering contractor in North China. The company owns more than 20 vessels of mainly AHTS vessels and most of them working in heavy cargo lifting/transportation or ocean engineering market in the pre-crisis time. However, with the shipping market depression we have mentioned before, the transportation market has been down, nearly to zero, and the department has decided to devote more in the ocean engineering market. But recently, the company has faced the problem that their vessels seem to be unfavorable by the customers, mainly offshore oil companies. And there are two vessels which were built last year were almost never chartered out since the delivery. Knowing that Chinese offshore oil and gas exploration and production are developing towards the deep sea from shallow water, and with talks with offshore oil company employees and the overview of the OSV market, the company has been considering whether or not to introduce a new type of vessel---diving support vessel (DSV) which can be used in deep water platform supply and search and rescue.

DSV is used as a floating base for professional diving projects below or around oil production platforms and associated installations. With more and more offshore oil field are moving far away from the land, DSVs are expected to be in great demand since they can be useful tools for multiple operations and have strong sustainable capacity.

The main specifications for the DSV that the company is planning to introduce are as follows: overall length: 125.7m, molded breadth: 25m, molded depth: 10.6m, designed draft: 7.2m, DWT: 7000 t, duration: 60 days, DP-2, one full revolved 140t crane, one 300m saturation dive system and one 3000m ROV system. The DSV will be able to work in the sea with 60m-3000m water depth which covers almost all the Huang Sea, Dong Sea and Nan Sea. After delivery, the DSV is expected to be able to accomplish the following tasks: deepwater rescue and salvage, deepwater tanker salvage and spilled oil recovery, subsea military facilities installation, maintenance and dismantlement, deepwater oil and gas field subsea facilities' installation, maintenance and removal.

4.2 Data collection

By communicating with certain people, a similar project proposal that is related to the DSV investment project was obtained and certain information was acquired and calculated (see Table 1). Initial capital investment would be 630 million RMB, in which 70% will be invested by state and 30% will be invested by the company. The 30% of investment would come from bank loans. The project life would be 18 years. Internal standard rate of return of the company is 12%.

For discount rate, we have considered both LIBOR and the interest rate of the bank loan. If LIBOR would be adopted, then the discount rate would be 1% (averaged LIBOR, relatively low at this moment) + 3% margin charged by the bank for the risk bank has to carry, 4% in total. However, the interest rate of bank loan is 6.1%, which has already included interbank offer rate and the actual charged risk margin. Therefore, 6.1% would be employed in this appraisal. For bunker price, we would adopt the rate from online resource and MGO rate in Shanghai would be used. However a premium would be given by 10% as preparation for the unexpected change of bunker price. So the bunker price is calculated by 7173RMB per ton.

Table 1 Annual income and cost estimation of DSV

No	Item	In 10,000	Remark
	Ocean engineering	16500	RMB 0.5 million × 330 d
	Total income	**16500**	
1	Crew	1179	
2	Bunker cost	1784	
3	Material	315	Vessel price×0.5%
4	Maintenance	945	Vessel price×1.5%
5	Insurance	756	Vessel price×1.2%
6	Management	825	income×5%
7	Depreciation	3500	Straight line depreciation
8	Tax	561	income×3.4%
9	Financial cost	608	Interest rate 6.1%
	Total	**10473**	
	Profit	**6027**	

4.3 Methodology application

With all the data collected and the methods introduced above, the methodology would be applied. To calculate economic indicators, several functions in Excel would be used to simplify the calculation. For the calculation of NPV, the function NPV (discount rate, cash flows before discounted of every year)-initial capital expenditure was used. For IRR, the function IRR (all cash flows including initial investment) was used. And for ROI, the result of EBIT over initial capital expenditure was employed. Discounted PBP was recorded as the first year when cumulative cash flow is positive. By inputting all the available data into Excel file according to accounting and finance principle (see appendix 1), the author is able to get result from Excel file. And after the calculation, the result would be as follows:

