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INTEGRATING PROACTIVE CSR INITIATIVES AS A STRATEGY IN INVESTMENT DECISIONS- A SPECIFIC CASE OF FLEET RENEWAL INVESTMENTS IN SHIPPING AS A CSR REAL OPTION

by

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Abstract

Purpose – The purpose of this research is to integrate CSR/ESG initiatives in a strategic manner into investment decisions of a dry-bulk shipping company where investment decisions are predominantly based on market sentiments and future expectations. Studies reveal that ship owners normally show a herd behavior when it comes to fleet renewal decisions. Viewing ESG initiatives solely through the lens of enhancing ESG performance may not provide any financial benefits and competitive advantage to the company. CSR/ESG criteria integration in investment strategies logically demand a prompt investment in an initiative like ordering an ammonia-fuel ready ship. This study analyses if such an unsighted investment analysis is clearly beneficial for the company in financial terms and helps to attain sustainable growth.

Methodology and approach – The methodology used in this study is the concept of real options analysis (ROA) and applied a binomial option pricing model to calculate the deferral option values and thereby finding the optimal investment timing in replacing an existing old ship with an ammonia-ready ship. ROA can identify the value of strategic options and flexibilities available to the management like deferring an investment to a later stage under uncertain conditions.

Findings and research limitations– Integrating CSR/ESG initiatives strategically in investment decisions requires a structured analysis of the prevailing conditions and should identify the potential financial and economic value created by such initiatives. With the specific conditions applied in the analysis, investing in an ammonia-ready ship now is not a strategic choice for the company and there is more value in deferring the decision to a later stage when considering the present level of financial benefits obtainable from replacing the old ship. To mention the limitations of the study, cash outflow analysis carried out is rudimentary and also findings from the study are very specific to the analyzed scenario.

Practical implications – Dry-bulk shipping is comparatively harder to abate within the shipping industry compared to other sectors like container shipping. Studies have shown that dry-bulk sector has minimal interest in environmental performance as raw materials transported are not a concern for end consumers and consumer pressure for improving environmental performance is very low for the sector. These aspects highlight the need for strict regulatory framework and its enforcement to decarbonize the shipping sector. Initiatives like Sea Cargo Charter from the side of charterers and cargo owners have emerged to address the environmental impacts of shipping by aligning bulk chartering activities with the decarbonization initiatives and targets of IMO. However, a clear indication of financial commitments from charterers and cargo owners to improve the environmental performance of shipping can definitely incentivize ship owners to take up proactive green initiatives beyond the minimum compliance stipulated by regulations. Results from this study also emphasize the impact of financial incentives for the ship owners which can accelerate green investments in shipping and ultimately attain the net-zero carbon emissions by 2050.

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LIST OF ABBREVIATIONS

ARCH	Auto Regressive Conditional Heteroscedasticity
BDI	Baltic Dry Index
CAPEX	Capital Expenditures
CF	Conversion Factor
CFP	Corporate Financial Performance
CII	Carbon Intensity Indicator
CSP	Corporate Social Performance
CSR	Corporate Social Responsibility
DCF	Discounted Cash Flow
EEXI	Energy Efficiency Existing Ship Index
EF	Efficiency Factor
ESG	Environmental Social and Governance
ESTs	Energy Saving Technologies
GHG	Greenhouse Gas
ILO	International Labour Organisation
IMO	International Maritime Organisation
LNG	Liquified Natural Gas

MGO	Marine Gas Oil
NGO	Non-Governmental Organisations
NPV	Net Present Value
OPEX	Operational Expenditures
O-U	Ornstein-Uhlenbeck process
PRI	Principles of Responsible Investments
RBV	Resource Based View
ROA	Real Options Analysis
USD	United States Dollar
VAR	Vector Autoregressive Model
VLCC	Very Large Crude Carrier

1. INTRODUCTION

1.1 Background

Corporate Social Responsibility (CSR) has emerged as a top priority for business leaders and organisations as companies are now being ranked based on their CSR initiatives and Corporate Social Performance(CSP). Companies are trying to improve the social and environmental consequences of their activities to gain and retain their competitive advantage. While voluntary approach has been the justification for CSR, the moral imperative has been strongly linked to CSR for a long time. Companies slowly started to consider the principle of sustainability which required companies to operate by avoiding short-term socially detrimental and environmentally wasteful actions while focusing on improving economic performance in a long-term perspective(Porter & Kramer, 2006). But all four justifications for CSR, which include moral obligation, reputation, license to operate and sustainability, focus on tension between business and society (Porter & Kramer, 2006). An approach to CSR, which is not in-line with the company strategy will not provide a long-term competitive advantage to companies in-return for the expenses incurred related to CSR activities. To advance the concept of CSR, companies should integrate CSR in strategies and activities specific to them. Adding a social dimension to the value proposition and integrating social impact to the overall strategy of the firm are the key aspects to the concept of strategic-CSR (Porter & Kramer, 2006).

A transition from the traditional voluntary approach to strategic-CSR is happening at a greater pace now with the advent of global scale environmental concerns especially related to climate change. Compared to the philanthropic approach where a portion of revenue can be set aside for CSR initiatives, incorporating CSR from a strategic perspective in to corporate decisions requires a systematic framework to measure CSR. However, no theoretical models are available to determine the appropriate level of social responsibility in investment decisions and no underlying financial framework is available to relate the performance of an investment and the marginal social responsibility of an investment (Berry & Junkus, 2013). Therefore, a debate on the relationship between CSP and Corporate Financial Performance (CFP) has been ongoing for a long time and empirical studies have given inconsistent results. Nowadays various reputation indices like Dow-Jones sustainability index, Fortune magazine reputation index, MSC KLD 400 social index, Vigeo Index etc. are available which are compiled by specialised rating agencies for measuring CSR which acknowledge the multidimensional nature of

CSR(Galant & Cadez, 2017). Emergence of these reputation indices have helped equity investors to incorporate social principles in assessing investment choices in addition to financial and economic considerations. There is a general consensus that Socially Responsible Investments (SRI) or investing responsibly considering environmental and social aspects can create a positive societal impact and can generate financial returns in a long-term perspective. SRI or sustainable investing adds a premium on social impacts by considering both moral values and financial benefits in investment decisions. Decision-making is primarily based on principle in socially responsible investing where investors avoid specific companies based on their business line (S&P Global, 2020).

As investment decision-makings are prioritized by companies and investors considering the benefits of all stakeholders, Environmental, Social and Governance (ESG) investing has emerged as a competitive alternative to sustainable investing (S&P Global, 2020). CSR has been associated with activities undertaken by firms for being socially responsible and for being a better corporate citizen. While ESG includes governance explicitly, CSR considers governance issues indirectly when relating to environmental and social considerations and hence ESG tends to be a more expansive terminology than CSR (Gillan et al., 2021). ESG investing uses metrics that quantify financial risk and opportunity while considering an organisation's environmental, social and governance risks. So, for a company, ESG performance and an ESG-minded investment strategy which takes into account climate risks, physical and human capital investments and good governance methods are of utmost importance (S&P Global, 2020).

Interest in CSR/ESG is on a consistent rise in the corporate world and this is indicated by the fact that 92% of S&P 500® firms released CSR or sustainability reports in 2020 compared to just under 20% in 2011 based on a report by Governance and Accountability Institute. (Gillan et al., 2021). Institutional investors adopting responsible investment initiatives like Principles of Responsible Investments (PRI) are consistently increasing and more and more investors are incorporating CSR/ESG issues into their investment analysis and decision making process. Investors aligning to these initiatives require companies in which they invest to be transparent about ESG issues and ESG reporting by companies is slowly becoming a requirement to continue in business. According to Barman (2018) CSR/ESG initiatives can either generate benefits or costs to a firm which in-turn determines the financial materiality of each ESG criteria. Therefore, managing CSR/ESG challenges can minimize risks, reduce costs and maximize opportunities for a firm thereby facilitating financial value creation.

1.2 Problem Identification

Megatrends like climate change are transforming the business environment and business-as -usual is not an option anymore for companies in all sectors. Long-term value creation and financial performance of companies are getting more and more correlated with environmental and social performance of companies. There has been a long standing debate on the link between traditional voluntary level CSR and its effect on financial performance of firms engaging in such initiatives. A transition from voluntary level CSR to strategic-CSR can be seen in all sectors which is mostly driven by the global efforts to tackle climate change and initiatives taken by all stakeholders in all business sectors towards decarbonisation. Strategic level CSR/ESG requires companies to rely on updated management practices and policies to find opportunities in CSR initiatives and to generate economic and financial benefits by engaging in such practices.

Shipping industry is infamous for its sluggish approach towards CSR and tackling environmental concerns which can be attributed to the small profit margins and highly cyclical markets (Stein & Acciaro, 2020). Maritime industry has been a heavily regulated industry globally by international governing bodies like the IMO and ILO for a long time. Regulations pertaining to safety and pollution issues are revised and updated mainly through leaning from incidents. For a long time, environmental performance of shipping companies are governed by regulations only and companies take a responsive approach to comply with regulations. Implementation of stringent regulations always used to take considerable time due to the delay in getting a consensus among all stakeholders owing to the global nature of shipping industry. The climate change crisis and global drive towards decarbonisation have slowly started to influence the shipping industry also in a positive manner in terms of dealing with environmental issues. Recently it is also seen that the maritime sector is also embracing the transition from a traditional CSR approach and started giving importance to ESG performance. In recent times many shipping companies have started publishing sustainability reports and ESG performance reports regularly. Initiatives like Poseidon principles are integrating climate considerations and decarbonisation even into shipping finance and influences lending decisions. Slowly the shipping sector also has jumped on the bandwagon of decarbonisation initiatives and has started taking proactive environmental initiatives to cut down the carbon emissions. Shipping companies committing to Science Based Targets initiatives (SBTi) and taking decisions to invest in alternate fuel powered ships without giving serious regard to technological readiness level of alternate fuels are signs of proactive efforts taken by industry in dealing with Green House Gas(GHG) emissions. However, there is the looming concern regarding how to integrate such proactive CSR decisions to the generic strategy of a shipping company while ensuring that such efforts can create financial benefits to the company and provide a long-term competitive advantage.

Shipping is a capital-intensive industry and ship owners are known for their irrational investment decisions especially when it comes to ordering of new ships. Studies (Lee & Yip, 2018), (Scarsi, 2007) have observed that ship owners tend to show a herd mentality in fleet renewal and investment decisions and most often do not follow a structured analysis in the decision making. Similarly, investment decisions related to CSR/ESG initiatives are also often taken irrationally following the herd mentality mentioned earlier and this typical behaviour may take away the competitive edge of the companies and may negatively affect their financial performance.

Considering the above mentioned facts and identified issues, this study aims to answer the main **research question**

How to optimize the fleet renewal investment decisions of a dry-bulk shipping company under market uncertainty while integrating CSR/ESG factors as a strategy in decision analysis?

Investing in an alternate fuel ready ship can be considered as a proactive CSR/ESG by a dry-bulk shipping company and can definitely add value to the ESG performance evaluation. At present, a certain level of incentives are available (Clarksons, 2022) for dry-bulk ship owners in terms of differentiated charter rates for new and energy efficient ships. These two aspects along with the shipping market uncertainties are considered in the replacement of an old ship owned by the company with an alternate fuel-ready ship. This study uses a methodology called Real Options Analysis (ROA) to optimize the timing of the investment under market uncertainties. ESG/CSR strategy of the company is considered as a real option and optimal timing of the investment is devised by calculating the investment deferral values. When the investment in an alternate fuel ready-ship is considered as a CSR/ESG initiative, it implicitly suggests to make the investment now or at the earliest. As a few capesize ship owners already made the move of ordering alternate fuel-ready ships (Clarksons, 2022) there will be a tendency for other ship owners too to follow suit. This study analyses whether a strategic evaluation linking to financial benefits also suggests to invest now or defer the investment to a later period incorporating managerial flexibilities in the decision analysis.

Following **sub-research questions** are also answered in the process of answering the main research question.

1. What is CSR and its link to the financial performance of a firm?
2. Which are the different factors affecting ship investment decisions?
3. What is Real Options Analysis (ROA), advantages of using ROA over traditional project appraisal methods and types of real options?
4. How ROA can be used to account for uncertainties and incorporate managerial flexibilities to find the optimal timing of a CSR investment?
5. How incentivizing dry-bulk ship owners help them to adopt proactive environmental investment initiatives contrary to being responsive to regulations?

1.3 Research Approach and Relevance of the Study

According to Cassimon et al. (2016) there are limitations in allocating resources through a traditional Net Present Value (NPV) framework. They also observed that many firms fail to justify CSR initiatives and investments on financial grounds as traditional capital budgeting techniques fail to capture the strategic value of CSR investments. In this study a real option model is used as an evaluation technique for a ship renewal investment. ROA helps to incorporate managerial flexibilities like deferring the investment in the process of fleet renewal decisions. Binomial option pricing model is used to calculate option values assuming that the value of underlying asset follows a discrete-time stochastic process. This assumption can be justified by the fact that real asset investment decisions like ordering a new ship can be assessed in a discrete time frame more effectively. Investing in an alternate fuel-ready ship is considered for successive years starting from 2023 until 2028 and the time horizon is selected based on a study (DNV, 2021) on maritime energy transition. Three scenarios are separately considered in which the conversion of new ship to alternate fuel will be carried out in 2028, 2029 and 2030.

For answering the main research question comprehensively, the above mentioned sub-research questions are proposed and are answered by a combination of qualitative assessment through an extensive literature review and quantitative assessment by applying the real option model in the case of ship investment.

A detailed study of existing literature is carried out to assess the evolution of different theories of CSR and the ongoing process of transition of CSR among firms from a voluntary approach to a strategic level. This thesis also attempts to research the ongoing debate in the academic circle about the link between CSR and financial performance of the companies. Through literature analysis it became evident that quantifying the effects of CSR initiatives and directly linking it to financial performance is rather difficult. The detailed literature review also indicates the necessity of integrating ESG/CSR initiatives from a strategic perspective so that the results of these initiatives provide firms with the much-desired competitive advantage while positively influencing their financial performance.

Fleet renewal for a shipping company is quite capital-intensive and a detailed literature analysis is carried out to study the critical factors influencing ship investment decision analysis. The importance of predicting the market in cognizance of the shipping market cycle theory and the appropriate methods of freight rate analysis in the investment decision making are devised from existing literature.

A detailed study of ROA, types of real options available and the advantages of this approach are discussed in the literature review section. Application of ROA in various cases of investment decisions in different sectors are also studied through literature analysis for the application in the specific case of ship investment decision.

ROA is further applied in the specific case of ship investment taking into account the uncertainties involved and incorporating relevant managerial flexibilities using the chosen model and selected type of real option.

Improving environmental performance of ships and reducing emissions from the ships are common goals for the shipping industry today. But, studies (Stein & Acciaro, 2020),(Poulsen et al., 2015) suggest that a differentiated evaluation of different shipping sectors is required to study the actual level of commitments related to sustainability and environmental performance in different sectors. They are of the view that a certain level of commitments can be seen in container shipping segment and tanker shipping segment due to demand from cargo (finished products) owners and oil corporations. This being said the dry-bulk sector on the contrary is showing minimal interest in improving environmental performance owing to the fact that raw materials like coal and iron ore handled by dry-bulk sector are not linked to any end consumers. When very high investments are required to reduce emissions from ships there is a menacing question of whether ship owners only need to take the initiatives in improving environmental performance of the shipping sector. Classic economists consider dry-bulk shipping as a nearly perfect competitive market and ship owners are price takers. This study incorporates two input variables called *efficiency factor* (EF) and alternate-fuel *conversion factor* (CF) as ship owner incentivizing factors in the analysis. These factors can quantitatively assess the level of financial commitments required from charterers and dry-bulk cargo owners to help the ship owners to take the proactive ship investment decisions irrespective of the market conditions. These level of incentives from other stakeholders like charterers are required to accelerate the decarbonisation efforts especially in the dry-bulk sector when ship owners consider CSR/ESG initiatives as a matter of strategic importance.

1.4 Thesis Structure

This thesis is structured in chapters and this Chapter 1 is the introduction discussing the background of this study and identification of problem leading to the main research question and following sub research questions. This chapter also gives an overview of the research approach followed in answering the main research question and sub research questions.

Introduction chapter is followed by the literature review giving the theoretical concepts about CSR, shipping market dynamics and detailed explanation of real options approach to investment decisions.

Chapter 3 gives the detailed explanation of methodology adopted and the choice of real option solution method. This chapter also explains input factors for binomial option valuation model and key assumptions taken in the calculations.

Chapter 4 provides the analysis of results obtained from ROA discussing the interpretation of option values and deferral values for different scenarios. This discussion is followed by a sensitivity analysis.

Chapter 5 provides conclusions of the study along with its limitations and future research scope.

2. LITERATURE REVIEW

2.1 Definition of Corporate Social Responsibility

The concept of CSR is evolving to different dimensions in the corporate world and definitional confusion of CSR is a real issue (Dahlsrud, 2008). A content analysis study of existing definitions of CSR by Dahlsrud (2008) based on extensive review of literature, found that many available definitions of CSR can be categorized into five dimensions viz. *Voluntariness, Stakeholder, Social, Environmental and Economical* dimensions. In his study it is found that environmental dimension received a significantly lower dimension ratio compared to others which may be due to the fact that environmental dimension was not included in early definitions and this influenced and led to its omission in future definitions too. But, more in-depth explanation of CSR emphasizes both environmental and social dimensions equally. The study also revealed that none of the definitions actually defines the social responsibility of business famously discussed by Milton Friedman in 1970's but rather describe what constitutes the social responsibility of business and consider CSR as a phenomenon. In the study it is found that most frequency count by Google search is obtained for the definition of CSR by Commission of the European Communities which states "*CSR is a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis"* and this definition includes all five dimensions of CSR. The real challenge is not in defining CSR but to understand the CSR as a phenomenon in specific context and account this in business strategies (Dahlsrud, 2008).

2.2 Theory of CSR

A lot of academic debate and ongoing research is going on related to the theory of CSR, its effects and implications on business and even its definition. According to van Marrewijk (2003) three approaches to CSR are prevalent in academic literature related to the responsibility aspect of an organization including and transcending one another.

2.2.1 Shareholder approach

This is the classical view of CSR based on Milton Friedman in 1970s stating that the "*social responsibility of business is to increase its profits".* This view of CSR constitutes the theory that organizations should engage in CSR purely in a business perspective and should always strive for the creation of long-term value for the shareholders.

2.2.2 Stakeholder approach

This approach is proposed by Edward Freeman in 1980s stating that the responsibility of organizations is not only towards its shareholders but also need to address the interests of various stakeholders affected by the fulfilment of organization's objectives.

2.2.3 Societal Approach

This approach points to the "*social license to operate"* concept and considers the need for organizations to serve and satisfy the needs of the society in which they are an integral part. Different approaches to corporate responsibility denote the fact that CSR is a distinct phenomenon defined by two principles of Self-determination and Communion which are based on natural tendencies of evolution in addition to the principles of charity and stewardship. Combination of these principles allow each individual or company or entity to act according to the situation awareness and capabilities without conflicting current regulations and interfering with freedom of others with similar objectives (van Marrewijk, 2003).

2.3 CSR as a Strategic Tool

Going back to the five different dimensions of definitions of CSR mentioned in section 2.1, even though the roots of CSR are more aligned to a philanthropic approach, the environmental dimension is also getting integrated much to the phenomenon of CSR along with the concept of CSR as a strategic approach.

A theoretical framework for the strategic engagement of firms in CSR was provided by Hart (1995) in his *Natural-Resource-Based View of the firm*, which is a theory on the competitive advantage of the firm based on the firm's relation to the natural environment. The theory consists of three interconnected strategies of sustainable development, pollution prevention and product stewardship. *Resource Based View (RBV*) theory states that valuable and inimitable resources and capabilities of firms provide them a with a sustainable competitive advantage(Hart, 1995). In the natural-resource-based view of the firm along with three interconnected strategies he provided a conceptual framework for incorporating the challenge of natural environment into strategic management.

Mcwilliams & Siegel (2001) used the RBV framework in a *theory of the firm* (assumption that management always attempts to maximize profits) perspective and used a basic supply-demand theory to assess the strategic implications of CSR initiatives. According to Mcwilliams & Siegel (2001) difference in stakeholder driven approach (where CSR initiatives are considered inconsistent with profit maximization) and motivation driven approach (where a more progressive view on CSR initiatives are taken), results in a varied level of response from managers and decision makers in resource allocation for CSR. This aspect stimulated an important debate on the relationship between CSR and financial performance of companies and raised two key questions related to

1. Performance improvement in CSR firms compared to non-CSR firms

2. Amount of resources to allocate for CSR

They proposed a methodology to answer these questions specifically the second one based on the *theory of the firm* perspective applicable to publicly held firms. In this perspective, CSR is viewed as a form of investment and it can be considered as a differentiation strategy. In their study they tried to assess the required level of CSR investment based on supply and demand theory of the firm framework and found that there is a level of CSR investment that maximizes profit while satisfying the stakeholder CSR demand. The ideal level of CSR is determined by cost-benefit analysis. Managers will evaluate the possibility of product/service differentiation on demand side and on supply side, managers will evaluate the resource costs of promoting CSR considering the possibility of economies of scale/scope associated with the provision of CSR (Mcwilliams & Siegel, 2001).

McWilliams et al. (2002) further extended the *resource-based theory of the firm* to suggest that competitive CSR strategies can be analysed for their effectiveness using RBV framework. They specifically pointed out that political strategies can be used by firms to raise cost for rivals by blocking the use of substitute resources. So, CSR strategies supported by political strategies can be helpful for firms investing in emission abatement techniques, R&D etc.

Bhattacharyya et al. (2008) developed a framework for designing firm level CSR initiatives which can be of strategic interest to companies by identifying firm's interests in CSR and salient stakeholders of the firm considering the stakeholder attributes of power, legitimacy and urgency. Firm's interests in CSR are assessed on the basis of firm value chain. They identified the expected benefits of strategic CSR such as

- Enhanced Reputation/Visibility
- Generation of tangible and intangible firm assets and resources
- Competitive advantage
- Cost based leadership
- Product differentiation
- Innovative products/ processes and services
- New product/market opportunities
- Better relationship with government and other key stakeholders

Proper utilization of resources is key to gain competitive advantage and managers are well aware of the need and benefits of strategic CSR. However, the real challenge for them is to design the firm CSR strategy in such a manner to address social issues while providing the firm with some business benefits (Bhattacharyya et al., 2008).

2.4 Classification of CSR in Research Context

According to Basu & Palazzo (2008), research in academic level whereby analysing CSR by examining CSR activities can be classified in to three fundamental lines.

2.4.1 Stakeholder driven

In this line of research, CSR actions by companies driven in response to specific demands of external stakeholders like Non-Governmental Organisations (NGO) and governments with regard to a firm's operations or generalized social concerns like poverty, global warming etc are studied.

2.4.2 Performance driven

This research line analyses the link between external expectations and CSR actions of companies and the effectiveness of such actions. In this aspect scholars have tried to establish the link between CSR and factors such as corporate strategy and profitability and tried to establish best methods to attain the desired results.