Table 2 Analysis result of economic indicators

NPV	￥393,792,931
IRR	13.60%
PBP	7y
PBP discounted	9y
ROI	10.46%

After 18 years, the NPV of this project would be about 393 million RMB, which is way more than zero and positive. The IRR would be about 13.60%, which is more than the company's required internal rate of return 12%. And ROI would be about 10.46%, which means that, without considering time value of money, every one hundred RMB investment would get about 10.5 RMB back as profit. PBP would be 7 years and discounted PBP would be 9 years. Without counting the time value of money, the investment would be repaid in 7 years. And the investment in this DSV will be repaid fully in 9 years considering the time value of money. Therefore, it can be suggested that this project is well repaid, has big potential to make profit in the future and is worth putting money in if the market status keeps the same. However, what if the market status change in the future, will it influence the investment evaluation a lot, if yes, which indicator would be affected a lot and which factor would have the most significant impact? Risk analysis would answer these questions.

4.4 Risk analysis and result analysis

After changing vessel price, bunker price, dayrate and discount rate in the range of 20%, 10% and 5%, NPV, IRR, ROI and discounted PBP were calculated separately (see Appendices 2,3,4,5) and the results are listed as follows:

Table 3 Sensitivity analysis of effect of vessel price on economic indicators

vessel price	NPV	IRR	ROI	PBP discounted
20%	211383717	9.63%	7.09%	13y
10%	302588324	11.48%	8.62%	11y
5%	348190628	12.50%	9.50%	10y
-5%	439395235	14.79%	11.52%	9y
-10%	484997539	16.09%	12.70%	8y
-20%	576202146	19.08%	15.50%	7y

Table 4 Sensitivity analysis of effect of bunker price on economic indicators

Bunker price	NPV	IRR	ROI	PBP discounted
20%	355438203	12.92%	9.89%	10y
10%	374629102	13.26%	10.17%	9y
5%	384197823	13.43%	10.31%	9y
-5%	403388721	13.77%	10.60%	9y
-10%	412957442	13.93%	10.74%	9y
-20%	432148341	14.27%	11.02%	9y

Table 5 Sensitivity analysis of effect of dayrate on economic indicators

dayrate	NPV	IRR	ROI	PBP discounted
20%	718646041	19.06%	15.43%	7y
10%	556219486	16.38%	12.94%	8y
5%	475006209	15.00%	11.70%	8y
-5%	312579654	12.16%	9.21%	10y
-10%	231366376	10.67%	7.97%	12y
-20%	68939821	7.53%	5.48%	16y

Table 6 Sensitivity analysis of effect of discount rate on economic indicators

R	NPV	IRR	ROI	PBP discounted
20%	306539845	13.60%	10.46%	10y
10%	348667867	13.60%	10.46%	10y
5%	370839740	13.60%	10.46%	9y
-5%	417561494	13.60%	10.46%	9y
-10%	442181179	13.60%	10.46%	9y
-20%	494125997	13.60%	10.46%	9y

In order to be more intuitively and visualized, a graph was drawn to show different influences of four factors on economic indicators. The line with steeper slope can be identified as the most sensitive in these four factors whose unit change would induce the biggest change in economic indicator compared with the other three factors. And the line with gentler incline means the factor is not so sensitive to particular economic index compared with three other factors.

From the graph of effect of four factors on NPV, we can clearly see that the steepest line was the line from dayrate and the gentlest line was the line from bunker price.

Therefore, it can be concluded that among vessel price, bunker price, dayrate and discount rate, dayrate was the most sensitive factor and bunker price was the least sensitive factor. In other words, day rate has the biggest influence on NPV per unit change and bunker price has the least impact on NPV. This result can be easily understood since day rate is the source of income and it generates profit and is used to pay back the loan, its level is related to the earning status of the investment directly and closely. On the other hand, since ocean engineering project is used to produce oil and during ocean engineering operation, the oil company normally pays the bunker price to the company and the influence of bunker price on the project's running and investment would be the smallest compared with other three variables.

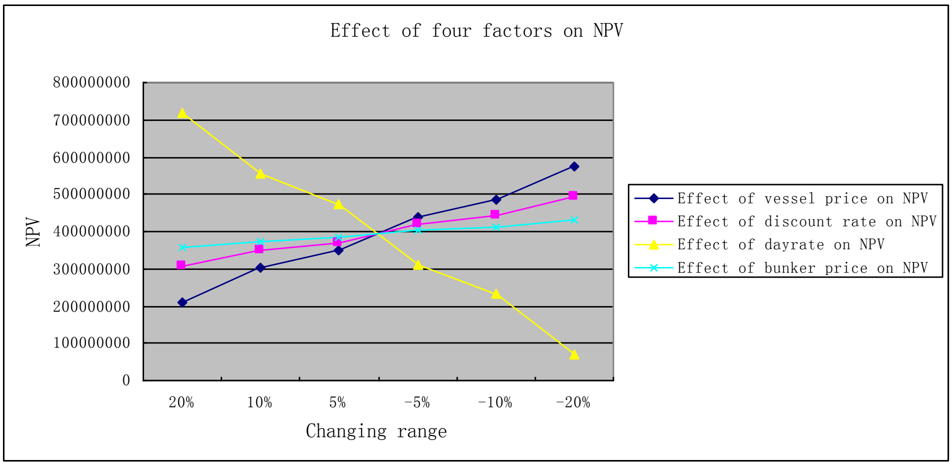

Figure 2 Sensitivity analysis of four influencing factors on NPV

And the graph for IRR had shown the similar pattern, only that discount rate will not influence IRR, so it is a flat line. After adding trend line to the figure, it was found that the formula of dayrate is $y = -0.0222x + 0.2123$ and $R^2 = 0.9905$ and the formula of vessel price is $y = 0.0181x + 0.0759$ and $R^2 = 0.9812$. Therefore, compared with vessel price, dayrate is still the most sensitive influencing factor. With discount rate eliminated, the graph shows that dayrate has the steepest slope and bunker price has the gentlest incline. In other words, day rate is the most sensitive factor for IRR and has the biggest impact on it and bunker price is the least sensitive factor for IRR and has the smallest influence on it. Meanwhile the company's required internal rate of return is 12%. Only when vessel price increased by 10% and 20% and day rate decreased by 10% and 20%, the IRR is below the required number. It suggested that every unit change of day rate would affect the IRR most significantly and vessel price also has certain effect on IRR.

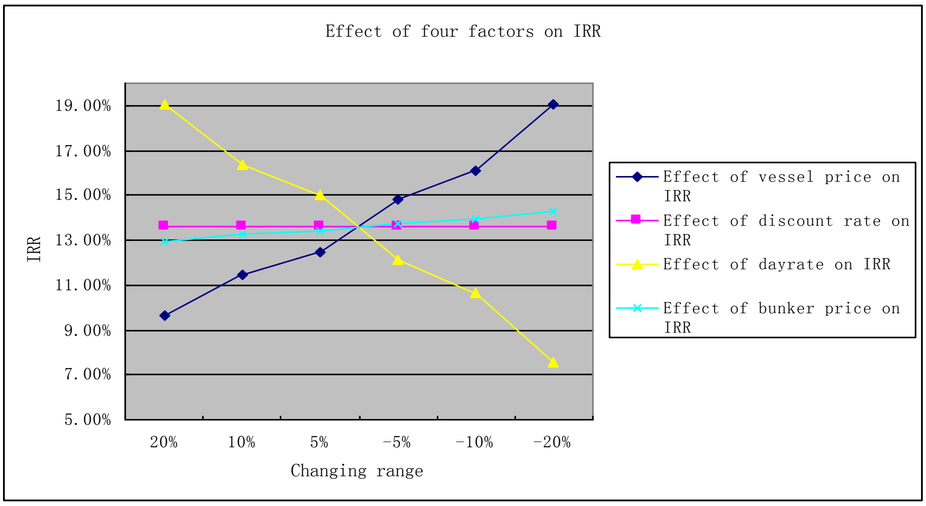

Figure 3 Sensitivity analysis of four influencing factors on IRR

The result did not change much when it comes to ROI. By adding trend line to the picture, it can be found that the formula for dayrate is y = -0.0192x + 0.1717 and R^2 = 0.9918 and the formula for vessel price is y = 0.0161x + 0.0519 and R^2 = 0.9758. Dayrate still have the most significant influence on ROI, then vessel price and bunker price. Discount rate is a flat line again since it doesn't affect ROI. Discount rate has no influence because ROI does not consider the time value of money. Day rate, as the source of income and profit, plays a significant part in influencing ROI. And vessel price, as the initial capital expenditure, plays a less significant, yet clear part in affecting ROI.