2.4.3 Motivation driven

This line of research analyses the extrinsic reasons for a firm to engage in CSR initiatives such as enhancing brand reputation, pre-empting regulations, responding to NGO actions, managing risks and generating customer loyalty.

The above three approaches have made significant contribution to CSR research but the analysis on content of CSR activities does not consider the *institutional factors* which trigger the CSR initiatives. A richer description of CSR will emerge by studying the internal institutional determinants such as mental frames and sensemaking processes (understanding what a company thinks, says and tends to do in relation to others) within which CSR is embedded and this will bring CSR closer to the domain of managerial decision-making (Basu & Palazzo, 2008).

2.5 Corporate Social Performance and Corporate Financial Performance– The Missing Link

Research line on performance driven aspects of CSR is very extensive and a lot of research is being carried out on finding the relation between CSR initiatives and performance of the firm or in other words the impact of CSR investments by a company on its financial performance.

First empirical CSP-CFP study by Bragdon and Marlin in 1972 found a positive link in CSP-CFP relationship and even now researchers are investigating similar questions like the link between environmental performance and financial performance (Margolis et al., 2009).

Orlitzky et al. (2003) conducted a meta-analytic review of quantitative studies carried out on CSP-CFP relationship and according to them meta-analysis is a proven technique where multiple individual studies showed inconclusive or conflicting results. They provided a statistical integration of the accumulated research on CSP-CFP relationship and assessed the validity of *instrumental stakeholder theory* which states that stakeholder satisfaction is instrumental for organisational financial performance. In their study they concluded that CSP and CFP are generally *positively related* in different study contexts and across different industries.

Margolis et al. (2009) conducted a comprehensive research on all the research works being carried out in relation to CSP-CFP effects from 1972 and they conducted a meta-analysis of

251 studies given in 214 manuscripts and found that the overall effect is *positive*. According to their view, the empirical link between CSP and CFP has been researched for the past thirty-five years and this may be due to the fact that finding a positive link between social and financial performance would legitimize CSP on economic grounds and motivate companies to pursue the good deeds and contribute to the well-being of the society. Another aspect they noticed in their analysis is that though theorists try to differentiate between CSP and CSR they are often used interchangeably in empirical studies.

Even though meta-analysis of empirical studies shows an overall positive correlation between CSP and CFP, many of the studies have been inconclusive and contradictory. For example, Baird et al. (2012) conducted an industry specific analysis of the empirical link between CSP and CFP and found that only 17% of industries in their sample of total 58 industrial sectors showed a *positive* relation. They also found that the unweighted average effect of CSP on CFP is *negative*.

No CSR measurements approach is without drawbacks and two inherent problems in most approaches are *researcher subjectivity* (where researchers specify their own variables, models and statistical analysis) and *selection bias* which influence the nature of CSR-CFP relationship in empirical literature. Studies based on reputation indices, questionnaire surveys and content analyses are biased towards finding positive relationship between CSP and CSR. (Galant & Cadez, 2017).

Kumar Pani (2009) in his study on exploring the strategic edge of CSR is of the view that absence of alternative theoretical explanations for CSR indulgence by companies is the main reason for the inconsistent results on the link between CSP and CFP. He proposes a process model which illustrates the link between CSR actions and competitive advantage. He states that mere participation in CSR by firms will not guarantee good financial results but it is dependent on various social and organisation factors affecting strategic CSR actions that create *social capital* for the firm. *Social capital* is ancillary to successful formulation and implementation of strategic initiatives and sub processes and research is scarce on how such organisational social capital is created that provide influence, reputation and control to business firms and consequently influence firm performance (Kumar Pani, 2009).

From the analysis of academic literature it is evident that evaluating the effectiveness, assessing the impact of CSR initiatives on firm performance and quantifying the value creation abilities of CSR initiatives are quite complex and difficult. In most of the studies related to the analysis of relation between CSR and financial performance of the firms, researchers are trying to find direct relationship between CSR initiatives and financial performance. But this approach is giving contradictory results and will not help and motivate companies in pursuing CSR initiatives. So, the only way out for firms to substantiate CSR initiatives and associated costs is to incorporate CSR as a strategic tool in the decision making process. Companies need to consider CSR associated costs as investments and they should choose initiatives in a strategic perspective.

In this thesis a specific case of incorporating CSR/ESG aspects as a strategy in fleet renewal decisions of a dry-bulk shipping company is considered. In the considered scenario, the company is planning to replace an old ship with a new energy efficient alternate fuel-ready ship as a proactive ESG/CSR strategy to improve environmental performance. Dynamics of shipping markets and present investment trends in shipping sector need to be analysed to understand the crucial changes required in the shipping industry for the strategic incorporation of CSR in fleet renewal investment decision making.

2.6 Rationality of Investments in Shipping and Shipping Market Cycles.

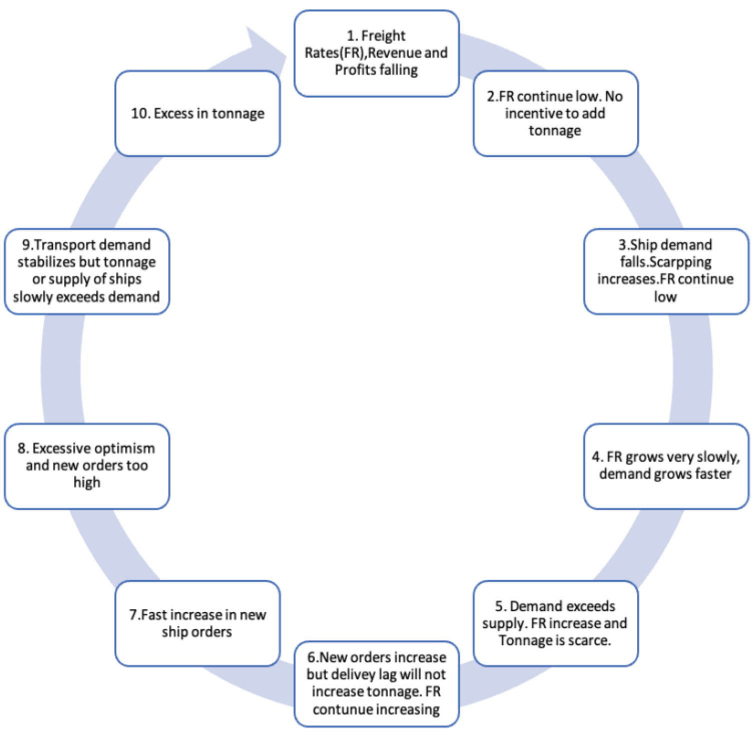
2.6.1 Theory of Shipping Cycles

According to Stopford (2008) shipping industry's economic thinking is dominated by market cycles. Shipping market in short-term follows a typical cyclical pattern and four stages of shipping cycle includes

- *Trough* when freight rates are low and profit is minimal due to surplus tonnage. Scrapping rate of ships will be high and order book reduces.
- *Recovery* when freight rates slowly picks up due to attained balance between supply and demand.
- *Peak* when freight rates peaks and profits will be maximum for ship owners and ship owners will be tempted order new ships and order books expands.
- *Collapse* when tonnage exceeds demand and freight rates fall again.

Theory of shipping cycles are shaped primarily based on two models, the Tinbergen-Koopman's model and the Beenstock-Vergottis model. Tinbergen- Koopman's model states that cyclical behavior of supply side is caused by the delivery lag (time lag between ordering the ship and delivery of ship) and shipping cycles arise even though demand for shipping cycles is not cyclical. Beenstock-Vergottis (BV) model is the first systematic approach to explain the interaction between four markets within shipping industry under the twin assumption of rational expectations and market efficiency and treat ships as assets and applies portfolio theory to assess their values (Karakitsos & Varnavides, 2014) . However, (Karakitsos & Varnavides, 2014) challenged the age-old BV model pointing out the drawbacks of considering shipping market as efficient and show with empirical evidence that shipping markets are inefficient for a time frame relevant to economic decisions in the shipping market. They used simulation results of their integrated model showing that business cycles cause shipping cycles and delivery lag cause distortion in the synchronization. They also stress on the importance of long- term profit maximization as the appropriate framework for fleet expansion strategies wherein BV model involves decisions intended to maximize short-term profits.

Figure 2 - 1 A simplified 10 step traditional shipping cycle process



Source: Adapted from Sanchez (2017)

In this elaboration the effect of the delivery lag and the excessive optimism about market during peak period leading to oversupply is evident. Ships ordered based on the current market conditions and the effect of delivery lag of 2-4 years causing the ships to be delivered during different market conditions have a negative impact on market as well the shipping company. Ship owners need to take decisions related to fleet renewal and ship operations based on these market cycles considering the underlying mechanism that drives these cycles.

2.6.1.1 Economic rationale

Rationality in ordering and operating the ships suggested by Stopford (2008) is to buy the ships when freight rates and profits are low to take advantage of the low new building prices during the trough period. Ships owners can sell their old fleet when freight rates are at maximum level when value of the ships will be at the highest to take advantage of the appreciation of assets. In operational perspective, ship owners should take a rational approach to opt for the right proportion of spot voyage charters and long term time charters depending on market conditions. Time charter is a sort of physical hedging instrument which guarantees fixed freight rate for a determined period but freight rates appreciation cannot be exploited. Voyage charters can exploit the positive spot market tendencies but involves the risk of sudden market downturn (Scarsi, 2007). Buying low, selling high, spot charter on rising market and time charter during peaks denotes a rational economic investment approach suggested by Stopford (2008) for ship owners.

2.6.1.2 Theory and practice

Economic theory of short market cycles and its practical application is a fact which needs greater emphasis. First and foremost is the randomness of the cyclic behaviour of the market. Appropriate analysis of demand and supply attributes related to economic and trade growth, fleet size and order book helps to tackle this problem to some extent and reduce uncertainties.

Next issue is the degree of market intelligence and analysis required to predict the market and further take rational investment decisions based on market conditions. Shipping market is highly volatile owing to the high degree of demand side uncertainties and is difficult to predict accurately. But, supply side uncertainty can be comparatively easily predicted knowing the age of ships, judging the phasing out moment and analysing the order book for next years. Third issue is the before mentioned delivery lag which needs to be carefully incorporated in fleet renewal decisions. Again the ultimate challenge in following the theoretical ship investment criteria for a ship owner is the financial difficulty in going anti-cyclical and invest in ships when revenues and profits are low (Scarsi, 2007).

2.6.1.3 Irrational investment behaviour a matter of fact

It is quite evident that high quality and energy efficient ships are one of the critical assets for shipping companies to gain a competitive advantage. Fleet renewal is one of the critical strategic decisions for a ship owner considering high capital investments required for ordering new ships. Even though it's a critical strategic decision whether the decision makers in shipping industry take always a rational approach when it comes to fleet renewal is a daunting question. A study on the effects of behaviour of ship owners on Korean shipping market since 2003 by Lee & Yip (2018) estimates that about 50% of vessels ordered and about 30% of total tonnage were purchased under the influence of herding behaviour caused by market sentiment. So, most of the time fleet renewal decisions are not rational and are not based on fundamental market factors like freight rate, available tonnage and many ship owners just follow the decisions of other ship owners. Fundamental business elements are well known to ship owners but they often tend to forget the scientific approach to management and so often will not rely on market analysis and forecasts but on emotional or affective elements (Scarsi, 2007).

This sort of crowd mentality in critical investment decisions among ship owners affects their competitive position and creates ripples within the industry itself. Considering the present day environmental management challenges in shipping industry and the added issue of technical uncertainties, ship owners should take a concentrated effort to incorporate scientific thinking and a more rational approach in the decision making process.

2.6.2 Dynamics of Shipping Market

Classical economists consider shipping business very close to perfect competition due to its global nature and mobility of assets (Stopford, 2008). Four closely related markets serve sea transport services. Each market serves different commodities where in freight market serves sea transport, new building market trades new ships, sale and purchase market trades second-hand ships and demolition market trades scrap ships. Freight market provides freight revenue which is the main source of cash for ship owners. Other mode of cash inflow for ship owners is from demolition market when ships are sold for scrapping. In a second-hand market cash is not moving out of the shipping industry as buyers and sellers will normally be ship owners or shipping companies and cash outflow occurs when new ships are ordered. Shipping market cycle is driven by these waves of cash flowing between four markets (Stopford, 2008).

Primary source of revenue for ship owners is from the freight market. So, freight rates and prevailing market conditions play a crucial role in the investment decisions of a ship owner. Fleet renewal decisions of shipping companies are framed on the basis of market expectations and the cash flow generated during the period. Another critical factor influencing the fleet renewal decisions are related to policy and regulations. Uncertainties about the future cashflow due to fright rate volatility is a serious concern for the shipowners in fleet renewal decisions along with the volatilities in ship prices.

2.6.2.1 Freight Rate Volatility

Numerous forecasting techniques are developed for handling increasingly complex managerial forecasting problems. Three general types are qualitative techniques, time series analysis and projection and casual models including regression models and econometric models (Chambers et al., 1971). Prediction of freight rates and market conditions are critical in timing the investment decisions related to fleet renewal. Various research studies have been conducted on identifying and analysing the determinants of freight rate and its dependency on the interaction between supply and demand and also in forecasting of freight rates. Kavussanos, (1996) applied Auto Regressive Conditional Heteroscedasticity (ARCH) model to shipping markets and investigated volatility in the spot and time charter markets in dry bulk sector. Study revealed that less risk is involved in investing in small ships due to the inherent flexibility and diverse nature of cargo carried by small ships. Veenstra & Franses, (1997) presented a multivariate time series model or Vector Autoregressive Model (VAR) in forecasting ocean dry bulk freight rates assuming that shipping markets are approximately efficient. This model generates forecasts as well as identify the long-term trend of freight rates. Alizadeh & Talley (2011) investigated the microeconomic determinants of dry bulk shipping freight rates by studying a large sample of individual dry bulk charter contracts between 2003 and 2009 using a hypothesized freight rate regression model. Study found that ships age, route and deadweight are important determinants of freight rates in bulk shipping sector. This study provides useful information on the link between freight rates and vessel and voyage specific factors in bulk sector that can be utilized by ship owners for more informed investment decisions. A successful risk management depends on the accuracy of forecasting freight rates and knowledge of freight rate dynamics is a must in formulating financial strategies. Ship owners/ decision makers should use their practical knowledge and experience along with a proper forecasting technique to predict future cash flows generated from volatile freight incomes while evaluating investment decisions.

2.6.2.2 Price dynamics of New-building market

Tsolakis (2005) conducted econometric analysis of bulk shipping markets and studied implications for investment strategies and financial decision making. In his analysis he states that various studies in analysing the dynamics of new vessel prices which used different methods like cobweb and cost-based supply- demand approaches and asset pricing approaches ignored some key variables that affect the new-building prices like exchange rates. According to him key variables determining new-building prices are

- Supply-demand related: Capacity of shipyard, Orderbook as percentage of fleet
- Cost based related: Shipbuilding costs, Exchange rates
- Asset pricing related: Second-hand ship prices, time-charter rates.

In his analysis all these factors affecting new-building prices are integrated in a supply-demand model providing a clear understanding of new-building price determinants. Results of his study indicate that freight rate fluctuations seem to affect Handysize and Capesize prices in short run say a 10 % increase in freight rates causing approximate 4.5 % increase in prices of handy-size ships. Panamax bulk carriers are not affected by freight rate fluctuations either in short or long run. Also, shipbuilding costs have significant impact on prices of new ships and newbuilding prices are primarily cost driven unlike second-hand ship prices which are market driven.

A clear understanding of the price determinants of new-building market and its dependence on prevailing market conditions is necessary for the ship owner/company to appropriately time the purchase of new of ships. When CSR/ESG strategies are involved in fleet renewal decisions a structured decision analysis is required to identify the value creation effects of CSR/ESG initiatives.

2.7 Real Options Analysis - Adding Economic Logic to CSR Investments

The strategic view of CSR initiatives calls for valuation techniques to value the CSR investments and to check its feasibility. Different methods are used by managers and financial experts for investment appraisals.

2.7.1 Which are the different tools for evaluating uncertainties and risks of an investment?

Three tools available to a firm's management to evaluate corporate risk and uncertainties are

- Capital Budgeting Method

This method takes each project in isolation and evaluates the future cash flow that may be generated by the asset/project. Future cash flows are discounted to present value considering the *time value* of money and perceived risk of cash flows. In this method, risk is measured indirectly and a project specific discount rate reflects the opportunity cost of the capital indicating a rate of return an investor expects from traded securities with similar risk as that of the investment project being valued (Brach, 2003).

- Portfolio Analysis

Portfolio analysis method is a comparative analysis and an investment project is compared to the existing assets and options already in place and risk is evaluated in the context of existing projects to established benchmarks. This method diversifies risk and new projects are only added if the new project reduces overall risk exposure of the portfolio and enhance returns (Brach, 2003).

- Option Pricing

Option pricing is concerned with direct analysis of project specific risks and risks are quantified using probability assignment. Expected cash flows from investment projects are calculated by incorporating probabilistic assumptions and insights on global economics, market dynamics, competitive environment as well as the probability distribution of the costs associated with the project. A risk-free rate is used to discount the risk-neutral expected cashflows to calculate the present value of the investment option (Brach, 2003).

2.7.2 What are Real Options?

An option is a right which represents freedom of choice after the revelation of specific information, but not an obligation to follow through in a business decision. In financial markets a financial call option gives rights to the option holder to buy an underlying stock in future for a price agreed today without any obligation. A financial put option gives the option owner to sell a stock in future without obligation for a price which is fixed today. A real option is an option related to tangible assets. Strategic investment decisions of a firm are related to acquiring, exercising, abandoning or let expiring real options where managerial decisions create real options on real assets that give management the right to utilise those assets without obligation to maximize the value of the firm and achieve strategic goals (Brach, 2003).

2.7.3 What is Real Options Analysis?

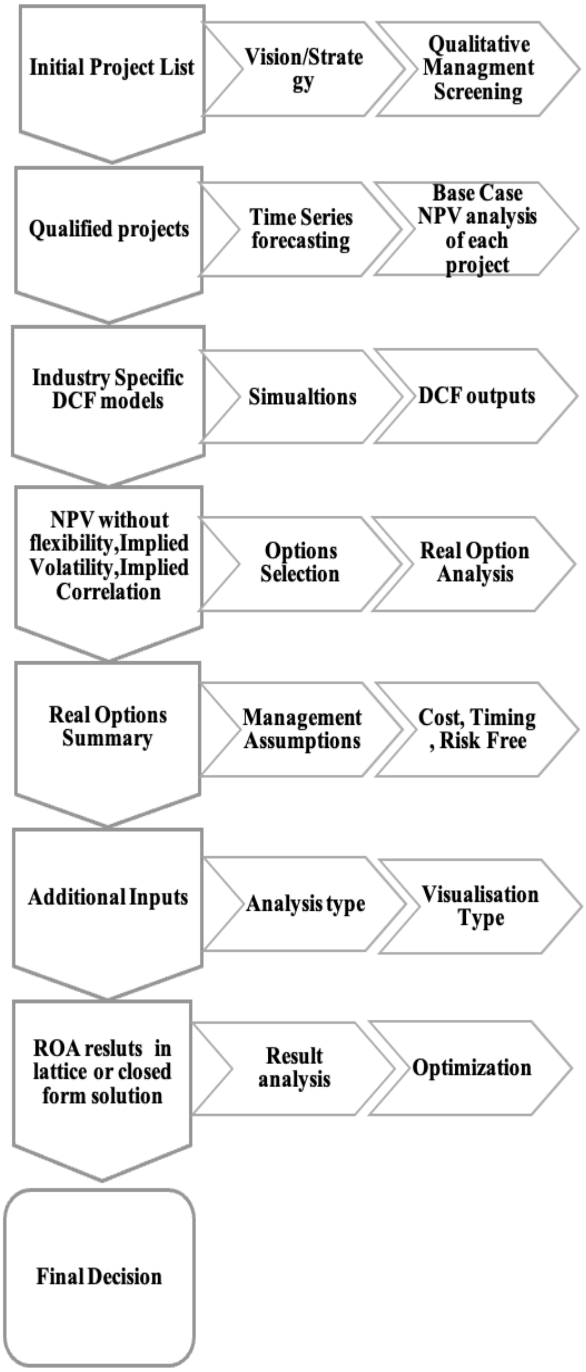
ROA is a strategic tool and a cross-organizational exercise conducted to list out the options, identify risks and managerial flexibilities and delivers a structure for real options pricing which is a benchmark to measure real option execution. Main advantage is that the ROA method can integrate managerial flexibility into the valuation process which assists in making best possible decisions. Uncertainties can arise from internal and external sources and can be related to market dynamics, organisational capabilities, technical know-how and political and regulatory issues. The ability of a firm in managing internal uncertainties and coping with external ones are valued ROA. Assets of firms, the options they have and exercisable options in the pipeline are the factors which drive the value of organisations (Brach, 2003).

According to (Mun, 2002) simple steps involved in ROA are

- Qualitative analysis of projects by management
- Initial NPV analysis creating a Discounted Cash Flow (DCF) model as base case
- Monte Carlo Simulation to get better estimate of single-point DCF model result
- Framing of real options problem, which identifies strategic options available
- Modelling of real options and analysis
- Optimization of resources and portfolio
- Reporting of analysis and updating the analysis to incorporate midcourse decisions

The seven major steps in ROA are as depicted in figure 2-2.

Figure 2 - 2 Real Options Process



Source: Adapted from (Mun, 2002)

2.7.4 What are the advantages of using ROA over traditional project appraisal methods?

Discounted Cash Flow(DCF) analysis and Net Present Value (NPV) calculation in a capital budgeting method will not consider the managerial flexibilities inherent in the project and assumes that the firm will follow an inflexible path forward. The assumption means that the management will ignore or fail to make any adjustments in decisions in relation to changes in market conditions. NPV method also ignores the fact that investments are done often in sequential steps and management is having an option to proceed or cancel further investments at different sequential decision points. Management also has other options in hand to accelerate, expand or contract the project at different time frames. In NPV method the risk involved in the project is considered as static and disregards the fact that managerial actions will mitigate risks in due course when additional information is available. But, ROA sees volatility and risk as a potential upside factor and ascribes value to it by incorporating uncertainty and risk with flexibility in the valuation process. Option valuation acknowledges the fact that managerial flexibility can mitigate risks and creates additional value to the project under evaluation (Brach, 2003).

2.7.5 Evolution of Option Pricing and emergence of Real options

'Theory of Speculation', the PhD thesis of Louis Bachelier (1870-1946) written in 1900 can be considered as the basis for the theory of options which contributed to the mathematics of stochastic processes. This thesis was completed even before Einstein developed the theory of the "Brownian motion" to mathematically explain the random motion of molecules. Bachelier's thesis assumed that the prices of shares undergo a random walk or shares follow a geometric Brownian motion. The seminal assumption of his thesis means that value of an option is equal to the expected gain or loss of the speculator or investor which is exactly Black-Scholes formula captures for financial options. For real options, their value is the expected benefit of an investment (Morel, 2020).