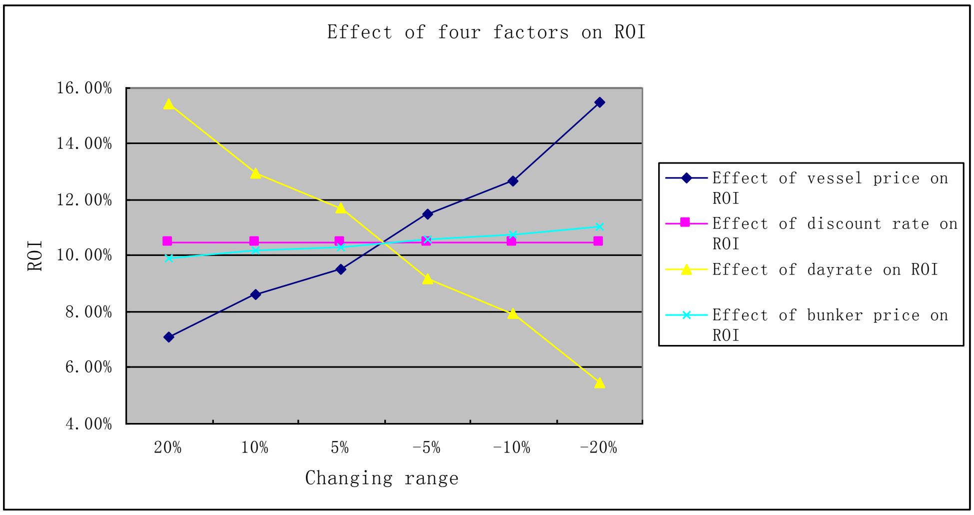

Figure 4 Sensitivity analysis of four influencing factors on ROI

Refer to discounted PBP, after adding trend line to the dots, we can find that the formula for dayrate is y = 1.6857x + 4.2667 and R^2 = 0.875 and the formula for vessel price is y = -1.1429x + 13.667 and R^2 = 0.9796. Dayrate still is the most sensitive factor and has the most significant effect on discounted PBP. The less sensitive factor is vessel price and bunker price and discount rate are not sensitive factors. The more the income is, the shorter the payback period is. The higher the vessel price is, the longer the payback period is. Bunker price and discount rate do not have clear influences on discounted payback period.