2.7.6 The Black-Scholes formula and Real options

The Black-Scholes formula is a milestone in financial options theory which earned Nobel Prize in 1997 for Myron Scholes and Robert Merton but Fischer Black was not awarded as Nobel prize is not given posthumously. The formula gives the value of European call or put options when the uncertainty on value of underlying asset follows a geometric Brownian motion. This formula is a continuation of Bachelier's theory with an additional concept of *risk neutrality.* A financial option which can be continuously traded as long as it is alive and returns from trading is the market rate or riskless rate and it is independent of the value of the underlying asset (Morel, 2020). At the time when financial options began trading, researchers started viewing corporate securities as call or put options and it was Stewart Myers who pioneered the concept that financial investments can generate real options and coined the term "Real Options" in 1977 (Brach, 2003). When it comes to real options, uncertainty has a completely different origin and in most cases cannot be described by a lognormal distribution as in the case of Black-Scholes formula. So, normally Black-Scholes formula cannot be applied normally in real options (Morel, 2020).

2.7.7 What exactly is the Real Option Value of an investment?

The real option value measures the expected benefit from the investment which is made today. The value of the real option helps to decide whether making the investment under uncertainty makes economic sense. The value of the real option is rarely paid and it is an abstract number helping to make investment decisions. For example, an investor has a choice to invest now or at a later time but delaying investment incurs an additional cost. Real option analysis will measure the expected benefit of waiting or the value of not investing immediately. If the real option value measured or the expected benefit of waiting is larger than the cost incurred for waiting then delaying the investment makes economic sense. In this case the additional cost gives the investor with a right to delay investment without obligation to invest now and this additional cost has the attribute of a financial option. But real option value is a separate number or a reference value not to be paid but is used for comparing with the additional cost paid to delay the investment and check whether delaying the investment makes sense(Morel, 2020).

2.7.8 Comparative analysis of real options and financial options

Financial options are available on various underlying assets like stocks, government bonds currencies , future contracts and precious metals like gold. Real options deal with capital budgeting, business transactions and investments. Uncertainty, Irreversibility and Choice of alternatives are common for both financial and real options (Brach, 2003).

Five key levers of real options and their analogies in financial options are

- Value of underlying asset or stock price

In real options, underlying asset is a project, investment or an acquisition and present value of future cashflows from the asset gives the value of underlying asset. In a call option, value of real option increases with increase in value of underlying asset and it is just the opposite in the case of a put option. Owner of the real options can influence the value of the underlying asset while in financial options it is not possible where the value is dependent on stock price (Peters, 2016).

- Exercise price or investment cost

A premium or an exercise price is paid for acquiring an asset in the case of a call option and a premium is received for selling the asset in the case of a put option. In a call option value of option will decrease with increase in exercise price and in put option the value will increase with an increase in exercise price (Peters, 2016).

- Time to expiration of the option

It is the valid time period till the option is viable in real options while in financial options it is time of expiry of the option. Option value will increase with increase in time to the expiry of the option (Peters, 2016)

- Volatility of the underlying risky asset

Higher the standard deviation of the value of underlying asset, volatility or riskiness will be higher and value of the real option will be higher. This is true for both call and put options because payoffs of options depend on difference between value of underlying asset and the exercise price. Volatility will increase the likelihood of this difference (Peters, 2016).

- Risk-free rate of interest over the life time of the option

Increase in interest rate will increase the value of a call option while value of a put option will reduce with increase in interest rate (Peters, 2016).

Below table gives the analogies in financial options and real options.

Table 2 - 1 Analogies in financial and real options

Financial Option	Real option
Stock price	Present value of future cash flows from asset
Exercise price	Cost to acquire asset
Time to expiration	Length of time option is viable
Volatility in stock returns	Volatility or riskiness of the asset
Risk-free rate of return	Risk free rate of return

Source:(Brach, 2003)

2.7.9 Classification of Real Options

Various real options can provide strategic adaptability and operating flexibility to a firm while taking investment decisions (Trigeorgis, 1996). Common Real options available to a firm are

- Option to Defer investment

Deferral real option gives the firm an option to delay the investment until some uncertainties are resolved. So, option to defer is analogous to an American call option on the present value of the completed project's expected cash flow with an exercise price equivalent to required outlay or investment to keep the option alive (Trigeorgis, 1996). For example, consider the case of a shipowner planning to invest in new ships. He pays a shipyard an amount (exercise price) to reserve berth for building a ship at later stage (option purchase) within a stipulated time limit (time to expiration). Shipowner has the option to procced with building the ship at any time within the timeframe. But it may be valuable for the shipowner to wait until certain uncertainties are resolved. So, in this case real option analysis will assess the value of option to wait and compare with the choice of investing immediately in building the ship.

- Option to Expand

This is similar to a call option to acquire an additional part of a base-scale project at an additional exercise price. This can be seen as an investment opportunity plus a call option on future investment (Trigeorgis, 1996). Considering the above given example, a ship-owner holds an option to expand if he decides to add more ships in the initial project.

- Option to Contract

Management can operate below the capacity and reduce the scale of operations if the market turns unfavourable. This flexibility to mitigate loss is equivalent to a put option on part of the base-scale project with exercise price equal to the potential cost savings (Trigeorgis, 1996). In the above example the ship owner holds an option to contract if he decides to sell a part of the newly acquired fleet.

- Option to Abandon

If the management decides to abandon the project in exchange of its salvage value it can be considered as an American put option on project's current value with the salvage value as the exercise price. Valuable abandonment options are found in capital-intensive industries, financial services and new-product introductions in uncertain markets (Trigeorgis, 1996).

- Option to Switch

This option provides management with built-in flexibility to switch from current input to cheapest future input or from current output to most profitable future product mix when there is fluctuation in the relative prices of inputs and outputs over time. The firm will be willing to pay a certain positive premium for such a bult-in flexibility (Trigeorgis, 1996).

The common types of real options enumerated above are listed below in a table format.

Table 2 - 2 Types of Real Options

Option to Defer	Defer investment until additional information is obtained which reduces market uncertainty
Option to Expand/Contract	Right to scale-up a fraction of a project / sell a fraction of a project. Altering capacity based on market conditions
Option to Abandon	Right to abandon a project
Option to Switch	Right to alter input/ output parameters or modes of operation
Option to Stage	Option to invest in incremental steps
Option to Grow	Option to include related opportunities

Source:(Brach, 2003)

2.7.10 Taxonomy of Real Options in research and its evolution

The concept of real options is used in research related to corporate investment decisions and a wide range of literature is available on different types of real options which are applied in different streams of research like strategic management and decision analysis. Real options are also applied by researchers in specific cases of investments in new technologies, R&D, green investments and emission abatement techniques. Researchers have incorporated various real options in different contexts and investment scenarios.

McDonald & Siegel (1986) studied the optimal timing of an investment *(option to defer)* in an irreversible project. Benefits and associated costs of the project follow a continuous-time stochastic process. They derived an explicit formula for the value of the option to invest and they observed that the normal rule of "invest if benefits exceed costs" does not properly account for the option value of waiting or the value of deferring the investment. Based on their studies they concluded that if the variance of the rate of change of a project's value equals risk-free rate and the project value has a zero expected rate of change, then it would always be optimal to defer. Deferring the project until the present value of the cash flows is double the investment cost should be adhered in a risk neutral world.

Ingersoll & Ross (1992) studied the importance of waiting to invest *(option to defer)* in an uncertain economy and found that nearly all investment projects have option rights values even though there is little or no uncertainty about their cash flows. They concluded that even the simplest of projects have an option value with uncertain interest rates and the effect of interest-rate uncertainty on the optimal delay of investment is sizeable.

Pindyck et al. (1988) analysed whether firms correctly compute and take into account the opportunity cost of investing when making capacity expansion decisions *(option to expand/contract)* and point out that ignoring such costs will lead to over-investments. They concluded that a firm's market value has two components 1) value of installed capacity or the value of the option to utilize some or all of its capacity over time and 2) the value of firm's options to add more capacity later. They proposed a capacity choice problem model to show how the value of marginal unit cost of capital, opportunity cost of investing and firm's optimal capacity depend on current demand as well as uncertainty over future demand.

Kogut & Kulatilaka (1994) studied the option value of a multinational network deriving from the operating flexibility to shift production between two plants *(switch option)* located in different countries. In their research work a stochastic dynamic programming model is used to treat this flexibility as owning an option, the value of which is dependent upon the real exchange rate. They concluded that the uncertainty of the international market drives the opportunities available to a multinational firm in its investments and operations.

Dixit (1989) constructed a model of optimal inertia in investment decisions to analyse entry and exit decisions *(option to abandon)* of firms in markets and this model shows how the optimal ex-post decisions are affected by the present conditions and how optimal choice of sunk investments is in turn dependent on rational expectations concerning future fluctuations in a real options perspective.

Trigeorgis & Reuer (2017) provided three different approaches to real options in research and how *Real Option Theory* can address fundamental issues of strategy including the managerial dilemmas of commitment versus flexibility as well competition versus cooperation. According to them, the most common approaches in real options decision making are 1) Real Options Reasoning where this approach relies on logic and heuristics and real options are considered as a way of thinking by managers 2) Real Options Valuation and Modelling where this approach uses formal mathematical models and simulations to value options and derive hypothesis for research 3) Behavioural Perspective which focuses on the implementation of real options in organisations. After critically analysing extensive literature on Real Options Theory they concluded that future research should focus on refining and extending the applicability of Real Options Theory considering the role of management and organisations and addressing critical implementation issues. So future research should take an organisational and implementation perspective rather than focusing only on valuation methods or purely strategic reasoning.

The concept of real options are even applied in optimal timing of policy interventions (Pindyck, 2000) where he focused on a one-time policy adoption to reduce emissions of a pollutant which imposes sunk costs on society. He pointed out that if the policy intervention can be delayed there is an opportunity cost of adopting the policy now rather than waiting for more information. This is considered analogous to an incentive to wait *(option to defer)* arising with irreversible investment decisions. So real options are applied in different realms in addition to direct capital investment decisions.

2.7.11 Application of Real Options in CSR research

Husted (2005) developed the notion of CSR as a real option and he studied the implications of real options perspective of CSR towards risk management. According to him real options theory allows for a strategic view of CSR and ex-ante downside business risk should be negatively related to CSR. He observed that many of the studies on relationship between CSR and CFP also looked at the relationship of CSR to risk and found evidence for a negative correlation: as CSR increased, risk decreased. Firms with a proactive CSR approach tend to anticipate potential sources of business risks such as potential governmental regulations and engage in sound managerial practices like environmental assessment and stakeholder management. This can viewed as a strategic move by engaging in CSR for reducing business risks.

Hitch et al. (2014) introduced the concept of optionality of CSR programs in the mining sector. Complex systems theory approach was applied in their study to recognize the different applications of CSR policy development and implementation at various stages of a mine's lifecycle.

According to Bosch-Badia et al. (2015) CSR initiatives often create value indirectly from new opportunities embedded in the projects. They state that value creation is the necessary condition for the financial sustainability of the CSR projects and real options can be regarded as an essential tool to identify this value creation capacity at both qualitative and quantitative level. Based on this argument they emphasize the need for incorporating real options in decision analysis of CSR projects. In their study they analysed CSR decisions from a real options perspective and real option based indicators (real option ratios) are proposed to help decision analysis on CSR.

Cassimon et al. (2016) analysed the process for firms to decide whether or not to invest in CSR from a real option perspective. Extending the framework of Husted (2005) with an additional parameter to understand the timing of CSR investment they developed a timing model which allowed for the impact of opportunity cost while delaying a CSR investment decision. They concluded that companies will always delay CSR investments in the absence of any opportunity cost of waiting. This model helps the firms to determine the optimal timing in exercising the CSR investment option.

According to K. J. Lee (2018) studying the effects of CSR on corporate valuation is essential, considering the long-term benefits of CSR implementation especially by raising the reputation of the firm. He applied real options approach and proposed a dynamic model for valuing CSR investments, CSR options value and the optimal timing for implementing CSR. Calculating CSR option values by the proposed model facilitates to answer the key questions of whether to invest and when to invest in CSR projects.

Extending the idea of using real options perspective in socially responsible investments Herath et al. (2019) demonstrated the incorporation of real options theory in a Bayesian decision-making framework for investments in an environmentally friendly technology which can be viewed as a profit-driven CSR real option. They viewed that monetary quantification of an environmental friendly CSR investment using real options enhances the value of the project by adding option value to the net present value of the investment making a business case for CSR investment. They concluded that Bayesian analysis combined with real options theory allows active risk management by proactively gathering additional information rather than passively resolving uncertainty by delaying investments.

Bosch-Badia et al. (2020) in their research work focused on evaluating CSR investments in the *triple bottom line* perspective. According to them, the primary goal of CSR projects is to improve corporate sustainability rather than maximising financial value creation and hence they must be evaluated for their impact on natural, social and financial capitals. They present a metric that unites the effects of CSR on natural, social and financial capitals in the form of a single indicator. In this approach they incorporated real options analysis in assessing the financial sustainability of the project by calculating profitability index which is a ratio of *gross present value* and *present value of capital outlays* of the concerned project.

Considering the diverse nature of CSR initiatives and the difference in inherent motivation for adopting CSR by companies, it is difficult to develop a "*fit for all*" model to accurately value the CSR projects. But, ROA is a proven methodology to value these investments in a better way by incorporating the value of managerial flexibilities associated with CSR investment decisions.

2.7.12 Real Options Analysis applied in Shipping sector

Table 2 - 3 List of previous studies applying ROA in Shipping sector

Author	**Type of Real Option**	**Scenario**	**Real option analysis approach**
(Bendall & Stent, 2007)	Choice option to alter strategies	New ship investment by an existing container shipping company	Continuous time stochastic bivariate Geometric Brownian motion approach
(Sødal et al., 2008)	Switch Option	Switch between dry bulk market and wet bulk market for a combination carrier	Ornstein-Uhlenbeck entry-exit model with continuous time stochastic approach
(Floriano C. M. Pires, 2012)	Abandonment option	Investment in suezmax tanker	Monte Carlo approach adding option to abandon
(Acciaro, 2014)	Investment timing (Deferment Option)	Investment timing of LNG fuel retrofit on ships	Discrete time binomial tree approach
(Gkochari, 2015)	Optimal Investment timing	Optimal timing of investment in dry-bulk shipping focusing Capesize sector	Option games theory approach
(Rau & Spinler, 2016)	Optimal investment timing	Optimal investment timing in container shipping industry	Options games theory approach in both continuous time and

			discrete time framework
(Luo & Kou, 2018)	Optimal investment timing	Optimal timing of investment in dry-bulk shipping	O-U continuous time stochastic approach
(Yin et al., 2019)	Deferral option and Abandonment option	Actual case analysis of second hand purchase of a bulk carrier and comparing the investment analysis using both NPV method and ROA method	Discrete time binomial valuation approach
(Zhang & Yin, 2021)	Expansion, Contraction, Deferral and Abandonment options	Investment decisions in bulk shipping with a real ship investment case study of investing in 4 VLCCs	Fuzzy real options binomial tree approach
(Pomaska & Acciaro, 2022)	Deferral option	Investment in hydrogen powered vessel	Discrete time binomial valuation approach

Source: Author’s compilation

3. METHODOLOGY

A positive link between CSR and CFP is yet to be ascertained as mentioned in the previous section. One of the main reasons for this failure is due to the differences that exist in corporate management structure among different firms and specific strategies chosen by various firms in different sectors. A case-by-case analysis is required to exactly evaluate the link between financial performance of a company and its CSR initiatives. In this thesis, a proactive CSR investment initiative by a shipping company is considered and ROA is used to evaluate the optimal timing of investment considering the CSR initiative and the associated investments as a real option.

Financial option pricing models serve as a base for real options solutions and several methods are available to calculate real option values. Solution methods include solving partial differential equations with specified boundary conditions, and optimizing decisions at various decisions points in decision tree like binomial lattices. Here a binomial method is used to develop a recombining binomial lattice and solution is obtained using a risk-neutral probability approach for risk adjustments which enables discounting cash flows at risk-free rate. In this study where investment analysis is pertaining to decisions of buying a new ship, it is reasonable to follow a discrete time stochastic approach and consider an yearly time increment in the model framework.

3.1 Binomial Option pricing model

The most commonly used valuation methods in ROA is the Binomial option pricing model. In this method a probability approach is incorporated in the valuation process and risk-adjusted discount rate in traditional NPV analysis can be replaced with the risk- free rate by using risk-neutral probabilities in the calculations. In this approach probability distributions are derived for the future asset value considering main drivers of uncertainty. This model assumes a discrete time approach and the value of underlying asset either moves up or down while moving from one time node to the succeeding time node.

Binomial model can be represented using a binomial lattice where evolution of possible values of underlying asset during the life of the option is represented and solution is obtained by optimizing future decisions at various decision nodes in a backward recursive manner into the decision node under consideration. A generic recombining binomial tree can represented as follows

Table 3 - 1 Generic Recombining Binomial Tree

Node(i,j)	**T0**	**T1**	**T2**	**T3**	**-**	**Ti**
0	S (0,0)	SU (1,0)	SU^2 (2,0)	SU^3 (3,0)	-	SU^iD^0 (i,0)
1		SD (1,1)	SUD (2,1)	SU^2D (3,1)	-	$SU^{i-1}D^1$ (i,1)
2			SD^2 (2,2)	SUD^2 (3,2)	-	$SU^{i-2} D^2$ (i,2)
3				SD^3 (3,3)	-	$SU^{i-3}D^3$ (i,3)
-					-	-
					-	$SU^{i-j}D^j$ (i,j)

Source: Author's representation

where S is present value of the underlying asset and U & D *up* and *down* factors in each node and U > 1 and D < 1.

Up and down factors are a function of the volatility of the underlying asset given by following equations

$$U = e^{\sigma\sqrt{t}} \text{ ------------------------------------- } 1$$

$$D = e^{-\sigma\sqrt{t}} \text{------------------------------------- } 2$$

where u and d denotes the corresponding upward and downward movements in each time node

σ is the volatility(%) indicating the standard deviation of the natural logarithm of free cash flow returns and *t* is the time within each time step of the binomial tree.

Risk-neutral probability is calculated as follows

$$P = \frac{e^{rt} - D}{U - D} \text{ ------------------------------------- } 3$$

where r is the risk-free rate.

So, corresponding probabilities in each node can be calculated by using P(U) which is the probability that the value of underlying asset goes up by a multiple of U and P(D) which is the probability of value of the asset going down by a multiple of D.

$$P(U) = \frac{e^{rt} - D}{U - D} \text{-------------------------------------} 4$$

$$P(D) = 1 - P(U) \text{ -------------------------------------} 5$$

Probability values for each node can be calculated by using the equation

$$p_{(i,j)} = \frac{i!}{j!(i-j)!} P(U)^{i-j} P(D)^{j} \text{-------------------------------------} 6$$

Inputs required for building binomial trees and calculate option values are present value of the asset (S), volatility factor (σ), risk-free rate (r), life of the option (T), cost of exercising the option (I) and time step in the analysis (t). Applying binomial option pricing needs to pre-determine the life of the option (T) and real option value calculations start from building the binomial tree of future asset values over the life of the option(T). Option value calculations start from the terminal node in a backward recursive manner.

Normally in ROA 'American style' options (options that allow to exercise prior maturity) are considered. When a real option of an investment in a project is considered, value maximization condition is calculated in each node comparing investing at that particular node or waiting until the next time period. Option calculations start from the terminal nodes at the termination time of the option. Exercise price (Investment cost) is deducted from all nodes and expected value of the asset is calculated. By the definition of the problem, option is not available beyond the termination time and if not invested at the termination time, option will be expired if not exercised. So rational decision will be to invest at the termination time instead of waiting and whether to invest at a particular termination node depends on the value of asset at the corresponding node. So, investment is considered at all nodes in the termination time frame and option value is set to zero in nodes where investment is not made.

Investment at termination node is considered and option values at termination nodes can be calculated by

Option value at terminal node($C_{(i,j)T}$) = Max (0, Value of asset at terminal node – $I.(1 + r_c)^{t}$*)---7*

Further, from the termination node intermediate nodes are considered. First step is to calculate the expected value of keeping the option to invest open. This value is actually the discounted value (at risk-free rate (r)) of weighted average of future option values using risk-neutral probability. Investment cost increases over time when opportunity cost of capital is considered and (r_c) is the rate of increase per year while (t) is the investment year from now. Value of option at any intermediate nodes is given by

$$C_{i,j} = Max\left(\frac{P(U).C_{i+1,j}+P(D).C_{i+1,j+1}}{e^{rt}}, S_{i,j} - I.(1+r_c)^t\right) \text{-------------------------------------} \quad 8$$

3.2 Fleet renewal of a dry bulk shipping company as a CSR real option

The objective of this study to integrate CSR/ESG initiatives strategically into fleet renewal decisions of a dry-bulk shipping company considering the CSR initiatives as a real option. Decision to order an alternate fuel-ready ship (ammonia-ready) by a dry-bulk shipping company under present circumstances can be considered as a CSR initiative to enhance environmental performance and ESG performance. According to (Clarksons, 2022), the orderbook as per June 2022 shows that only six alternate fuel-ready ships (ammonia-ready) are ordered as of now by a single company. For a dry-bulk shipping company considering to order an ammonia-ready ship as a proactive environmental initiative to improve ESG performance a logical decision will be to invest immediately and order now. But, strategic level integration of CSR/ESG initiatives require a structured framework augmenting the traditional NPV analysis to incorporate managerial flexibilities into investment decision analysis. When CSR initiatives are viewed in a strategic perspective, company should consider the competitive advantage of such initiatives and the effect of CSR initiatives on financial performance. This study uses ROA to incorporate managerial flexibilities such as deferring the investment to a later stage which will add more value to the project when uncertainties resolve passively at a later stage.

3.2.1 Investment scenario

In the investment scenario for analysis, a shipping company is considering to replace one old non-eco capesize ship (2006 built) with an alternate fuel-ready (ammonia-ready) ship. Analysis considers delivery of ship in different years each as a separate case ranging from 2023 to 2028. This indicates the managerial flexibility to invest until 2028. Option values are calculated for investment in each year ranging from 2023 to 2028.Further three scenarios of conversion to alternate fuel is considered. Conversion will take place either in 2028, 2029 or 2030.

Table 3 - 2 Investment Scenarios

Scenario 1: Conversion to alternate fuel in 2028	Scenario 2: Conversion to alternate fuel in 2029	Scenario 3: Conversion to alternate fuel in 2030
Investment/ Delivery of ship in 2023	Investment/ Delivery of ship in 2023	Investment/ Delivery of ship in 2023
Investment/ Delivery of ship in 2024	Investment/ Delivery of ship in 2024	Investment/ Delivery of ship in 2024
Investment/ Delivery of ship in 2025	Investment/ Delivery of ship in 2025	Investment/ Delivery of ship in 2025
Investment/ Delivery of ship in 2026	Investment/ Delivery of ship in 2026	Investment/ Delivery of ship in 2026
Investment/ Delivery of ship in 2027	Investment/ Delivery of ship in 2027	Investment/ Delivery of ship in 2027
Investment/ Delivery of ship in 2028	Investment/ Delivery of ship in 2028	Investment/ Delivery of ship in 2028

Source: Author's elaboration

In each scenario, real option values are calculated as sequential options of investment in two steps. One investment in alternate fuel-ready ship and other investment is the additional capital required for conversion to alternate fuel.

3.2.2 Major calculation steps in the ROA

- Calculation of present value of the project using a firm specific discount rate from net-revenue cashflow.
- Apply the binomial option pricing model to build a binomial tree starting with the present value of the project.
- Calculate option values for each investment case in all three conversion scenarios by applying investment decisions in the relevant nodes in a backward induction manner.
- Calculate the value of deferring investment for each case in all three fuel conversion scenarios with a base case efficiency factor of 8% and conversion factor of 20%.

- Calculate the deferral values for each investment case in all conversion scenarios with efficiency factor ranging from 0% to 50% and three assumed values for conversion factor (0%, 20% & 50%) to determine the effect of additional revenue on investment decision.

3.2.3 Efficiency factor and Conversion factor in cash flow analysis

This study incorporates two charter rate differentiation factors called *Efficiency factor (EF)* and *alternate fuel Conversion factor (CF)* for new energy efficient and fuel flexible ships in the net revenue cash flow calculations. These factors are considered based on increased charter rates (Clarksons, 2022) presently received by energy efficient eco-bulk carriers. Increased charter rates are due to the increased efficiency of these ships achieved by a combination of design features or energy saving technologies (ESTs) and operational flexibilities like reduced speed operation which can considerably reduce the fuel consumption compared to old ships.

3.2.3.1 Calculation of Efficiency factor

Efficiency factor (EF) = F (Cost savings to charterers from increased fuel efficiency, Voluntary addition factor from charterers/cargo owners)

In this study Efficiency factor (EF) is taken as 8% (base case) which is calculated from difference in charter rates between non-eco ships and eco-ships based on Clarksons (2022) data as given below. Value is taken as the average of % difference for 1year, 3year and 5year time charter rates and incorporated in calculating the initial project value. Further, ROA is carried out based on the initial project value and deferral values are calculated. Efficiency factor is further varied from 0% to 50% and again deferral values are calculated to analyse the effect of incentivizing factor on investment decisions.

Table 3 - 3 Average of weekly data of charter rates from Aug 2019 to Sep 2022

1 Year Time charter Rate 180,000 dwt Bulk carrier	1 Year Time charter Rate 180,000 dwt Eco Bulk carrier	3 Year Time charter Rate 180,000 dwt Bulk carrier	3 Year Time charter Rate 180,000 dwt Eco Bulk carrier	5 Year Time charter Rate 180,000 dwt Bulk carrier	5 Year Time charter Rate 180,000 dwt Eco Bulk carrier
21396 $/day	23026 $/day	17976 $/day	19578 $/day	17106 $/day	18598 $/day
% difference = 7.3%		% difference = 8.5 %		% difference = 8.4%	

Source: Author’s calculation based on Clarksons data

3.2.3.2 Calculation of Conversion factor

Conversion factor = F (Price differential between traditional fossil fuel/carbon-neutral MGO and alternate fuel, Voluntary addition factor from charterers/cargo owners)

In the analysis of major running cost of a bulk carrier by Stopford (2008), voyage costs account for 40% of the total running cost. 76 % of voyage costs are associated with fuel oil and rest include port costs and canal costs. Normally for a time chartered ship, voyage costs are borne by the charterer/cargo owner. Based on these estimates fuel cost accounts for approximately 30% of the total running costs of a bulk carrier. So, it can be assumed that the price differential between alternate fuel and carbon-neutral MGO from 2028 onwards can cause a 30% difference in charter rates and net revenue for the ship owner.

*Conversion factor = 0.3 * (% difference in price between fuels)*

In a study by DNV (2021) on future usage of various alternate fuels on a newly built capesize bulk carrier until 2050, the price for carbon neutral ammonia is forecasted as 959 USD/tonne and that of carbon neutral MGO is forecasted as 1675 USD/tonne. Based on this forecast, a 54% price difference in fuels is predicted and conversion factor will be 16%. In this analysis, conversion factor is taken as 20% (base case) implying a 20% increase in net revenue after conversion to ammonia.

3.2.4 Data strategy, calculation and assumptions of input parameters

3.2.4.1 Net-revenue expected cash flow

Net yearly revenue = (Daily charter rate- Daily operational expenses(OPEX)) No. of days in service per year.*

Daily charter rate is taken from (Clarksons, 2022) and average weighted earnings of all bulk carriers in 2022 is taken as the daily rate (USD/day). Daily OPEX is taken from (Clarksons, 2022) and average operational expense for capesize ships from 2000 to 2022 is taken daily OPEX (USD/day). No. of days in service per year is assumed to be 360 days. Cash inflows considered in this analysis are only the time-charter income for the ship owner. Cash outflows considered are only the OPEX and it is assumed that only fixed operational costs are incurred to the ship owner and voyage costs like fuel costs, port costs and cargo handling expenses are borne by the charterer. All operational costs like crew costs, lube oil costs, capital costs, taxes, maintenance and other administrative costs are assumed to be incorporated in OPEX. It is also assumed that the existing ship can continue in service until 2028 without any additional modifications to comply with upcoming emission regulations (EEXI/CII requirements).

For all scenarios cashflow is considered from 2022 to 2040 irrespective of the time of investment. Net-revenue cashflow is also assumed to be constant for all years until 2040. It is reasonable to assume a short life span for new ship due to high level of uncertainties related to alternate fuel viability and emission regulations and also providing a buffer zone until carbon-neutral 2050. In the investment scenario, the decision of the company is to replace an existing ship with a new ship. In the cash flow analysis it is assumed that switch between new ship and old ship is happening at the same time and at the first day of the year. So, the increased revenue due to efficiency factor and conversion factor is assumed to receive for the full investment year and onwards. Yearly OPEX is assumed to be constant in the analysis and also assumed to be same for old and new ships. Time to build or delivery delay is not considered in this analysis. Present value of the net revenue is calculated using a discount factor of 15% and continuous discounting is applied in the analysis. Discount factor is taken based on similar ship investment analysis of LNG fuel retrofit on ships by (Acciaro, 2014). Risk-free rate assumed in this study is 5%. The discounted net-revenue value (underlying asset value) for each scenario is taken as the base for ROA using binomial option pricing model.

3.2.4.2 Volatility of the underlying asset and risk-free rate

Volatility of underlying asset is the daily charter rate volatility. Average weighted earnings of all bulk carriers from 1990 to 2022 on an yearly basis are taken from (Clarksons, 2022) and percentage change of daily rates are calculated. Standard deviation of these values are calculated to obtain the volatility of the underlying asset (σ). In this study, σ is taken as 0.519. Taking standard deviation of log values of yearly data from 1990 to 2022 of daily charter earnings also give a close value equal to 0.538. In this study the volatility is assumed to be constant over the option life and a sensitivity analysis is carried out to analyse the effect of varying volatility.

3.2.4.3 Option exercise price or Investment cost and opportunity cost of capital

In this analysis two investment costs are considered. One investment is the cost of alternate fuel-ready ship and other investment is the capital required for conversion of ammonia-ready ship to use ammonia as fuel onboard from traditional fuel. As this analysis considers replacement of an existing old ship with a new ship, the capital investment required for new ship is taken as the difference in value between new ship cost and value of existing ship.

Cost of ship renewal investment = Cost of new ship – Resale value of existing old ship

In this study, cost of new ammonia-ready capesize ship is taken as 66 million USD and resale value of a 2006 built capesize bulk carrier is taken as 20 million USD and both rates are sourced from random actual deals given in (Clarksons, 2022). So the cost of investment in the analysis is taken as 46 million USD.

Investment cost of conversion to ammonia is taken as 12 million which is sourced from DNV(2021) case study of future alternate fuel adoption in a capesize bulk carrier. As investment is considered in different time frame, opportunity cost of capital is considered and investment cost is assumed to increase at a rate of 6% every year starting from 2022 for ship investment and also for the conversion investment.

3.2.4.4 Calculation of revenue loss and defining option life

Revenue loss for each scenario is incorporated in the initial project valuation calculation. Delaying option of ship investment is considered until year 2028. So delaying the ship investment to next year creates a revenue loss for 1 year and delaying until 2028 creates a revenue loss for 6 years from now (2022). Delivery delay is not considered in this analysis as there are practical options for the ship owner to buy a second-hand eco bulk carrier and later convert it to ammonia fuel. Conversion delay revenue loss is considered for delaying conversion to 2029 and 2030. As an example, the case of investing in 2028 with conversion in 2028 assumes that ship is delivered with the ability of actually using ammonia as the fuel and ship owner receives additional revenues from both efficiency factor and conversion factor. Revenue loss for the owner is only due to delaying ship investment until 2028 where the loss is for failing to gain additional revenue for an eco-ship for 6 years. But, if the ship owner opts to delay conversion to 2029 while replacing the old ship in 2028, there will be revenue loss due to efficiency factor for 6 years until 2028 and additional revenue loss due to conversion factor for 1 year.

4. RESULTS AND DISCUSSION

The main objective of this study is to use ROA as a supplement to traditional DCF method while integrating certain CSR/ESG factors strategically in the investment analysis. This approach helps to find the optimal timing of the investment when due importance is also given to the financial benefits associated with the CSR/ESG initiative of proactively investing in an ammonia fuel-ready ship.

Results presented below starts with the NPV analysis of the project in three fuel conversion scenarios. Further, results of the application of Binomial option pricing model are presented for all three fuel conversion scenarios. Results of both NPV analysis and Real Options analysis are based on the incorporation of Efficiency factor (EF) as 8% and Conversion factor (CF) as 20 % which can be considered as a base-case scenario. Deferral option values for various Capex levels are also analysed in the base case scenario. Further, to answer the fifth and final sub research question, the effect of financial incentives for the ship owner which affects the investment decisions are analysed and presented for all three fuel conversion scenarios by varying the Efficiency factor (EF) and Conversion factor (CF). Finally, the volatility of the underlying asset being a sensitive variable, a sensitivity analysis is carried out by changing the volatility factor for deferral value calculations in all three base-case fuel conversion scenarios.

4.1 Valuation of project by NPV analysis

First we need to analyse the results from traditional DCF analysis for each ship investment scenario. Cashflow analysis of net revenue for the ship owner is carried out incorporating the increased revenue received by replacing the existing ship (Efficiency factor, EF) and future conversion to alternate fuel (Conversion factor, CF). Net revenue is assumed to be constant for the entire time frame except for the changes in charter rates due to addition of Efficiency factor and Conversion factor when old ship is replaced with a new ship and at a later stage converted to ammonia fuel. Investment costs considered are the total costs required for the project which include cost of the new ammonia ready ship and also the cost required for future conversion to ammonia fuel. As the analysis considers replacement of old ship with the new one, resale value of existing ship is deducted from new ship investment cost.

4.1.1 Conversion Scenario 1: Conversion to Ammonia fuel in 2028

Table 4 - 1 NPV in scenario: Conversion to Ammonia Fuel in 2028

	Investment in 2023	Investment in 2024	Investment in 2025	Investment in 2026	Investment in 2027	Investment in 2028
Discounted Present Value of Project (Million USD)	47.66	47.23	46.87	46.56	46.28	46.05
Investment Cost (Million USD)	46.0 + 12.0	46.0 + 12.0	46.0 + 12.0	46.0 + 12.0	46.0 + 12.0	46.0 + 12.0
Net Present Value	Negative	Negative	Negative	Negative	Negative	Negative

Source: Author's Calculation

4.1.2 Conversion Scenario 2: Conversion to Ammonia in 2029

Table 4 - 2 NPV in scenario: Conversion to Ammonia Fuel in 2029

	Investment in 2023	Investment in 2024	Investment in 2025	Investment in 2026	Investment in 2027	Investment in 2028
Discounted Present Value of Project (Million USD)	47.12	46.69	46.33	46.02	45.75	45.52
Investment Cost (Million USD)	46.0 + 12.0	46.0 + 12.0	46.0 + 12.0	46.0 + 12.0	46.0 + 12.0	46.0 + 12.0
Net Present Value	Negative	Negative	Negative	Negative	Negative	Negative

Source: Author's calculation

4.1.3 Conversion Scenario 3: Conversion to Ammonia in 2030

Table 4 - 3 NPV in scenario: Conversion to Ammonia Fuel in 2030

	Investment in 2023	Investment in 2024	Investment in 2025	Investment in 2026	Investment in 2027	Investment in 2028
Discounted Present Value of Project (Million USD)	46.65	46.23	45.87	45.55	45.28	45.05
Investment Cost (Million USD)	46.0 + 12.0	46.0 + 12.0	46.0 + 12.0	46.0 + 12.0	46.0 + 12.0	46.0 + 12.0
Net Present Value	Negative	Negative	Negative	Negative	Negative	Negative

Source: Author’s calculation

From the NPV analysis of all three fuel conversion scenarios we can see that the project is not viable when considering the total investment costs which include net-cost of new ship and also the additional alternate fuel conversion cost. Net-cost of new ship is the price difference between new order ammonia-ready ship and resale value of existing old ship. In all three fuel conversion scenarios present value of the project is decreasing as the investment is deferred. This is indicating the loss in revenue by running less energy efficient old ship when replacement of ship is delayed. In a real case, maintenance costs are less for a new ship but capital costs will be increased due to the high investments costs for the new ship. These differences in OPEX for a new ship and old ship are not considered and OPEX is assumed to be same for the new ship and old ship. When the old ship is replaced by a new energy efficient ship, additional revenue in the form of better charter rates (Efficiency Factor) increases the net-cash flow for the company. By delaying the investment, company will be losing this additional revenue from differentiated increased charter rates for eco-ships. Comparing three fuel conversion scenarios where actual conversion to ammonia fuel is carried out in different years from 2028-2030, we can see a reduction in present value of the project in all corresponding ship investment scenarios when delaying the conversion. This is due to the effect of Conversion factor which creates a revenue loss when conversion to ammonia is delayed. Delaying the conversion fails to earn additional revenue to the ship owner generated by the increased charter rate that may arise due to the assumed price differential between alternate fuel and traditional fuel (carbon neutral MGO).

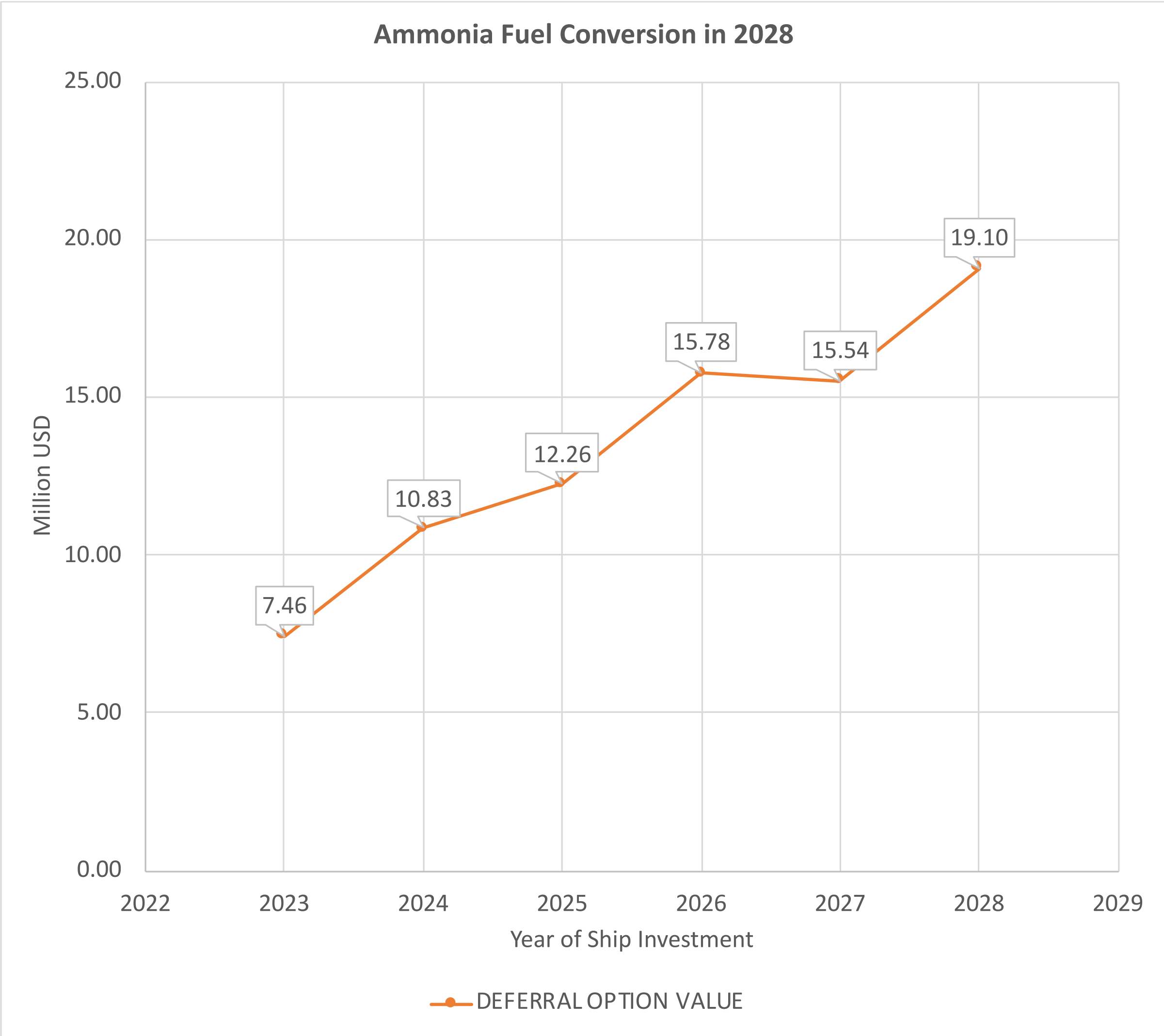
4.2 Project Valuation by Real Options Analysis

NPV analysis indicates that the project is not viable in all cases of investment and conversion strategies considered. As the NPV analysis indicates that the project does not generate enough returns company will not proceed with the investment decision. But, when the company considers investing in an ammonia-ready ship as a CSR/ESG initiative, the logical decision will be to invest immediately which enhances ESG performance and reputation. This study analyses the investment conditions using ROA framework to find the optimal timing of investment taking into consideration the uncertainties of the future cashflow and in this specific case, it is the uncertainty related to daily charter earnings. ROA captures the value of deferring the investment decisions to a later stage until 2028 and delaying conversion to ammonia from 2028 to 2030. As time elapses uncertainties related to charter earnings will be resolved passively and more information is available while investment decisions are taken which adds economic value and provides competitive advantage to the firm. ROA can quantify effect of the value-maximising decisions at a later stage by accounting the value changes in the underlying asset caused by uncertainties over the option life.

4.2.1 Deferral option values for the base case scenario

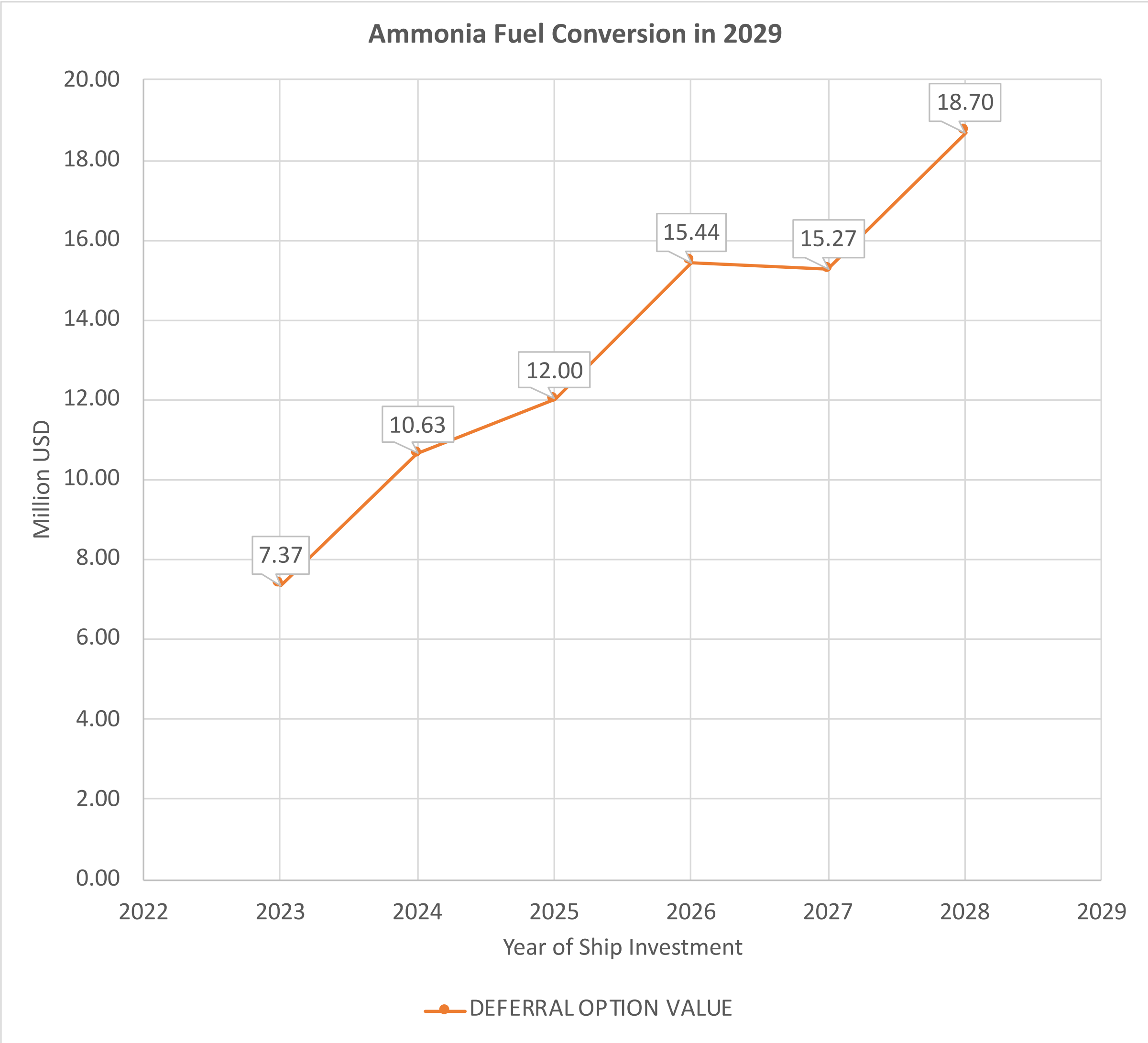
The results from real options analysis with selected input parameters for three ammonia conversion scenarios are given below (Figures 4-1, 4-2 & 4-3) with an applied efficiency factor (EF) of 8% and conversion factor (CF) of 20%. From the results we can observe that the deferral option value is maximum in the case of investing in 2028 in all three alternate fuel conversion scenarios. So in all three scenarios based on the inputs to the model, it is favourable to invest in 2028 and this makes more economic sense in all three scenarios. As the additional value generated in ROA is dependent on the volatility factor, the deferral option value will normally increase as time elapses in the case of cashflows with high volatility. So we can observe a progressive increase in option values in all three scenarios from 2023 to 2028 with an exception in the case of investment in year 2027. This is due to the difference in the present value of the project in each scenario due to the incorporation of efficiency factor and conversion factor that results in certain revenue loss as a result of delaying the investment. Testing the model without efficiency factor and conversion factor results in a progressive increase in deferral option values from the year 2023 to 2028 which can be observed in the next section where different efficiency and conversion factors are considered for the analysis.