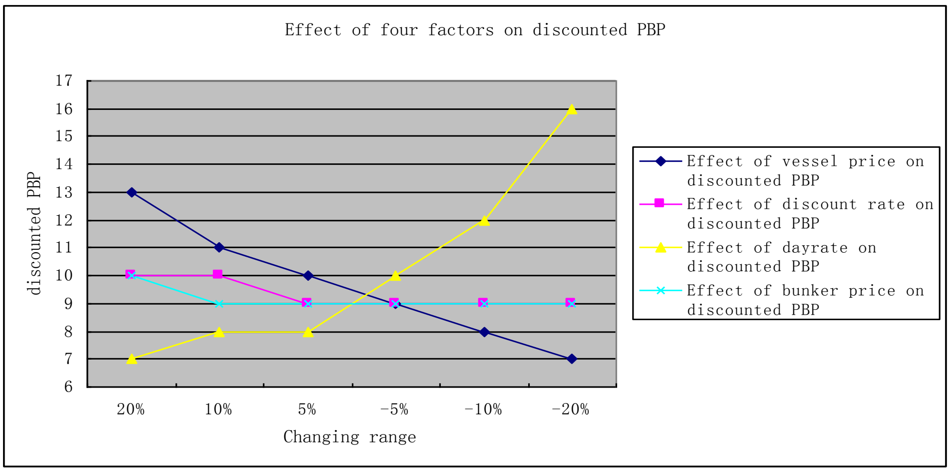

Figure 5 Sensitivity analysis of four influencing factors on discounted PBP

The result of the risk analysis showed that dayrate is the most sensitive influencing factor compared with other three and its change will induce significant change in the economic indicators. The second sensitive factor is vessel price which actually stands for initial capital expenditure. And bunker price and discount rate does not have significant effect on economic indicators. In other words, daily income and initial capital expenditure are relatively sensitive factors in terms of DSV's economic evaluation and their levels have significant influences on the ocean engineering projects' appraisal. This result shows differences from the result of other marine project economic evaluation. The result of the research conducted by Zhang et al.(2006) showed that operating cost had the biggest influence on NPV, followed by ship price and unit fuel cost. And Li and Song (2012) had done economic evaluation for iron ore ship type coming from Brazil. And they found the order of sensitive factors for RFR are bunker price> vessel price>handling efficiency and both bunker price and vessel price are critical factors for the cost control of shipping company.

Chapter 5 Conclusions

5.1 Summary

In this paper, the general development of ocean engineering industry was introduced, and the features, indexes, influencing factors of ocean engineering project economic evaluation were presented, followed by the evaluation methodology research, and the theory is applied in a case study afterwards. At last, conclusions and recommendation are given.

NPV, IRR, ROI and discounted PBP are chosen as the economic indicators that would show the investment value of one project, meanwhile, sensitivity analysis was employed to analyze the risks and the influencing level of influencing factors. In the case study, the manufacture of one DSV has been evaluated economically. The result shows that this DSV is worth investing and with robust profitability. And dayrate has been found to be the most sensitive factor that will influence the value, quality and result of the investment. Vessel price as the initial capital expenditure showed the second significant influence on economic indicators. And bunker price and discount rate were less significant. The change in dayrate and vessel price will severely affect the result of the investment, however, bunker price or discount rate change may not have obvious impact.

In a variable market we have today, in order to deal with the unpredictable change of dayrate and vessel price and mitigate the negative influence it may have on ocean engineering projects investment, the following measures can be taken:

(1) By looking at the international oil price and ocean engineering industry dynamics, try to get a preview of how the ocean engineering market would change.

(2) Try to forecast the market change and make decisions accordingly, for example, putting the equipment in spot market if the market is going up and putting it in charter market when the market is going down.

(3) Try to build the equipment at the low manufacturing price and charter in equipment when the market is rising instead of building up equipment at high price.

(4) Build up equipment with unique and advanced technique and functions and enhance the competitiveness of the company.

(5) Try to purchase or take over upstream and downstream companies and construct an industrial chain to cut the cost and alleviate the vulnerability of the market.

(6) Shipping companies can also get involved in other industries and turn to diversification to fight against the high risk in ocean engineering market.

5.2 Conclusion and recommendation

With more and more ocean engineering project developed, bigger and bigger amount of capital involved and deeper and deeper ocean engineering project located, the investment in ocean engineering project is getting more and more attention. But no economic evaluation of this kind of project has been studied. It is expected that this paper would shed some lights on this field and more investments are to be decided based on scientific economic evaluation instead of blindly throwing money around.

However, this paper is just a tryout in the economic evaluation for ocean engineering projects, there are more questions than answers that this paper could give. In the writing of this paper, more researches are found yet to be done in the following fields:

(1) As for the economic appraisal methodology of ocean engineering project, the determination of economic indicators should be given more thoughts. NPV, IRR, ROI and discounted PBP were adopted in this paper, however, are there more powerful and comprehensive tools can be used to show a more full-scale picture of the effect of the investment is a question needed to be answered.

(2) The changing range of influencing factors are positive and negative 20%, 10% and 5%, and their variety did not change the conclusion of our case study, which is the investment is economically feasible. It means that this project is robust. However, ocean engineering market may not change in such a mild way. Look at the shipping market, the BDI index dropped by more than 90% in less than a year. In order to better show how this project or investment will function in front of big crisis, a bigger scale of change in influencing factors should be studied.

(3) In our literature search, there are many papers talking about ocean engineering project, yet, very few of them are related to the emerging DSV market. Only a few was about the design of DSV and none of them was about the market or operation of DSV. In consulting institutes' ocean engineering industry report, most contents are related to PSV or AHTSV and contents for DSV are seldom included. And it is even harder to find the data for day rate, operation cost and other influencing factors of DSV. With deeper and deeper water human beings explore and wider and wider

ocean human beings navigate, more attention is expected to be put on this vessel type and more research are anticipated to be done in this field.