Figure 4 - 1 Deferral option values in scenario: Conversion to Ammonia fuel in 2028



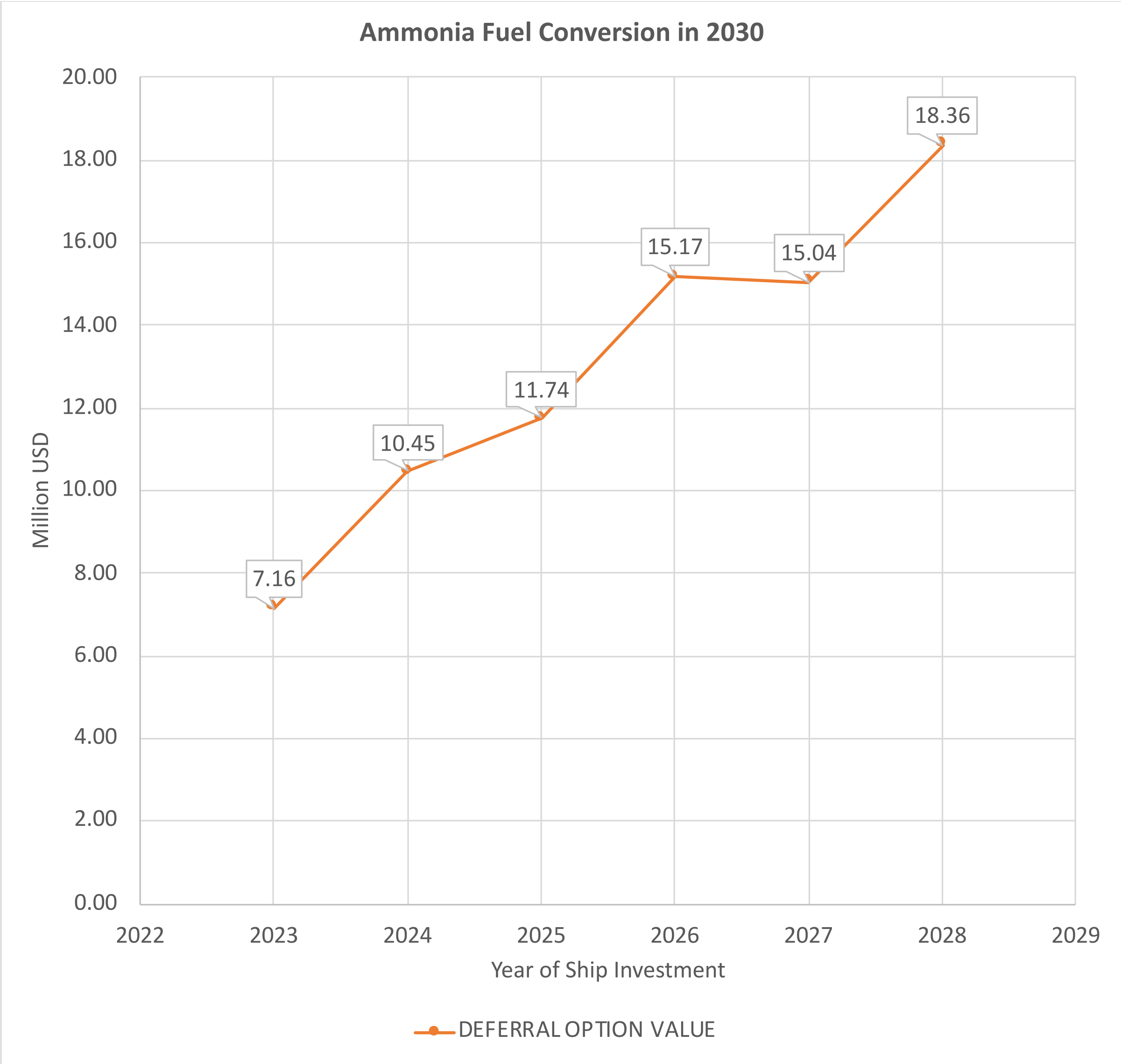
Source: Author's analysis

Figure 4 - 2 Deferral option values in scenario: Conversion to Ammonia fuel in 2029



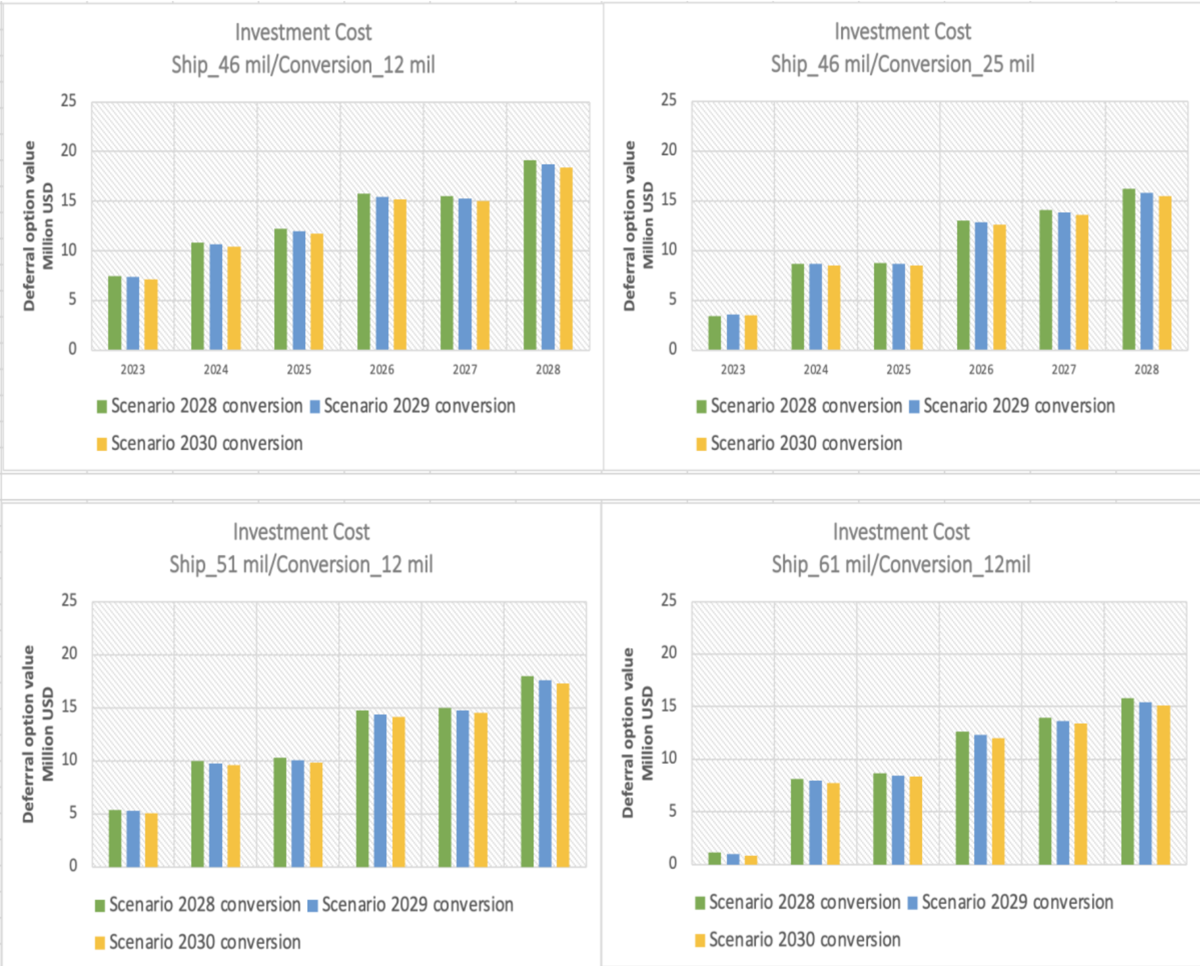
Source: Author's analysis

Figure 4 - 3 Deferral option values in scenario: Conversion to Ammonia fuel in 2030



Source: Author’s analysis

Figure 4 - 4 Deferral option values for different Capex levels



Source: Author's analysis

Even though deferral option value is highest in the case of ship investment in 2028 we can see that option value is higher in the year 2026 compared to 2027 in all three fuel conversion scenarios. So it is better to invest in 2026 if the company is not considering to defer investment until 2028. Comparing the option values of all three fuel conversion scenarios as shown in (Figure 4-4) we can observe that value of option is highest for conversion in the year 2028 irrespective of the year of ship investment in the base-case scenario where net ship investment cost is 46 million USD and conversion cost is 12 million USD. We also can observe the obvious decrease in option value as total investment cost increases. When conversion costs are increased to 25 million, option values in the case of ship investment in 2024 is almost same for all three conversion scenarios. In the case of ship investment in 2023 the option value is highest if conversion is done in 2029. So, when ship investment is done in next two years and conversion costs are high there is no prominent advantage in doing the conversion to ammonia in the year 2028.

4.2.2 Deferral option values for varying Efficiency factor and Conversion factor

In the specific case of investing in ammonia-ready and fuel efficient ship, additional revenue which can be gained by the ship owner through an increased charter rate in the case of a time-chartered ship is considered as the direct link to the financial performance of the company. The effect of varying incentivising factors on investment decisions are analysed by calculating deferral option values for different efficiency factors and conversion factors. By optimising investment decisions based on deferral option values can generate maximum benefits for the company and in turn improve financial performance of the firm from the investment.

Results presented in tables (4-4, 4-5 and 4-6) and figure (4-5) shows the deferral values obtained in the case of ammonia conversion in 2028. Complete set of results for all three fuel conversion scenarios are given in appendix 2. In the worst case scenario where both EF and CF are 0% (EF = 1,CF = 1), we can see an increase in option values as the investment is deferred from 2023 to 2028 and deferral option value is the highest when investing in 2028 which is equal to 15.96 million USD. In the best case scenario where EF and CF are 50% (EF = 1.5, CF = 1.5) (implying a 50% increase in charter rates for eco-ships and an additional 50% increase in charter rates for eco ships running on ammonia) we can again see that the deferral value is maximum in case of ship investment in 2028 which is equal to 29.22 million USD.

Table 4 - 4 Deferral values in million USD with CF=1 and varying EF (2028 Ammonia Conversion)

DEFERRAL OPTION VALUES (2028 CONVERSION, CF =1.0)									
	EFFICIENCY FACTOR								
	0%	5%	10%	15%	20%	25%	30%	35%	50%
OPTION INV_23-CONV_28-CF1	3.50	4.64	5.78	6.91	8.07	9.25	10.43	11.62	15.17
OPTION INV_24-CONV_28-CF1	8.28	8.95	9.62	10.29	10.96	11.64	12.32	13.00	15.04
OPTION INV_25-CONV_28-CF1	8.33	9.27	10.20	11.14	12.07	13.01	13.96	14.91	17.78
OPTION INV_26-CONV_28-CF1	12.74	13.39	14.04	14.70	15.35	16.00	16.65	17.30	19.25
OPTION INV_27-CONV_28-CF1	13.29	13.72	14.15	14.58	15.01	15.44	16.10	16.83	19.01
OPTION INV_28-CONV_28-CF1	15.96	16.49	17.02	17.55	18.08	18.61	19.14	19.67	21.26

Source: Author’s calculation

Table 4 - 5 Deferral values in million USD with CF=1.2 and varying EF (2028 Ammonia Conversion)

DEFERRAL OPTION VALUES (2028 CONVERSION,CF =1.2)									
	EFFICIENCY FACTOR								
	0%	5%	10%	15%	20%	25%	30%	35%	50%
OPTION INV_23-CONV_28-CF1.2	5.48	6.72	7.96	9.25	10.53	11.82	13.11	14.39	18.25
OPTION INV_24-CONV_28-CF1.2	9.65	10.39	11.13	11.88	12.63	13.37	14.12	14.87	17.12
OPTION INV_25-CONV_28-CF1.2	10.58	11.63	12.68	13.74	14.81	15.88	16.95	18.02	21.22
OPTION INV_26-CONV_28-CF1.2	14.59	15.34	16.08	16.82	17.57	18.31	19.05	19.80	22.03
OPTION INV_27-CONV_28-CF1.2	14.73	15.24	15.88	16.73	17.58	18.44	19.29	20.14	22.69
OPTION INV_28-CONV_28-CF1.2	18.08	18.72	19.35	19.99	20.63	21.26	21.90	22.54	24.45

Source: Author's calculation

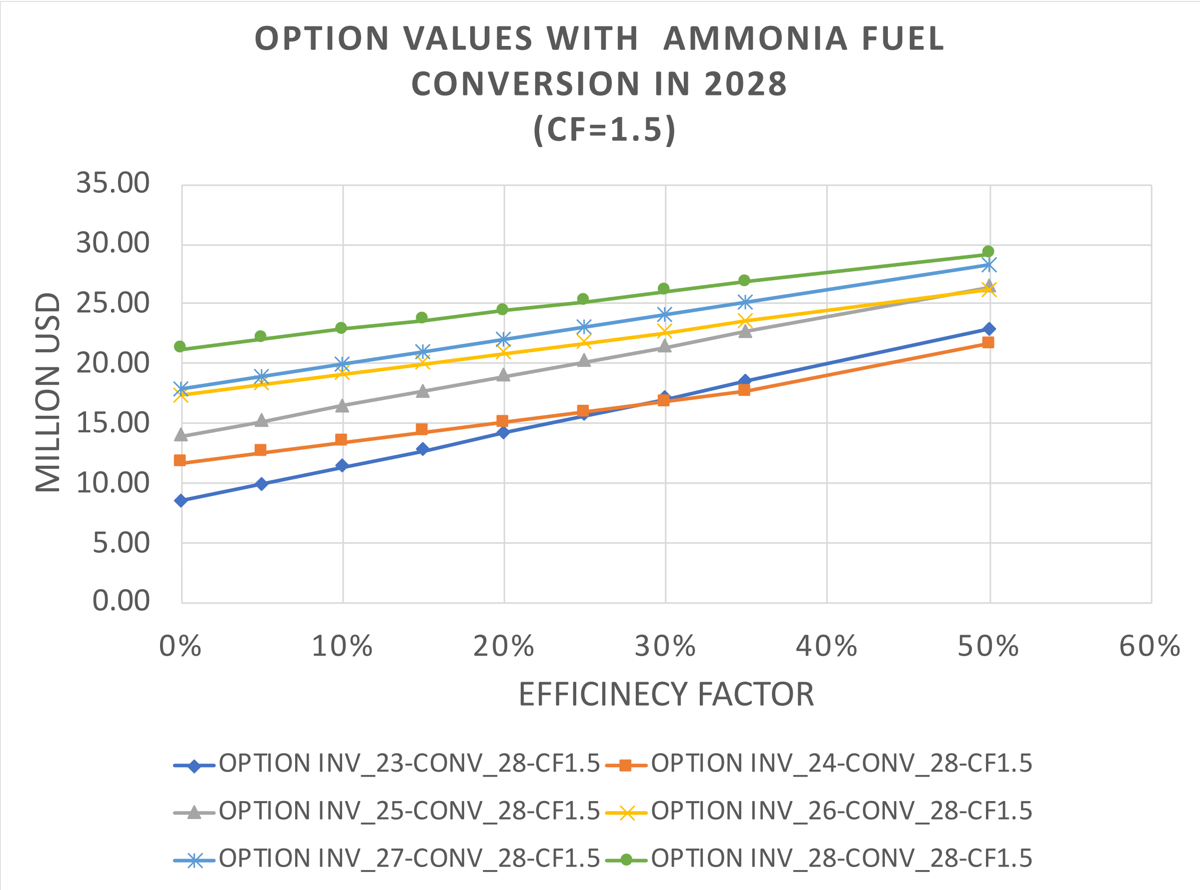
Table 4 - 6 Deferral values in million USD with CF=1.5 and varying EF (2028 Ammonia Conversion)

DEFERRAL OPTION VALUES (CONVERSION 2028, CF =1.5)									
	EFFICIENCY FACTOR								
	0%	5%	10%	15%	20%	25%	30%	35%	50%
OPTION INV_23-CONV_28-CF1.5	8.47	9.91	11.35	12.79	14.24	15.68	17.12	18.56	22.88
OPTION INV_24-CONV_28-CF1.5	11.71	12.56	13.42	14.27	15.12	15.97	16.83	17.68	21.66
OPTION INV_25-CONV_28-CF1.5	13.97	15.22	16.46	17.70	18.94	20.18	21.43	22.67	26.39
OPTION INV_26-CONV_28-CF1.5	17.37	18.25	19.13	20.01	20.89	21.78	22.66	23.54	26.19
OPTION INV_27-CONV_28-CF1.5	17.86	18.89	19.93	20.96	22.00	23.03	24.07	25.10	28.21
OPTION INV_28-CONV_28-CF1.5	21.26	22.06	22.85	23.65	24.45	25.24	26.04	26.83	29.22

Source: Author's calculation

So, in any case, irrespective of the amount of differentiated charter rates, it is better to invest in 2028. Revenue loss occurring due to delay in investing in eco-ships does not change the optimal timing of ship investment even if the charter rates are 50% more for the new ship compared to a non-eco ship. So, investing in ammonia-ready ship immediately as a CSR/ESG initiative does not provide any economic advantage for the company in the specific analysis with the selected input variables for the model. But, from the graph given below (figure 4-5) we can clearly observe that the option value of investing in 2023 (22.88) is more compared to investing in 2024 (21.66) when charter rates are 50% more for eco-ships along with an additional 50% increase in charter rate after conversion to ammonia. Option values almost reach same level in both cases when EF is around 30% (exactly 27.6%). We can also see from the table (4-6) that investing in 2025 is better compared to investing in 2026 under same conditions. This indicates that differentiated charter rates can definitely accelerate investment in new ammonia-ready ship if time horizon considered is only up to 2026 instead of 2028. Even without additional earnings after conversion (CF =1) we can see from table (4-4) that option value is higher in the case of investing in 2023 compared to 2024 when charter rates are 50% higher for eco-ships (EF = 50% or 1.5).

Figure 4 - 5 Deferral values with CF=1.5 and varying EF (2028 Ammonia conversion)



Source: Author's analysis

4.2.3 Sensitivity Analysis

Volatility of the underlying asset is a critical input variable in the binomial option pricing model used in this analysis. In this study specific to dry-bulk shipping industry, time charter rates are considered as the determinant of the value of the project which directly affects the net-revenue cash flow of the shipping company. Market uncertainty is directly related to the volatility of the freight rates and various previous studies used different approaches in freight rate analysis as discussed in section 2.6.2.1. A detailed study by Yin et al. (2019) related to volatility of the dry-bulk shipping market based on Baltic Dry Index (BDI) found that the volatility of dry bulk market over a recent 10 year span is around 0.861 while the volatility over a recent 5 year span is around 0.271. Value of volatility factor taken in this analysis is 0.519

As volatility factor is a critical and dynamic variable in the option pricing model, sensitivity analysis is carried out by varying the volatility from 0.1 to 1.1 in the base case scenario for all three fuel conversion cases which is given in below tables (4-7, 4-8 & 4-9). From analysing the results we can see that option values increase as volatility or uncertainty increases. This is in line with the general assumption that uncertainty increases the value of options. ROA ascribes value to uncertainty and considers volatility as an upside factor (Brach, 2003). We can see that value of options are zero in most cases when volatility factor is at 0.1 indicating that option is not in money in all those cases. When volatility is increased from 0.1 to 0.3, we can see that option values are higher for investment in 2027 and not 2028 if fuel conversion is carried out in 2029 or 2030. In all other cases option values are highest in the case of investment in 2028 and change in volatility factor is not affecting the optimal investment timing.

Table 4 - 7 Sensitivity analysis: Ammonia conversion in 2028

Sensitivity Analysis with varying volatility of underlying asset Scenario: Conversion to Ammonia in 2028 [EF = 1.08,CF = 1.2]							
		Volatility					
		0.1	0.3	0.5	0.7	0.9	1.1
Investment in 2023	Option Value	**0**	**1.15**	**6.93**	**12.62**	**17.78**	**22.34**
Investment in 2024	Option Value	**0**	**4.81**	**10.34**	**15.32**	**19.79**	**23.78**
Investment in 2025	Option Value	**0**	**5.23**	**11.52**	**18.9**	**25.19**	**30.4**
Investment in 2026	Option Value	**0**	**6.9**	**15.09**	**21.83**	**27.46**	**32.07**
Investment in 2027	Option Value	**0**	**8.13**	**14.96**	**23.02**	**29.69**	**34.82**
Investment in 2028	Option Value	**0.19**	**8.14**	**18.27**	**26.07**	**32.1**	**36.59**

Source: Author's calculation

Table 4 - 8 Sensitivity analysis: Ammonia conversion in 2029

Sensitivity Analysis with varying volatility of underlying asset Scenario: Converion to Ammonia in 2029 [EF = 1.08, CF = 1.2]							
		Volatility					
		0.1	0.3	0.5	0.7	0.9	1.1
Investment in 2023	Option Value	0	0.75	6.82	12.38	17.4	22.01
Investment in 2024	Option Value	0	4.55	10.14	15.07	19.5	23.5
Investment in 2025	Option Value	0	5.06	11.26	18.54	24.75	30.03
Investment in 2026	Option Value	0	6.56	14.74	21.47	27.07	31.69
Investment in 2027	Option Value	0	7.87	14.7	22.54	29.2	34.42
Investment in 2028	Option Value	0.06	7.75	17.88	25.66	31.65	36.13

Source: Author's calculation

Table 4 - 9 Sensitivity analysis: Ammonia conversion in 2030

Sensitivity Analysis with varying volatility of underlying asset Scenario: Converion to Ammonia in 2030 [EF = 1.08, CF = 1.2]							
		Volatility					
		0.1	0.3	0.5	0.7	0.9	1.1
Investment in 2023	Option Value	0	0.47	6.58	12.42	17.59	22.07
Investment in 2024	Option Value	0	4.33	9.95	14.96	19.42	23.36
Investment in 2025	Option Value	0	4.92	10.97	18.5	24.82	29.97
Investment in 2026	Option Value	0	6.26	14.48	21.26	26.87	31.44
Investment in 2027	Option Value	0	7.65	14.47	22.4	29.14	34.26
Investment in 2028	Option Value	0	7.5	17.54	25.3	31.27	35.72

Source: Author's calculation

5. CONCLUSION

5.1 Summary and Conclusions

ESG performance and reporting is becoming the new normal for all businesses especially due to the megatrend of global scale climate change mitigation initiatives. Even finance institutions like banks and institutional investors whose activities are not directly linked to environmental impacts started taking initiatives to tackle climate change. Shipping industry is not different with almost 3% of the world's emissions. Environmental performance of shipping industry has been controlled by regulatory requirements for a long time and ship owners always took a responsive approach to comply with regulations until recently. But, there are obvious limitations in implementing regulations especially in terms of time frame by getting consensus from all stakeholders. The overriding goal of decarbonisation and limitations in implementing regulations on a global scale forced many ship owners to take proactive measures to improve ESG performance. Investments in shipping are quite capital intensive with moderate returns and added hurdles of decarbonisation targets make investment decisions especially related to fleet renewal extremely crucial for shipping companies.