(4) The case study of this paper has shown that among dayrate, vessel price, bunker price and discount rate, dayrate is the most sensitive factor and has the most significant influence on economic indexes. In order to better evaluate an ocean engineering project, to know the market change in the future is very important. However, the day rate of ocean engineering project was not forecasted and therefore, the risks in the future is still hard to judge. More researches about a better forecasting system or method are yet to be discovered.

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Appendices

Appendix 1 Excel file of economic evaluation indicators calculation (in 10,000 RMB)

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1																				
2	year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3	ship purc	63000																		
4	working days per year		330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
5	bunker price		0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173
6	rate		0.061																	
7	earnings		16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500
8	fixed cost		3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488
9	variable cost		2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924
10	depreciation		3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
11	EBIT		6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525
12	taxation		561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561
13	cash flow	-63000	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525
14	discounted time		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
15	discount factor		0.942507	0.88832	0.837247	0.789112	0.743743	0.700983	0.660682	0.622697	0.586897	0.553154	0.521352	0.491378	0.463127	0.4365	0.411405	0.387752	0.365459	0.344448
16	discounted cashflow		8979	8463	7976	7517	7085	6678	6294	5932	5591	5270	4967	4681	4412	4158	3919	3694	3482	3281
17	cumulativ	-63000	-54021	-45559	-37583	-30065	-22980	-16302	-10008	-4076	1515	6785	11752	16433	20845	25003	28922	32616	36098	39379

NPV= =NPV(D6,D13:U13)-C3

IRR= =IRR(C13:U13)

ROI= =D11/C3

Appendix 2 Excel file of calculating the influence of vessel price change on four economic indicators (taking vessel price decrease by 20% as example)

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1																				
2	year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3	ship purchase	50400																		
4	working days per year		330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
5	bunker price		0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173
6	rate		0.061																	
7	earnings		16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500
8	fixed cost		3027	3027	3027	3027	3027	3027	3027	3027	3027	3027	3027	3027	3027	3027	3027	3027	3027	3027
9	variable cost		2861	2861	2861	2861	2861	2861	2861	2861	2861	2861	2861	2861	2861	2861	2861	2861	2861	2861
10	depreciation		2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800
11	EBIT		7812.42	7812.42	7812.42	7812.42	7812.42	7812.42	7812.42	7812.42	7812.42	7812.42	7812.42	7812.42	7812.42	7812.42	7812.42	7812.42	7812.42	7812.42
12	taxation		561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561
13	cash flow	-50400	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42	10051.42
14	discounted time		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
15	discount factor		0.94250707	0.88832	0.837247	0.789112	0.743743	0.700983	0.660682	0.622697	0.586897	0.553154	0.521352	0.491378	0.463127	0.4365	0.411405	0.387752	0.365459	0.344448
16	discounted cashflow		9474	8929	8416	7932	7476	7046	6641	6259	5899	5560	5240	4939	4655	4387	4135	3897	3673	3462
17	cumulative cas	-50400	-40926	-31998	-23582	-15650	-8175	-1129	5512	11771	17670	23230	28470	33409	38065	42452	46587	50485	54158	57620
18	NPV	57,620.2146																		

NPV= =NPV(D6,D13:U13)-C3

IRR= =IRR(C13:U13)

ROI= =D11/C3

Appendix 3 Excel file of calculating the influence of bunker price change on four economic indicators (taking bunker price increase by 20% as example)

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1																				
2	year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3	ship purchase	63000																		
4	working days per year		330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
5	bunker price		0.8608	0.8608	0.8608	0.8608	0.8608	0.8608	0.8608	0.8608	0.8608	0.8608	0.8608	0.8608	0.8608	0.8608	0.8608	0.8608	0.8608	0.8608
6	rate		0.061																	
7	earnings		16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500
8	fixed cost		3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488
9	variable cost		3280.896	3280.896	3280.896	3280.896	3280.896	3280.896	3280.896	3280.896	3280.896	3280.896	3280.896	3280.896	3280.896	3280.896	3280.896	3280.896	3280.896	3280.896
10	preciation		3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
11	EBIT		6230.629	6230.629	6230.629	6230.629	6230.629	6230.629	6230.629	6230.629	6230.629	6230.629	6230.629	6230.629	6230.629	6230.629	6230.629	6230.629	6230.629	6230.629
12	taxation		561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561
13	cash flow	-63000	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629	9169.629
14	discounted time		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
15	discount factor		0.942507	0.88832	0.837247	0.789112	0.743743	0.700983	0.660682	0.622697	0.586897	0.553154	0.521352	0.491378	0.463127	0.4365	0.411405	0.387752	0.365459	0.344448
16	discounted cashflow		8642	8146	7677	7236	6820	6428	6058	5710	5382	5072	4781	4506	4247	4003	3772	3556	3351	3158
17	cumulative ca	-63000	-54358	-46212	-38535	-31299	-24479	-18051	-11993	-6283	-902	4171	8951	13457	17704	21706	25479	29034	32385	35544
18	NPV	35,543.8203																		

NPV= =NPV(D6,D13:U13)-C3

IRR= =IRR(C13:U13)

ROI= =D11/C3

Appendix 4 Excel file of calculating the influence of dayrate change on four economic indicators (taking dayrate increase by 20% as example)

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1																				
2	year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3	vessel pri	63000																		
4	working days per year		330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
5	bunker price		0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173
6	rate		0.061																	
7	earnings		19800	19800	19800	19800	19800	19800	19800	19800	19800	19800	19800	19800	19800	19800	19800	19800	19800	19800
8	fixed cost		3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488
9	variable cost		3089	3089	3089	3089	3089	3089	3089	3089	3089	3089	3089	3089	3089	3089	3089	3089	3089	3089
10	depreciation		3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
11	EBIT		9722.525	9722.525	9722.525	9722.525	9722.525	9722.525	9722.525	9722.525	9722.525	9722.525	9722.525	9722.525	9722.525	9722.525	9722.525	9722.525	9722.525	9722.525
12	taxation		673.2	673.2	673.2	673.2	673.2	673.2	673.2	673.2	673.2	673.2	673.2	673.2	673.2	673.2	673.2	673.2	673.2	673.2
13	cash flow	-63000	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33	12549.33
14	discounted time		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
15	discount factor		0.942507	0.88832	0.837247	0.789112	0.743743	0.700983	0.660682	0.622697	0.586897	0.553154	0.521352	0.491378	0.463127	0.4365	0.411405	0.387752	0.365459	0.344448
16	discounted cashflow		11828	11148	10507	9903	9333	8797	8291	7814	7365	6942	6543	6166	5812	5478	5163	4866	4586	4323
17	cumulative	-63000	-51172	-40024	-29517	-19615	-10281	-1484	6807	14621	21986	28928	35471	41637	47449	52927	58090	62956	67542	71865
18	NPV	71864.6041																		

NPV= =NPV(D6,D13:U13)-C3

IRR= =IRR(C13:U13)

ROI= =D11/C3

Appendix 5 Excel file of calculating the influence of discount rate change on four economic indicators (taking discount rate increase by 20% as example)

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
2	year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3	ship purc	63000																		
4	working days per year		330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
5	bunker price		0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173	0.7173
6	rate		0.0732																	
7	earnings		16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500	16500
8	fixed cost		3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488	3488
9	variable cost		2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924	2924
10	preciation		3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
11	EBIT		6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525	6587.525
12	taxation		561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561
13	cash flow	-63000	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525	9526.525
14	discounted time		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
15	discount factor		0.931793	0.868238	0.809018	0.753837	0.70242	0.65451	0.609867	0.56827	0.52951	0.493393	0.45974	0.428383	0.399164	0.371938	0.346569	0.322931	0.300905	0.280381
16	discounted cashflow		8877	8271	7707	7181	6692	6235	5810	5414	5044	4700	4380	4081	3803	3543	3302	3076	2867	2671
17	cumulativ	-63000	-54123	-45852	-38145	-30963	-24272	-18037	-12227	-6813	-1769	2932	7311	11392	15195	18738	22040	25116	27983	30654
18	NPV	30,653.9845																		

NPV= =NPV(D6,D13:U13)-C3

IRR= =IRR(C13:U13)

ROI= =D11/C3