Fleet renewal decisions by ship owners are primarily based on market sentiments and future expectations. Now decarbonisation has become a major controlling factor in ship renewal investments and ship owners are trying to improve their environmental performance beyond minimum compliance as the capital availability is also getting reliant on ESG performance. But, untoward investment decisions just to improve ESG credentials will not provide competitive advantage to companies and a strategic approach to CSR/ESG initiatives is required to get sustainable results. Strategic CSR/ESG initiatives giving competitive advantage to the companies definitively need to be linked to the financial performance of the firms and there has been a long-standing debate on the link between CSR/ESG initiatives and their financial benefits to the companies committing them.

This research applies the concept of Real Options Analysis and uses the binomial option pricing model to strategically evaluate CSR/ESG investment decisions complimentary to traditional DCF analysis viewing the CSR/ESG initiative as a real option. In this study we applied the model in the case of evaluating a CSR/ESG initiative of proactively investing in an ammonia-ready ship by a dry-bulk shipping company. When the investment is viewed as an ESG performance improving credential, it seems logical to invest immediately. But a strategic perspective analysis is required to link the ESG initiative to financial benefits. By using the model, the value of deferring the decision to a later stage is considered and option values are calculated to find the optimal timing of the ship investment. In the specific scenarios considered in the analysis, ship owner has the option to replace an old ship with new ammonia-ready ship until 2028 from now. Conversion to ammonia fuel is also considered in the analysis with the actual conversion happening either in 2028, 2029 or in 2030. The time horizons are selected based on a techno-economic study of using alternate fuels on a new-build bulk carrier by DNV (2021). Results from the model with specific values for input variables suggest that deferring the investment to 2028 is more valuable than investing now. Model also analysed the effect of changing investment costs related to ship purchase and future ammonia conversion. Results with various Capex levels considered also suggest to invest in 2028 and do the conversion in the same year.

In the framework of ROA, an option to defer is always embedded into an investment decision. Based on uncertainties involved in the analysis, deferring decisions will be more valuable with increasing uncertainties. But, deferring investment decisions are always not optimal as delaying investments may result in revenue loss and there are risks of competitors taking the advantage. In this study, revenue loss factor considered is the differentiated charter earnings for new energy efficient eco-ships and old ships. An efficiency factor (EF) is considered which adds additional revenue for a new energy efficient eco-ship and a conversion factor (CF) is considered for additional revenue gained after conversion to ammonia mainly due to fuel price differential between ammonia and carbon neutral MGO. Optimal investment timing is calculated in a base case scenario where daily charter rates for eco-ships are 8% high and an additional expected increase of 20% in charter rates for ships running on ammonia. In the base case scenario, model results show that optimal timing of ship investment is in 2028 and take delivery of the ship after doing actual conversion to run on ammonia fuel because deferral option value is highest (19.10 mil USD) in this investment scenario compared to 18.70 and 18.36 mil USD for conversion scenario in 2029 and 2030 respectively.

This study also analysed the influence of differentiated charter earnings on the optimal investment timing by calculating deferral values with different efficiency factors and conversion factors. Energy efficient eco-ships are already earning higher charter rates and an efficiency factor of around 8% already exists. Model results without additional earnings after conversion (CF=1) also shows that investment in 2028 is optimal with deferral value15.96 mil

USD compared to 15.94 and 15.91 mil USD for conversion scenario in 2029 and 2030 respectively. Model results indicate that differentiated charter rates for green ships can definitely influence optimal investment timings when investment time horizon is reduced in the specific case. This indicates that financial incentives for ship owners can enhance and promote green investments which is definitely required for decarbonising the shipping industry meeting the industry emission reduction targets.

This study clearly demonstrates the strategic incorporation of a CSR/ESG initiative in the investment decisions of a dry-bulk shipping company. This analysis also emphasizes the need for strategic perspective of CSR/ESG activities linking to financial performance to gain competitive advantage rather than following an unsighted approach in CSR/ESG investments. Financial incentives for ship owners in the form of increased charter rates for energy efficient and green ships can accelerate the investments in such ships and technologies and can definitely enhance the decarbonisation of shipping industry to achieve the tough target of net-zero carbon emissions by 2050.

5.2 Limitations of the study

Conclusions from this specific analysis need to account for the limitations of this study also. Operational expenses for the ship owner are assumed to be constant for entire life cycle of the ship in the analysis. In the actual case, maintenance costs increase as the ships get older and there will be variations in OPEX after conversion to ammonia also. Detailed analysis of cash outflows are not carried out in the net revenue calculations and all expenses are assumed to be included in the OPEX. Dynamics and market related variations of new build ship prices and second hand ship prices are not considered in the analysis.

5.3 Future Scope

ROA is a valuable capital budgeting tool when high level of uncertainties are involved and management has the flexibility to act and alter decisions at a later stage according to the information flow. This method can be applied to evaluate other CSR/ESG initiatives in different sectors and ROA can capture the value of these initiatives where traditional capital budgeting methods fail to justify those investments. ROA applied in the specific case of investing in ammonia-ready ships can also be applied in assessing other green investments like carbon capture modules, methanol-hydrogen generators etc analysing the clear financial benefits those investments can generate in the prevailing conditions. ROA can also be used to evaluate the benefits of switching to alternate fuels based on cost savings.

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APPENDIX- I : DEFERRAL OPTION VALUE CALCULATIONS

Table A-I- 1 Generic Binomial lattice

2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
S	SU	SU^2	SU^3	SU^4	SU^5	SU^6	SU^7	SU^8	SU^9
	SD	SUD	SU^2D	SU^3D	SU^4D	SU^5D	SU^6D	SU^7D	SU^8D
		SD^2	SUD^2	SU^2D^2	SU^3D^2	SU^4D^2	SU^5D^2	SU^6D^2	SU^7D^2
			SD^3	SUD^3	SU^2D^3	SU^3D^3	SU^4D^3	SU^5D^3	SU^6D^3
				SD^4	SUD^4	SU^2D^4	SU^3D^4	SU^4D^4	SU^5D^4
					SD^5	SUD^5	SU^2D^5	SU^3D^5	SU^4D^5
						SD^6	SUD^6	SU^2D^6	SU^3D^6
							SD^7	SUD^7	SU^2D^7
								SD^8	SUD^8
									SD^9

Table A-I- 2 Calculated probability values of Binomial lattice

PROBABILITIES									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	0.4203305	0.17667773	0.074263039	0.03121502	0.013120625	0.005514999	0.002318122	0.000974377	0.000409561
	0.5796695	0.48730554	0.307244074	0.172192074	0.090471976	0.045633757	0.022378137	0.010749958	0.005083352
		0.33601673	0.423714239	0.356200037	0.249536233	0.157331535	0.09258374	0.051887693	0.028041403
			0.194778649	0.327485628	0.344130495	0.289297086	0.212800681	0.143114587	0.090233139
				0.112907242	0.237291787	0.299222927	0.29346922	0.246708129	0.186658112
					0.065448884	0.165060974	0.242830566	0.272184249	0.257416519
						0.037938722	0.111627614	0.187681964	0.236665361
							0.02199192	0.073950998	0.13987737
								0.012748045	0.04822553
									0.007389653

SCENARIO-1: CONVERSION TO AMMONIA IN 2028

Case 1: Investment in 2023

Table A-I- 3 Input Parameters

Time period		1
S		47.65509711
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		17.02222935
INVESTMENT COST SHIP (FUTURE VALUE)		48.76
WACC		6%
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46

Table A-I- 4 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
ANNUAL NET REVENUE	6136560	6627484.8	6627484.8	6627484.8	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5704329.031	4909761.5	4225870.88	3637240.78	3130602.15	3233441.09	2783048.54	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,38,51,208.20																		
PV CONTINUOS DISCOUNTING	47655097.11																		

Table A-I- 5 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
47.6550971	80.0770739	134.557228	226.1027618	379.930976	638.4156717	1072.759516	1802.607658	3029.005401	5089.778512
	28.3602806	47.6550971	80.07707387	134.5572278	226.1027618	379.930976	638.4156717	1072.759516	1802.607658
		16.8776387	28.36028055	47.65509711	80.07707387	134.5572278	226.1027618	379.930976	638.4156717
			10.04414215	16.87763874	28.36028055	47.65509711	80.07707387	134.5572278	226.1027618
				5.977423332	10.04414215	16.87763874	28.36028055	47.65509711	80.07707387
					3.557256473	5.977423332	10.04414215	16.87763874	28.36028055
						2.116977988	3.557256473	5.977423332	10.04414215
							1.25984613	2.116977988	3.557256473
								0.74975379	1.25984613
									0.446190001

Table A-I- 6 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
47.6550971	50.0984262	52.6670274	55.36732367	58.20606705	61.19035593	64.32765256	67.62580184	71.08349294	74.67401556

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
36.8462541	67.409841	120.633971	211.4515932	364.528626	622.2236262	1055.737286			
	17.9429654	34.7782313	65.45014555	119.1548778	209.9107164	362.9087467			
		7.32239577	15.61347786	32.29670846	63.88502844	117.5349985			
			1.958015835	4.897111795	12.2479622	30.63286776			
				0	0	0			
					0	0			
						0			

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
7.45677974	18.649841								
	0								

Case 2: Investment in 2024

Table A-I- 7 Input Parameters

Time period		1
S		47.23255422
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		17.02222935
INVESTMENT COST SHIP (FUTURE VALUE)		51.6856
WACC		6%
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46

Table A-I- 8 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
ANNUAL NET REVENUE	6136560	6136560	6627484.8	6627484.8	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4909761.5	4225870.88	3637240.78	3130602.15	3233441.09	2783048.54	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,34,79,998.52																		
PV CONTINUOS DISCOUNTING	47232554.22																		

Table A-I- 9 Binomial lattice

PROJECT VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
47.2325542	79.3670554	133.364151	224.0979791	376.5622465	632.7550389	1063.247691	1786.624497	3002.148155	5044.649032
	28.1088188	47.2325542	79.36705541	133.3641508	224.0979791	376.5622465	632.7550389	1063.247691	1786.624497
		16.72799	28.10881879	47.23255422	79.36705541	133.3641508	224.0979791	376.5622465	632.7550389
			9.955083875	16.72798998	28.10881879	47.23255422	79.36705541	133.3641508	224.0979791
				5.924423383	9.955083875	16.72798998	28.10881879	47.23255422	79.36705541
					3.525715389	5.924423383	9.955083875	16.72798998	28.10881879
						2.098207404	3.525715389	5.924423383	9.955083875
							1.248675467	2.098207404	3.525715389
								0.743105957	1.248675467
									0.442233774

Table A-I- 10 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
47.2325542	49.6542191	52.2000453	54.87639887	57.689972	60.64780011	63.75727932	67.02618493	70.45321777	74.01190435

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
36.4638923	66.7301796	119.454728	209.4468105	361.1598964	616.5629935	1046.225462			
	17.7423621	34.400712	64.76521534	117.9618008	207.9059337	359.5400171			
		7.23233501	15.42547744	31.91966486	63.17500999	116.3419215			
			1.931007405	4.829562136	12.07901656	30.21032487			
				0	0	0			
					0	0			
						0			

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
10.8338859	27.0961806	67.7691278							
	0	0							
		0							

Case 3: Investment in 2025

Table A-I- 11 Input Parameters

Time period		1
S		46.86886818
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		17.02222935
INVESTMENT COST SHIP (FUTURE VALUE)		54.786736
WACC		6%
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46

Table A-I- 12 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
ANNUAL NET REVEN	6136560	6136560	6136560	6627484.8	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4546075.46	4225870.88	3637240.78	3130602.15	3233441.09	2783048.54	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,31,57,207.50																		
PV CONTINUOS DISCOUNTING	46868868.18																		

Table A-I- 13 Binomial lattice

PROJECT VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
46.8688682	78.7559369	132.33726	222.3724466	373.6627541	627.8828872	1055.060788	1772.867664	2979.031908	5005.805729
	27.8923836	46.8688682	78.75593687	132.3372599	222.3724466	373.6627541	627.8828872	1055.060788	1772.867664
		16.5991861	27.89238364	46.86886818	78.75593687	132.3372599	222.3724466	373.6627541	627.8828872
			9.878430705	16.59918609	27.89238364	46.86886818	78.75593687	132.3372599	222.3724466
				5.878805904	9.878430705	16.59918609	27.89238364	46.86886818	78.75593687
					3.498567726	5.878805904	9.878430705	16.59918609	27.89238364
						2.082051412	3.498567726	5.878805904	9.878430705
							1.239060788	2.082051412	3.498567726
								0.737384114	1.239060788
									0.438828617

Table A-I- 14 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
46.8688682	49.2718864	51.7981101	54.45385597	57.24576487	60.180818	63.26635452	66.51008988	69.9107349	73.44201994

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
36.1347903	66.1451896	118.439744	207.7212781	358.2604041	611.6908417	1038.038559			
	17.5697014	34.0757781	64.17569045	116.9349099	206.1804012	356.6405248			
		7.15481899	15.26366398	31.59514042	62.56389144	115.3150306			
			1.907761033	4.771421605	11.93360371	29.84663884			
				0	0	0			
					0	0			
						0			

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
12.2582757	28.5887158	66.3249883	152.9345421						
	1.50096164	3.75399261	9.388954451						
		0	0						
			0						

Case 4: Investment in 2026

Table A-I- 15 Input Parameters

Time period		1
S		46.55584071
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		17.02222935
INVESTMENT COST SHIP (FUTURE VALUE)		58.07394016
WACC		6%
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46

Table A-I- 16 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
ANNUAL NET REVEN	6136560	6136560	6136560	6136560	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4546075.46	3912843.41	3637240.78	3130602.15	3233441.09	2783048.54	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,28,76,519.65																		
PV CONTINUOS DISCOUNTING	46555840.71																		

Table A-I- 17 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
46.5558407	78.2299423	131.453407	220.8872671	371.1671379	623.6893873	1048.014256	1761.027048	2959.13557	4972.372989
	27.7060962	46.5558407	78.22994226	131.4534068	220.8872671	371.1671379	623.6893873	1048.014256	1761.027048
		16.4883236	27.70609618	46.55584071	78.22994226	131.4534068	220.8872671	371.1671379	623.6893873
			9.812454711	16.48832356	27.70609618	46.55584071	78.22994226	131.4534068	220.8872671
				5.839542575	9.812454711	16.48832356	27.70609618	46.55584071	78.22994226
					3.475201516	5.839542575	9.812454711	16.48832356	27.70609618
						2.068145822	3.475201516	5.839542575	9.812454711
							1.230785357	2.068145822	3.475201516
								0.732459278	1.230785357
									0.435897771

Table A-I- 18 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
46.5558407	48.9428097	51.4521612	54.09016994	56.86343225	59.77888277	62.84381163	66.06588275	69.44381557	72.95151588

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
35.8515297	65.641684	117.566139	206.2360985	355.7647878	607.4973418	1030.992026			
	17.4210908	33.7961049	63.66828167	116.0510567	204.6952216	354.1449086			
		7.08810034	15.12438985	31.31581965	62.03789684	114.4311774			
			1.887752696	4.721379587	11.8084457	29.53361136			
				0	0	0			
					0	0			
						0			

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
15.7815476	34.3599379	73.1542172	150.9944578	297.6908477					
	3.70582712	9.26848976	23.18103344	57.97711655					
		0	0	0					
			0	0					
				0					

Case 5: Investment in 2027

Table A-I- 19 Input Parameters

Time period		1
S		46.28641547
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		17.02222935
INVESTMENT COST SHIP (FUTURE VALUE)		61.55837657
WACC		6%
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46

Table A-I- 20 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
ANNUAL NET REVENUE	6136560	6136560	6136560	6136560	6136560	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4546075.46	3912843.41	3367815.53	3130602.15	3233441.09	2783048.54	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,26,32,443.26																		
PV CONTINUOS DISCOUNTING	46286415.47																		

Table A-I- 21 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
46.2864155	77.7772145	130.692667	219.6089612	369.0191411	620.0800085	1041.949249	1750.835735	2942.010634	4943.597162
	27.5457571	46.2864155	77.77721451	130.6926673	219.6089612	369.0191411	620.0800085	1041.949249	1750.835735
		16.3929033	27.54575708	46.28641547	77.77721451	130.6926673	219.6089612	369.0191411	620.0800085
			9.755668646	16.3929033	27.54575708	46.28641547	77.77721451	130.6926673	219.6089612
				5.805748316	9.755668646	16.3929033	27.54575708	46.28641547	77.77721451
					3.455090033	5.805748316	9.755668646	16.3929033	27.54575708
						2.056177169	3.455090033	5.805748316	9.755668646
							1.223662628	2.056177169	3.455090033
								0.728220433	1.223662628
									0.433375169

Table A-I- 22 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
46.2864155	48.6595707	51.1544003	53.77714246	56.53435552	59.43293391	62.48012559	65.68355013	69.04193437	72.52933513

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
35.607725	65.2083128	116.81422	204.9577926	353.6167911	603.887963	1024.92702			
	17.2931806	33.5553879	63.23155089	115.2903172	203.4169158	351.9969118			
		7.03067507	15.00451549	31.07540603	61.58516908	113.6704379			
			1.870531361	4.678308023	11.7007212	29.26418612			
				0	0	0			
					0	0			
						0			

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
15.5422244	33.8670339	72.1889473	149.2574701	295.0606519	542.3295865				
	3.62921289	9.07451135	22.68997528	56.73417811	141.8585392				
		0.00171254	0.004283175	0.01071247	0.026792512				
			0	0	0				
				0	0				
					0				

Case 6: Investment in 2028

Table A-I- 23 Input Parameters

Time period		1
S		46.05451901
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		17.02222935
INVESTMENT COST SHIP (FUTURE VALUE)		65.25187916
WACC		6%
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46

Table A-I- 24 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
ANNUAL NET REVENUE	6136560	6136560	6136560	6136560	6136560	6136560	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4546075.46	3912843.41	3367815.53	2898705.69	3233441.09	2783048.54	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	42420202.92																		
PV CONTINUOS DISCOUNTING	46054519.01																		

Table A-I- 25 Binomial lattice

PROJECT VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
46.054519	77.3875481	130.037893	218.5087131	367.1703431	616.9733873	1036.729049	1742.06399	2927.271064	4918.829578
	27.4077519	46.054519	77.38754812	130.0378927	218.5087131	367.1703431	616.9733873	1036.729049	1742.06399
		16.3107743	27.40775193	46.05451901	77.38754812	130.0378927	218.5087131	367.1703431	616.9733873
			9.706792427	16.31077432	27.40775193	46.05451901	77.38754812	130.0378927	218.5087131
				5.776661327	9.706792427	16.31077432	27.40775193	46.05451901	77.38754812
					3.437779919	5.776661327	9.706792427	16.31077432	27.40775193
						2.045875654	3.437779919	5.776661327	9.706792427
							1.217532039	2.045875654	3.437779919
								0.724572025	1.217532039
									0.431203946

Table A-I- 26 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
46.054519	48.4157847	50.8981151	53.50771722	56.25111655	59.13517297	62.16709812	65.3544734	68.69603202	72.16596079

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
35.3978803	64.8353067	116.167037	203.8575445	351.7679931	600.7813419	1019.70682			
	17.1830872	33.3482009	62.85565323	114.6355427	202.3166677	350.1481138			
		6.98124868	14.90133867	30.86848011	61.19550269	113.0156634			
			1.85570882	4.641235984	11.60800187	29.03228967			
				0	0	0			
					0	0			
						0			

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
19.0978885	39.109012	78.486531	153.7668566	292.7256512	538.7118345	954.4549405			
	6.27658963	14.0146947	30.84123228	66.60542325	140.2471602	284.8962346			
		1.22068456	3.053003283	7.635739263	19.09742922	47.76378423			
			0	0	0	0			
				0	0	0			
					0	0			
						0			

SCENARIO-2: CONVERSION TO AMMONIA IN 2029

Case 1: Investment in 2023

Table A-I- 27 Input Parameters

Time period		1
S		47.11619026
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		18.04356311
INVESTMENT COST SHIP (FUTURE VALUE)		48.76
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46
WACC		6%

Table A-I- 28 Net revenue and present value of the project

	NET REVENUE								
	2022	2023	2024	2025	2026	2027	2028	2029	2030
	0	1	2	3	4	5	6	7	8
ANNUAL NET REVENUE	6136560	6627484.8	6627484.8	6627484.8	6627484.8	6627484.8	6627484.8	7952981.76	7952981.76
DISCOUNT RATE	15%								
CONTINUOS DISCOUNT VALUE	6136560	5704329.031	4909761.5	4225870.88	3637240.78	3130602.15	2694534.24	2783048.54	2395392.07
PROJECT PRESENT VALUE	4,33,52,904.80								
PV CONTINUOS DISCOUNTING	47116190.26								

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	9	10	11	12	13	14	15	16	17	18
ANNUAL NET REVENUE	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE										
CONTINUOS DISCOUNT VALUE	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE										
PV CONTINUOS DISCOUNTING										

Table A-I- 29 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
47.1161903	79.1715236	133.03559	223.5458826	375.6345331	631.196159	1060.628233	1782.2229	2994.751946	5032.220839
	28.0395688	47.1161903	79.17152365	133.0355897	223.5458826	375.6345331	631.196159	1060.628233	1782.2229
		16.6867782	28.03956881	47.11619026	79.17152365	133.0355897	223.5458826	375.6345331	631.196159
			9.930558144	16.68677825	28.03956881	47.11619026	79.17152365	133.0355897	223.5458826
				5.909827743	9.930558144	16.68677825	28.03956881	47.11619026	79.17152365
					3.5170293	5.909827743	9.930558144	16.68677825	28.03956881
						2.093038178	3.5170293	5.909827743	9.930558144
							1.245599181	2.093038178	3.5170293
								0.741275213	1.245599181
									0.441144269

Table A-I- 30 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
47.1161903	49.531889	52.0714433	54.74120324	57.54784474	60.49838584	63.60020441	66.86105662	70.27964648	73.82956574

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
37.1924232	67.2048614	119.396782	208.7730626	360.1042944	614.869668	1043.464665	1764.179337		
	18.7194022	35.3035984	65.14867494	117.505351	207.2193916	358.470965	613.1525959		
		8.34956359	16.78487036	32.94607687	62.84503259	115.8720216	205.5023195		
			2.971455119	6.550643226	14.17975991	29.95262211	61.12796054		
				0.638932587	1.598007663	3.99671036	9.9960057		
					0	0	0		
						0	0		
							0		

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
7.37482258	18.4448614								
	0								

Case 2: Investment in 2024

Table A-I- 31 Input Parameters

Time period		1
S		46.69364737
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		18.04356311
INVESTMENT COST SHIP (FUTURE VALUE)		51.6856
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46
WACC		6%

Table A-I- 32 Net revenue and present value of the project

	NE REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
ANNUAL NET REVENUE	6136560	6136560	6627484.8	6627484.8	6627484.8	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4909761.5	4225870.88	3637240.78	3130602.15	2694534.24	2783048.54	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,29,81,695.12																		
PV CONTINUOS DISCOUNTING	46693647.37																		

Table A-I- 33 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
46.6936474	78.4615052	131.842513	221.5410999	372.2658036	625.5355262	1051.116409	1766.23974	2967.894699	4987.091359
	27.788107	46.6936474	78.4615052	131.8425127	221.5410999	372.2658036	625.5355262	1051.116409	1766.23974
		16.5371295	27.78810704	46.69364737	78.4615052	131.8425127	221.5410999	372.2658036	625.5355262
			9.841499866	16.53712949	27.78810704	46.69364737	78.4615052	131.8425127	221.5410999
				5.856827794	9.841499866	16.53712949	27.78810704	46.69364737	78.4615052
					3.485488215	5.856827794	9.841499866	16.53712949	27.78810704
						2.074267594	3.485488215	5.856827794	9.841499866
							1.234428518	2.074267594	3.485488215
								0.734627379	1.234428518
									0.437188042

Table A-I- 34 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
46.6936474	49.0876819	51.6044611	54.25027844	57.03174969	59.95583002	63.02983116	66.26143971	69.64937131	73.16745452

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
36.7877742	66.5066195	118.208244	206.7682799	356.7355649	609.2090352	1033.952841	1748.196177		
	18.4918528	34.8991214	64.44688909	116.312274	205.2146088	355.1022354	607.4919631		
		8.23018153	16.56020281	32.53846438	62.13501414	114.6789446	203.4975368		
			2.917858578	6.438761289	13.95537547	29.53007922	60.41794209		
				0.622859455	1.557807822	3.896168216	9.744543932		
					0	0	0		
						0	0		
							0		

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
10.6346173	26.5977981	66.5226443							
	0	0							
		0							

Case 3: Investment in 2025

Table A-I- 35 Input Parameters

Time period		1
S		46.32996134
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		18.04356311
INVESTMENT COST SHIP (FUTURE VALUE)		54.786736
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46
WACC		6%

Table A-I- 36 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
ANNUAL NET REVENUE	6136560	6136560	6136560	6627484.8	6627484.8	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4546075.46	4225870.88	3637240.78	3130602.15	2694534.24	2783048.54	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,26,58,904.09																		
PV CONTINUOS DISCOUNTING	46329961.34																		

Table A-I- 37 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
46.3299613	77.8503867	130.815622	219.8155674	369.3663112	620.6633745	1042.929506	1752.482906	2944.778452	4948.248056
	27.5716719	46.3299613	77.85038665	130.8156218	219.8155674	369.3663112	620.6633745	1042.929506	1752.482906
		16.4083256	27.57167189	46.32996134	77.85038665	130.8156218	219.8155674	369.3663112	620.6633745
			9.764846696	16.40832561	27.57167189	46.32996134	77.85038665	130.8156218	219.8155674
				5.811210314	9.764846696	16.40832561	27.57167189	46.32996134	77.85038665
					3.458340552	5.811210314	9.764846696	16.40832561	27.57167189
						2.058111603	3.458340552	5.811210314	9.764846696
							1.22481384	2.058111603	3.458340552
								0.728905536	1.22481384
									0.433782885

Table A-I- 38 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
46.3299613	48.7053492	51.2025259	53.82773554	56.58754256	59.48884791	62.53890636	65.74534466	69.10688844	72.59757011

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
36.4394896	65.9056371	117.185261	205.0427474	353.8360725	604.3368834	1025.765938	1734.439343		
	18.2959992	34.5509849	63.84285641	115.2853831	203.4890764	352.202743	602.6198114		
		8.12742844	16.36682965	32.18762906	61.5238956	113.6520537	201.7720043		
			2.871727607	6.342463614	13.76224599	29.16639318	59.80682354		
				0.609025182	1.523207499	3.80963079	9.528108784		
					0	0	0		
						0	0		
							0		

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
11.9990501	28.0137562	65.0705052	150.2560114						
	1.44775326	3.62091533	9.056120409						
		0	0						
			0						

Case 4: Investment in 2026

Table A-I- 39 Input Parameters

Time period		1
S		46.01693386
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		18.04356311
INVESTMENT COST SHIP (FUTURE VALUE)		58.07394016
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46
WACC		6%

Table A-I- 40 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
ANNUAL NET REVENUE	6136560	6136560	6136560	6136560	6627484.8	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4546075.46	3912843.41	3637240.78	3130602.15	2694534.24	2783048.54	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,23,78,216.25																		
PV CONTINUOS DISCOUNTING	46016933.86																		

Table A-I- 41 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
46.0169339	77.324392	129.931769	218.3303879	366.870695	616.4698746	1035.882973	1740.64229	2924.882115	4914.815316
	27.3853844	46.0169339	77.32439204	129.9317687	218.3303879	366.870695	616.4698746	1035.882973	1740.64229
		16.2974631	27.38538443	46.01693386	77.32439204	129.9317687	218.3303879	366.870695	616.4698746
			9.698870701	16.29746308	27.38538443	46.01693386	77.32439204	129.9317687	218.3303879
				5.771946986	9.698870701	16.29746308	27.38538443	46.01693386	77.32439204
					3.434974342	5.771946986	9.698870701	16.29746308	27.38538443
						2.044206013	3.434974342	5.771946986	9.698870701
							1.216538409	2.044206013	3.434974342
								0.7239807	1.216538409
									0.430852039

Table A-I- 42 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
46.0169339	48.3762725	50.856577	53.46404951	56.20520994	59.08691268	62.11636347	65.30113753	68.63996911	72.10706606

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
36.1397182	65.3883668	116.30477	203.5575679	351.3404563	600.1433835	1018.719405	1722.598727		
	18.1274265	34.251341	63.32296066	114.40153	202.0038968	349.7071268	598.4263115		
		8.03898804	16.20039183	31.8856623	60.99790099	112.7682005	200.2868248		
			2.832022312	6.259579436	13.5960179	28.85336571	59.28082894		
				0.597117913	1.493426725	3.735147337	9.341821325		
					0	0	0		
						0	0		
							0		

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
15.4359278	33.6409269	71.7195935	148.3159272	293.2665161					
	3.60039137	9.0047888	22.52150194	56.32758981					
		0	0	0					
			0	0					
				0					

Case 5: Investment in 2027

Table A-I- 43 Input Parameters

Time period		1
S		45.74750862
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		18.04356311
INVESTMENT COST SHIP (FUTURE VALUE)		61.55837657
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46
WACC		6%

Table A-I- 44 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
ANNUAL NET REVENUE	6136560	6136560	6136560	6136560	6136560	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4546075.46	3912843.41	3367815.53	3130602.15	2694534.24	2783048.54	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,21,34,139.86																		
PV CONTINUOS DISCOUNTING	45747508.62																		

Table A-I- 45 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
45.7475086	76.8716643	129.171029	217.052082	364.7226982	612.8604958	1029.817966	1730.450977	2907.757178	4886.039489
	27.2250453	45.7475086	76.87166429	129.1710292	217.052082	364.7226982	612.8604958	1029.817966	1730.450977
		16.2020428	27.22504533	45.74750862	76.87166429	129.1710292	217.052082	364.7226982	612.8604958
			9.642084637	16.20204281	27.22504533	45.74750862	76.87166429	129.1710292	217.052082
				5.738152726	9.642084637	16.20204281	27.22504533	45.74750862	76.87166429
					3.414862859	5.738152726	9.642084637	16.20204281	27.22504533
						2.03223736	3.414862859	5.738152726	9.642084637
							1.20941568	2.03223736	3.414862859
								0.719741855	1.20941568
									0.428329437

Table A-I- 46 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
45.7475086	48.0930335	50.5588161	53.15102203	55.87613321	58.74096382	61.75267744	64.91880491	68.23808791	71.68488531

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
35.8817026	64.9431481	115.546925	202.279262	349.1924595	596.5340047	1012.654398	1712.407414		
	17.9823345	33.9934351	62.87548225	113.6407905	200.7255909	347.55913	594.8169327		
		7.96286668	16.05713747	31.6257571	60.54517324	112.007461	199.0085189		
			2.797847649	6.188240363	13.45294406	28.58394047	58.82810118		
				0.586869232	1.467794176	3.671038835	9.181482223		
					0	0	0		
						0	0		
							0		

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
15.2722425	33.2918573	70.9974062	146.8869943	290.6363204	534.9756282				
	3.55665434	8.89539992	22.24791398	55.64333036	139.1672144				
		0	0	0	0				
			0	0	0				
				0	0				
					0				

Case 6: Investment in 2028

Table A-I- 47 Input Parameters

Time period		1
S		45.51561216
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		18.04356311
INVESTMENT COST SHIP (FUTURE VALUE)		65.25187916
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46
WACC		6%

Table A-I- 48 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
ANNUAL NET REVENUE	6136560	6136560	6136560	6136560	6136560	6136560	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4546075.46	3912843.41	3367815.53	2898705.69	2694534.24	2783048.54	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,19,21,899.52																		
PV CONTINUOS DISCOUNTING	45515612.16																		

Table A-I- 49 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
45.5156122	76.4819979	128.516255	215.9518339	362.8739002	609.7538747	1024.597766	1721.679233	2893.017609	4861.271905
	27.0870402	45.5156122	76.4819979	128.5162546	215.9518339	362.8739002	609.7538747	1024.597766	1721.679233
		16.1199138	27.08704019	45.51561216	76.4819979	128.5162546	215.9518339	362.8739002	609.7538747
			9.593208418	16.11991383	27.08704019	45.51561216	76.4819979	128.5162546	215.9518339
				5.709065737	9.593208418	16.11991383	27.08704019	45.51561216	76.4819979
					3.397552745	5.709065737	9.593208418	16.11991383	27.08704019
						2.021935845	3.397552745	5.709065737	9.593208418
							1.20328509	2.021935845	3.397552745
								0.716093447	1.20328509
									0.426158214

Table A-I- 50 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
45.5156122	47.8492475	50.3025309	52.88159679	55.59289424	58.44320288	61.43964996	64.58972818	67.89218556	71.32151097

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
35.6596265	64.5599448	114.894642	201.1790139	347.3436615	593.4273836	1007.434198	1703.63567		
	17.8574528	33.7714534	62.49033401	112.986016	199.6253428	345.7103321	591.7103116		
		7.89734841	15.9338373	31.40205462	60.15550685	111.3526865	197.9082708		
			2.768433243	6.126838254	13.32979927	28.35204401	58.43843479		
				0.57804811	1.445732036	3.615860136	9.043477079		
					0	0	0		
						0	0		
							0		

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
18.7038956	38.3477402	77.0622724	151.2023675	288.3013197	531.3578762	942.1823192			
	6.11407005	13.666835	30.11780468	65.16271874	137.5558354	280.4584529			
		1.17818437	2.946707812	7.369888091	18.43251993	46.10080733			
			0	0	0	0			
				0	0	0			
					0	0			
						0			

SCENARIO-3: CONVERSION TO AMMONIA IN 2030

Case 1: Investment in 2023

Table A-I- 51 Input Parameters

Time period		1
S		46.65234884
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		19.12617689
INVESTMENT COST SHIP (FUTURE VALUE)		48.76
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46
WACC		6%

Table A-I- 52 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
ANNUAL NET REVENUE	6136560	6627484.8	6627484.8	6627484.8	6627484.8	6627484.8	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5704329.031	4909761.5	4225870.88	3637240.78	3130602.15	2694534.24	2319207.11	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,29,19,597.49																		
PV CONTINUOS DISCOUNTING	46652348.84																		

Table A-I- 53 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
46.6523488	78.3921094	131.725904	221.3451563	371.9365504	624.9822669	1050.186741	1764.677576	2965.269723	4982.680491
	27.7635296	46.6523488	78.39210936	131.7259037	221.3451563	371.9365504	624.9822669	1050.186741	1764.677576
		16.5225031	27.76352965	46.65234884	78.39210936	131.7259037	221.3451563	371.9365504	624.9822669
			9.832795481	16.52250311	27.76352965	46.65234884	78.39210936	131.7259037	221.3451563
				5.85164768	9.832795481	16.52250311	27.76352965	46.65234884	78.39210936
					3.48240545	5.85164768	9.832795481	16.52250311	27.76352965
						2.072432994	3.48240545	5.85164768	9.832795481
							1.233336719	2.072432994	3.48240545
								0.733977633	1.233336719
									0.436801368

Table A-I- 54 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
46.6523488	49.0442659	51.5588192	54.20229639	56.98130755	59.90280166	62.97408398	66.20283431	69.58776942	73.10274104

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
36.9792939	66.6681595	118.248351	206.5823883	356.2773612	608.5202139	1032.880661	1746.484194	2946.143546	
	18.7220511	35.1630035	64.65441917	116.3073997	204.8831033	354.6304699	606.7888846	1031.060565	
		8.45631574	16.88828692	32.91836915	62.36655584	114.4198231	203.151774	352.8103735	
			3.090068087	6.75828782	14.47646355	30.13789063	60.19872712	112.5997268	
				0.703478037	1.759439598	4.400461045	11.00580971	27.52617195	
					0	0	0	0	
						0	0	0	
							0	0	
								0	

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
7.16023269	17.9081595								
	0								

Case 2: Investment in 2024

Table A-I- 55 Input Parameters

Time period		1
S		46.22980595
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		19.12617689
INVESTMENT COST SHIP (FUTURE VALUE)		51.6856
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46
WACC		6%

Table A-I- 56 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
ANNUAL NET REVENUE	6136560	6136560	6627484.8	6627484.8	6627484.8	6627484.8	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4909761.5	4225870.88	3637240.78	3130602.15	2694534.24	2319207.11	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,25,48,387.81																		
PV CONTINUOS DISCOUNTING	46229805.95																		

Table A-I- 57 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
46.2298059	77.6820909	130.532827	219.3403736	368.5678209	619.3216341	1040.674917	1748.694416	2938.412476	4937.551011
	27.5120679	46.2298059	77.6820909	130.5328267	219.3403736	368.5678209	619.3216341	1040.674917	1748.694416
		16.3728543	27.51206788	46.22980595	77.6820909	130.5328267	219.3403736	368.5678209	619.3216341
			9.743737203	16.37285434	27.51206788	46.22980595	77.6820909	130.5328267	219.3403736
				5.798647731	9.743737203	16.37285434	27.51206788	46.22980595	77.6820909
					3.450864366	5.798647731	9.743737203	16.37285434	27.51206788
						2.05366241	3.450864366	5.798647731	9.743737203
							1.222166056	2.05366241	3.450864366
								0.7273298	1.222166056
									0.43284514

Table A-I- 58 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
46.2298059	48.6000588	51.0918371	53.71137159	56.4652125	59.36024585	62.40371073	65.6032174	68.95749425	72.44062982

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
36.5917096	65.988209	117.075063	204.5852334	352.9086317	602.8595811	1023.368837	1730.501034	2919.2863	
	18.5121862	34.7806416	63.97475776	115.1281563	202.8783206	351.2617404	601.1282519	1021.54874	
		8.35296979	16.6876837	32.54084982	61.68162563	113.2267462	201.1469913	349.441644	
			3.048104583	6.668227062	14.28846314	29.76084702	59.48870866	111.4066498	
				0.692679237	1.732431168	4.332911386	10.83686407	27.10362906	
					0	0	0	0	
						0	0	0	
							0	0	
								0	

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
10.4534617	26.1447172	65.3894626							
	0	0							
		0							

Case 3: Investment in 2025

Table A-I- 59 Input Parameters

Time period		1
S		45.86611991
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		19.12617689
INVESTMENT COST SHIP (FUTURE VALUE)		54.786736
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46
WACC		6%

Table A-I- 60 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
ANNUAL NET REVENUE	6136560	6136560	6136560	6627484.8	6627484.8	6627484.8	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4546075.46	4225870.88	3637240.78	3130602.15	2694534.24	2319207.11	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	42422876.3																		
PV CONTINUOS DISCOUNTING	45866119.91																		

Table A-I- 61 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
45.8661199	77.0709724	129.505936	217.6148411	365.6683285	614.4494823	1032.488014	1734.937583	2915.29623	4898.707708
	27.2956327	45.8661199	77.07097236	129.5059358	217.6148411	365.6683285	614.4494823	1032.488014	1734.937583
		16.2440505	27.29563273	45.86611991	77.07097236	129.5059358	217.6148411	365.6683285	614.4494823
			9.667084033	16.24405046	27.29563273	45.86611991	77.07097236	129.5059358	217.6148411
				5.753030252	9.667084033	16.24405046	27.29563273	45.86611991	77.07097236
					3.423716703	5.753030252	9.667084033	16.24405046	27.29563273
						2.037506418	3.423716703	5.753030252	9.667084033
							1.212551378	2.037506418	3.423716703
								0.721607957	1.212551378
									0.429439983

Table A-I- 62 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
45.8661199	48.2177262	50.6899019	53.2888287	56.02100537	58.89326373	61.91278593	65.08712235	68.41501138	71.87074542

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
36.2581126	65.4029701	116.065204	202.8662663	350.0091393	597.9874293	1015.181934	1716.7442	2896.170053	
	18.3315539	34.4515397	63.38976776	114.1131722	201.1527881	348.362248	596.2561001	1013.361837	
		8.2640191	16.51502291	32.21591592	61.09210074	112.1998553	199.4214589	346.5421516	
			3.01198626	6.590711048	14.12664968	29.43632258	58.87759012	110.3797589	
				0.683384623	1.709184796	4.274770856	10.69145122	26.73994302	
					0	0	0	0	
						0	0	0	
							0	0	
								0	

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
11.740114	27.4660325	63.9504486	148.0795303						
	1.37532041	3.43975656	8.603031759						
		0	0						
			0						

Case 4: Investment in 2026

Table A-I- 63 Input Parameters

Time period		1
S		45.55309244
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		19.12617689
INVESTMENT COST SHIP (FUTURE VALUE)		58.07394016
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46
WACC		6%

Table A-I- 64 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
ANNUAL NET REVENUE	6136560	6136560	6136560	6136560	6627484.8	6627484.8	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4546075.46	3912843.41	3637240.78	3130602.15	2694534.24	2319207.11	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,19,44,908.94																		
PV CONTINUOS DISCOUNTING	45553092.44																		

Table A-I- 65 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
45.5530924	76.5449778	128.622083	216.1296615	363.1727123	610.2559825	1025.441482	1723.096966	2895.399892	4865.274967
	27.1093453	45.5530924	76.54497775	128.6220826	216.1296615	363.1727123	610.2559825	1025.441482	1723.096966
		16.1331879	27.10934527	45.55309244	76.54497775	128.6220826	216.1296615	363.1727123	610.2559825
			9.601108039	16.13318793	27.10934527	45.55309244	76.54497775	128.6220826	216.1296615
				5.713766923	9.601108039	16.13318793	27.10934527	45.55309244	76.54497775
					3.400350493	5.713766923	9.601108039	16.13318793	27.10934527
						2.023600828	3.400350493	5.713766923	9.601108039
							1.204275947	2.023600828	3.400350493
								0.716683121	1.204275947
									0.426509138

Table A-I- 66 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
45.5530924	47.8886494	50.343953	52.92514266	55.63867275	58.4913285	61.49024304	64.64291522	67.94809205	71.38024136

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
35.9709831	64.8992503	115.196011	201.3867376	347.5135231	593.7939294	1008.135401	1704.903584	2876.273715	
	18.1760822	34.168279	62.8862622	113.2395672	199.6676085	345.8666318	592.0626002	1006.315305	
		8.18745853	16.36641239	31.93624272	60.58469197	111.3160021	197.9362793	344.0465354	
			2.980898931	6.523992397	13.98737554	29.15700181	58.35159551	109.4959057	
				0.675384674	1.689176459	4.224728838	10.56629321	26.42691555	
					0	0	0	0	
						0	0	0	
							0	0	
								0	

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
15.1743117	33.0890359	70.5954554	146.1450969	289.4395829					
	3.52612012	8.81903206	22.0569135	55.16562702					
		0	0	0					
			0	0					
				0					

Case 5: Investment in 2027

Table A-I- 67 Input Parameters

Time period		1
S		45.2836672
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		19.12617689
INVESTMENT COST SHIP (FUTURE VALUE)		61.55837657
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46
WACC		6%

Table A-I- 68 Net revenue and present value of the project

	NET REVENUE																		
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
ANNUAL NET REVENUE	6136560	6136560	6136560	6136560	6136560	6627484.8	6627484.8	6627484.8	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE	15%																		
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4546075.46	3912843.41	3367815.53	3130602.15	2694534.24	2319207.11	2395392.07	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE	4,17,00,832.55																		
PV CONTINUOS DISCOUNTING	45283667.2																		

Table A-I- 69 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
45.2836672	76.09225	127.861343	214.8513557	361.0247155	606.6466037	1019.376475	1712.905653	2878.274956	4836.499141
	26.9490062	45.2836672	76.09225	127.8613431	214.8513557	361.0247155	606.6466037	1019.376475	1712.905653
		16.0377677	26.94900617	45.2836672	76.09225	127.8613431	214.8513557	361.0247155	606.6466037
			9.544321974	16.03776767	26.94900617	45.2836672	76.09225	127.8613431	214.8513557
				5.679972664	9.544321974	16.03776767	26.94900617	45.2836672	76.09225
					3.38023901	5.679972664	9.544321974	16.03776767	26.94900617
						2.011632175	3.38023901	5.679972664	9.544321974
							1.197153218	2.011632175	3.38023901
								0.712444275	1.197153218
									0.423986536

Table A-I- 70 Deferral option values

MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
45.2836672	47.6054105	50.0461921	52.61211519	55.30959601	58.14537964	61.12655701	64.2605826	67.54621085	70.95806061

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
35.7238484	64.4656947	114.447889	200.1132954	345.3655263	590.1845506	1002.070394	1694.712271	2859.148779	
	18.0422664	33.9244743	62.45289095	112.4876484	198.3893026	343.718635	588.4532214	1000.250298	
		8.12156224	16.23850213	31.69552576	60.14796118	110.5552626	196.6579734	341.8985386	
			2.95414182	6.466567122	13.86750119	28.91658819	57.89886776	108.7351662	
				0.668499055	1.671955124	4.181657273	10.45856872	26.1574903	
					0	0	0	0	
						0	0	0	
							0	0	
								0	

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
15.0427475	32.8002188	69.9737313	144.8417963	286.8093872	528.6261741				
	3.49694652	8.7460672	21.87442414	54.70921048	136.8309261				
		0	0	0	0				
			0	0	0				
				0	0				
					0				

Case 6: Investment in 2028

Table A-I- 71 Input Parameters

Time period		1
S		45.05177074
Annual volatility		0.519
U		1.680346463
D		0.595115366
Risk free rate Rf		5%
R		1.051271096
P(U)		0.420330501
P(D)		0.579669499
INVESTMENT COST CONVERSION (FUTURE VALUE)		19.12617689
INVESTMENT COST SHIP (FUTURE VALUE)		65.25187916
INVESTMENT COST CONVERSION (PRESENT VALUE)		12
INVESTMENT COST SHIP (PRESENT VALUE)		46
WACC		6%

Table A-I- 72 Net revenue and present value of the project

	NET REVENUE								
	2022	2023	2024	2025	2026	2027	2028	2029	2030
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
ANNUAL NET REVENUE	6136560	6136560	6136560	6136560	6136560	6136560	6627484.8	6627484.8	7952981.76
DISCOUNT RATE	15%								
CONTINUOS DISCOUNT VALUE	6136560	5281786.14	4546075.46	3912843.41	3367815.53	2898705.69	2694534.24	2319207.11	2395392.07
PROJECT PRESENT VALUE	4,14,88,592.21								
PV CONTINUOS DISCOUNTING	45051770.74								

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
ANNUAL NET REVENUE	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76	7952981.76
DISCOUNT RATE										
CONTINUOS DISCOUNT VALUE	2061733.06	1774550.094	1527369.42	1314619.04	1131503.1	973893.74	838238.11	721478.228	620982.065	534484.217
PROJECT PRESENT VALUE										
PV CONTINUOS DISCOUNTING										

Table A-I- 73 Binomial lattice

PROJECT VALUE									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
45.0517707	75.7025836	127.206569	213.7511076	359.1759175	603.5399825	1014.156275	1704.133909	2863.535386	4811.731557
	26.811001	45.0517707	75.70258361	127.2065686	213.7511076	359.1759175	603.5399825	1014.156275	1704.133909
		15.9556387	26.81100103	45.05177074	75.70258361	127.2065686	213.7511076	359.1759175	603.5399825
			9.495445755	15.95563869	26.81100103	45.05177074	75.70258361	127.2065686	213.7511076
				5.650885675	9.495445755	15.95563869	26.81100103	45.05177074	75.70258361
					3.362928896	5.650885675	9.495445755	15.95563869	26.81100103
						2.00133066	3.362928896	5.650885675	9.495445755
							1.191022628	2.00133066	3.362928896
								0.708795867	1.191022628
									0.421815312

Table A-I- 74 Deferral option values

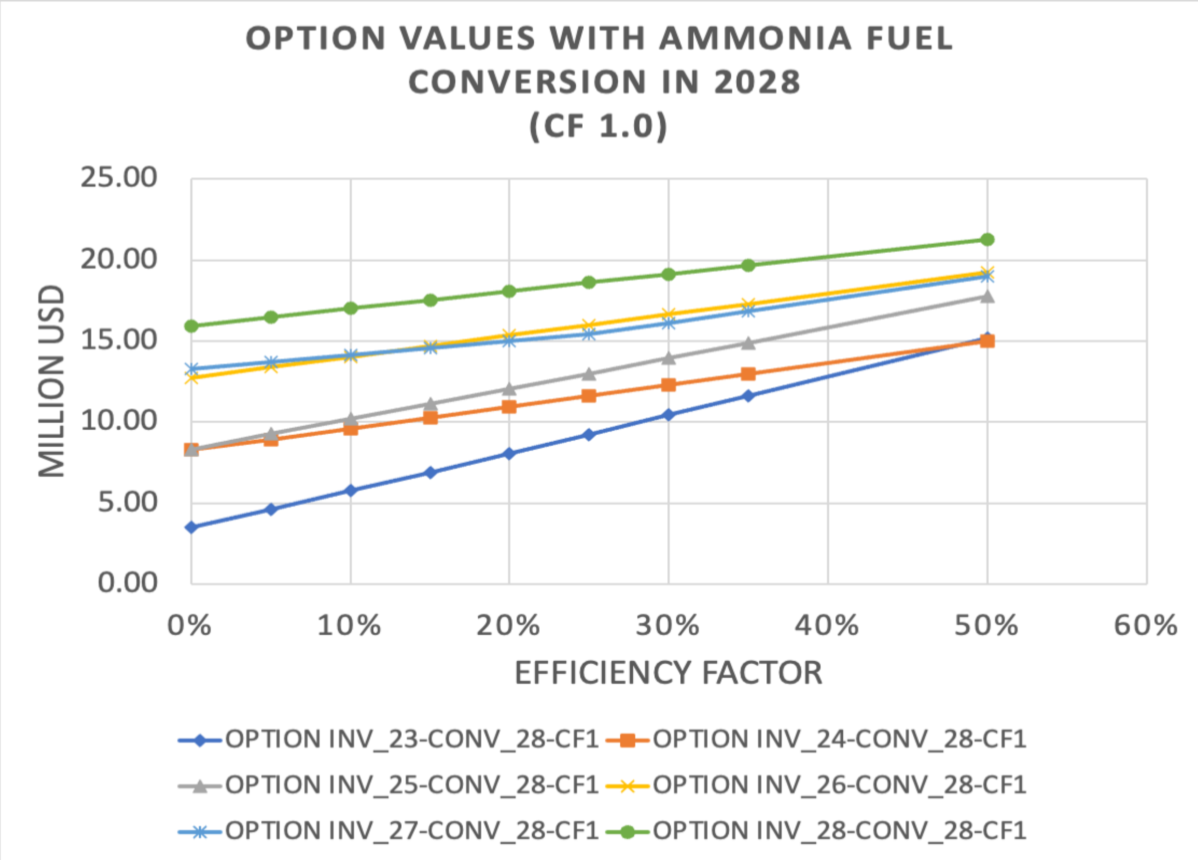
MEAN EXPECTED VALUE									
2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0	1	2	3	4	5	6	7	8	9
45.0517707	47.3616244	49.7899068	52.34268994	55.02635704	57.8476187	60.81352953	63.93150587	67.2003085	70.59468627

REAL OPTION SEQUENCE 1									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
35.5111376	64.0925299	113.803975	199.0172336	343.5167283	587.0779295	996.8501943	1685.940527	2844.409209	
	17.9270902	33.7146297	62.07988486	111.8404659	197.2890546	341.869837	585.3466003	995.0300979	
		8.06484478	16.12840875	31.48833876	59.77206352	109.9004881	195.5577253	340.0497406	
			2.93111176	6.417140729	13.76432437	28.70966227	57.50920137	108.0803917	
				0.662572548	1.657132583	4.144585234	10.36584938	25.92559385	
					0	0	0	0	
						0	0	0	
							0	0	
								0	

REAL OPTION SEQUENCE 2									
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
0	1	2	3	4	5	6	7	8	9
18.3615608	37.6867704	75.8268439	148.9806333	284.4743865	525.0084221	931.5983151			
	5.97250513	13.3639552	29.48829475	63.90843828	135.2195471	276.6179578			
		1.14107097	2.853885047	7.137732941	17.85188636	44.64860891			
			0	0	0	0			
				0	0	0			
					0	0			
						0			

APPENDIX-II: DEFERRAL OPTION VALUES FOR VARYING EF AND CF

Figure A-II- 1 Deferral values with CF=1 and varying EF (2028 Ammonia conversion)



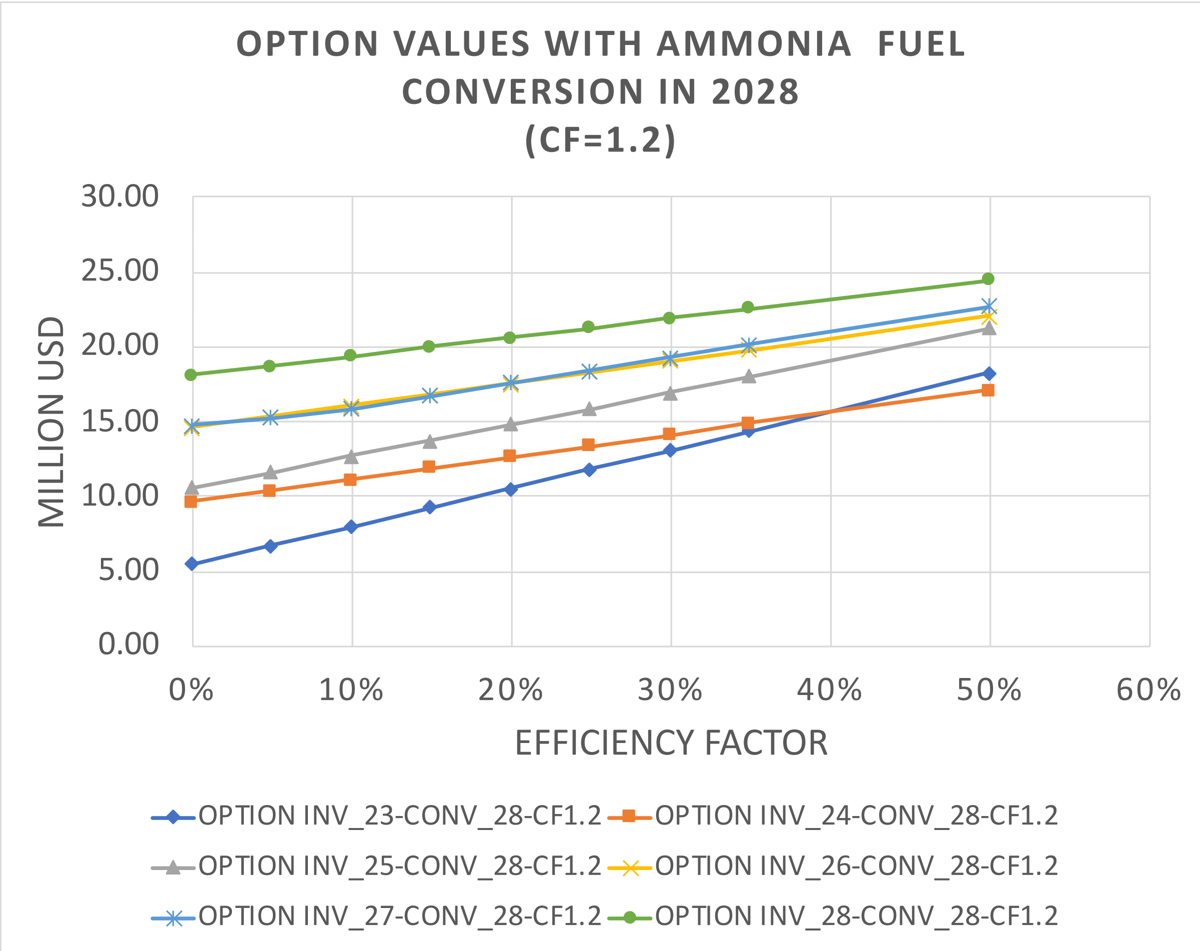
Source: Author’s analysis

Table A-II- 1 Deferral values with CF=1 and varying EF (2028 Ammonia Conversion)

DEFERRAL OPTION VALUES (2028 CONVERSION, CF =1.0)									
	EFFICIENCY FACTOR								
	0%	5%	10%	15%	20%	25%	30%	35%	50%
OPTION INV_23-CONV_28-CF1	3.50	4.64	5.78	6.91	8.07	9.25	10.43	11.62	15.17
OPTION INV_24-CONV_28-CF1	8.28	8.95	9.62	10.29	10.96	11.64	12.32	13.00	15.04
OPTION INV_25-CONV_28-CF1	8.33	9.27	10.20	11.14	12.07	13.01	13.96	14.91	17.78
OPTION INV_26-CONV_28-CF1	12.74	13.39	14.04	14.70	15.35	16.00	16.65	17.30	19.25
OPTION INV_27-CONV_28-CF1	13.29	13.72	14.15	14.58	15.01	15.44	16.10	16.83	19.01
OPTION INV_28-CONV_28-CF1	15.96	16.49	17.02	17.55	18.08	18.61	19.14	19.67	21.26

Source: Author’s calculation

Figure A-II- 2 Deferral values with CF=1.2 and varying EF (2028 Ammonia conversion)



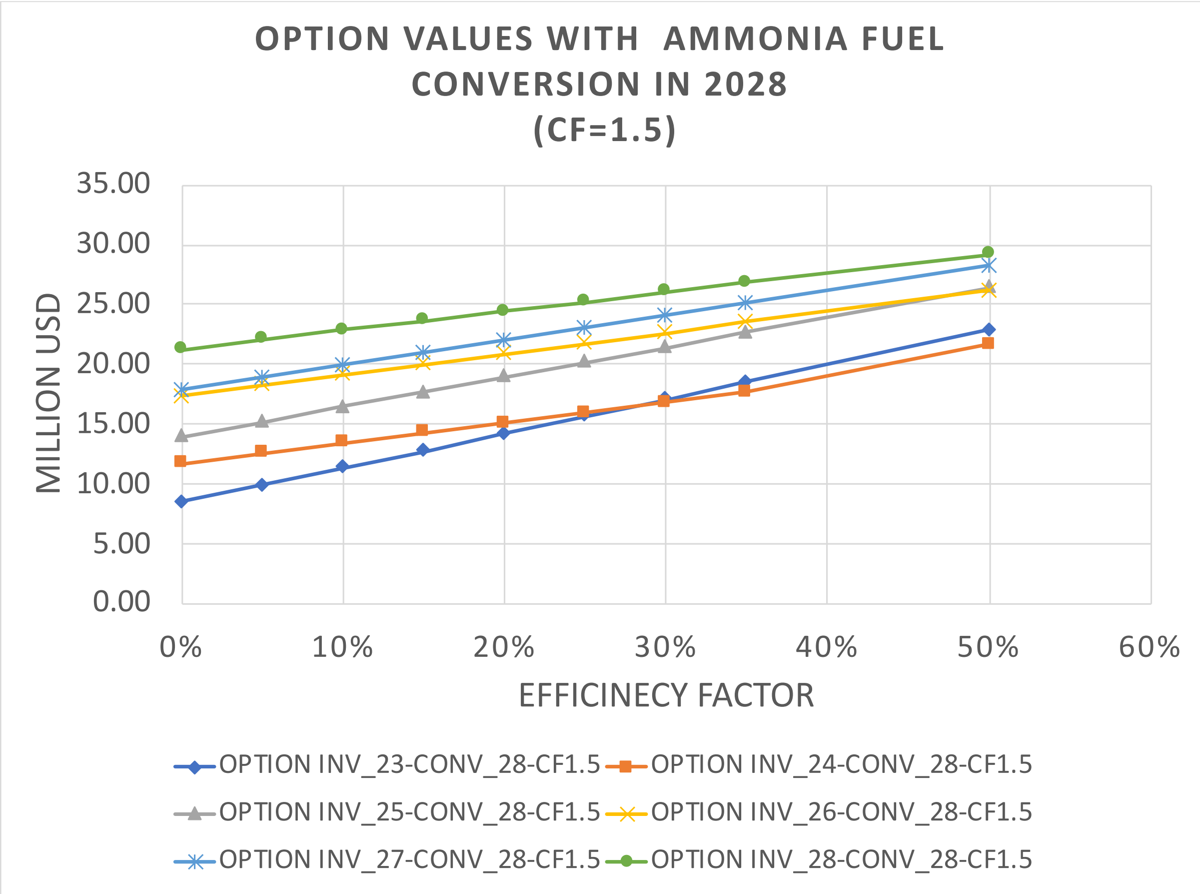
Source: Author's analysis

Table A-II- 2 Deferral values with CF=1.2 and varying EF (2028 Ammonia Conversion)

DEFERRAL OPTION VALUES (2028 CONVERSION,CF =1.2)									
	EFFICIENCY FACTOR								
	0%	5%	10%	15%	20%	25%	30%	35%	50%
OPTION INV_23-CONV_28-CF1.2	5.48	6.72	7.96	9.25	10.53	11.82	13.11	14.39	18.25
OPTION INV_24-CONV_28-CF1.2	9.65	10.39	11.13	11.88	12.63	13.37	14.12	14.87	17.12
OPTION INV_25-CONV_28-CF1.2	10.58	11.63	12.68	13.74	14.81	15.88	16.95	18.02	21.22
OPTION INV_26-CONV_28-CF1.2	14.59	15.34	16.08	16.82	17.57	18.31	19.05	19.80	22.03
OPTION INV_27-CONV_28-CF1.2	14.73	15.24	15.88	16.73	17.58	18.44	19.29	20.14	22.69
OPTION INV_28-CONV_28-CF1.2	18.08	18.72	19.35	19.99	20.63	21.26	21.90	22.54	24.45

Source: Author's calculation

Figure A-II- 3 Deferral values with CF=1.5 and varying EF (2028 Ammonia conversion)



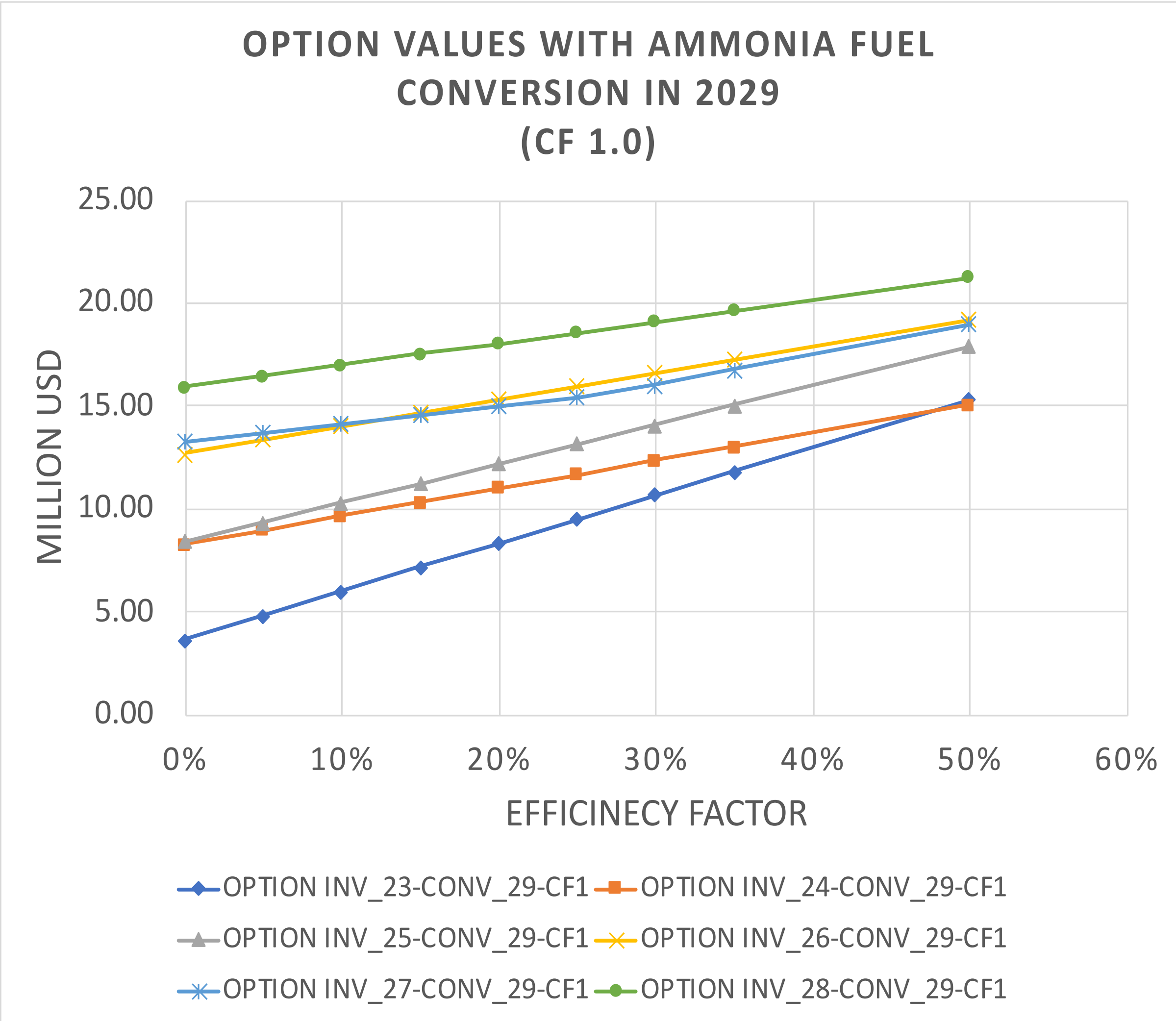
Source: Author's analysis

Table A-II- 3 Deferral values with CF=1.5 and varying EF (2028 Ammonia Conversion)

DEFERRAL OPTION VALUES (CONVERSION 2028, CF =1.5)									
	EFFICIENCY FACTOR								
	0%	5%	10%	15%	20%	25%	30%	35%	50%
OPTION INV_23-CONV_28-CF1.5	8.47	9.91	11.35	12.79	14.24	15.68	17.12	18.56	22.88
OPTION INV_24-CONV_28-CF1.5	11.71	12.56	13.42	14.27	15.12	15.97	16.83	17.68	21.66
OPTION INV_25-CONV_28-CF1.5	13.97	15.22	16.46	17.70	18.94	20.18	21.43	22.67	26.39
OPTION INV_26-CONV_28-CF1.5	17.37	18.25	19.13	20.01	20.89	21.78	22.66	23.54	26.19
OPTION INV_27-CONV_28-CF1.5	17.86	18.89	19.93	20.96	22.00	23.03	24.07	25.10	28.21
OPTION INV_28-CONV_28-CF1.5	21.26	22.06	22.85	23.65	24.45	25.24	26.04	26.83	29.22

Source: Author's calculation

Figure A-II- 4 Deferral values with CF=1.0 and varying EF (2029 Ammonia conversion)



Source: Author's analysis

Table A-II- 4 Deferral values with CF=1.0 and varying EF (2029 Ammonia Conversion)

DEFERRAL OPTION VALUES (CONVERSION 2029, CF =1.0)									
	EFFICIENCY FACTOR								
	0%	5%	10%	15%	20%	25%	30%	35%	50%
OPTION INV_23-CONV_29-CF1	3.67	4.84	6.01	7.17	8.34	9.51	10.68	11.85	15.35
OPTION INV_24-CONV_29-CF1	8.30	8.98	9.66	10.33	11.01	11.68	12.36	13.04	15.07
OPTION INV_25-CONV_29-CF1	8.42	9.37	10.31	11.26	12.21	13.16	14.11	15.06	17.90
OPTION INV_26-CONV_29-CF1	12.72	13.37	14.02	14.67	15.33	15.98	16.63	17.28	19.23
OPTION INV_27-CONV_29-CF1	13.27	13.70	14.13	14.56	15.00	15.43	16.06	16.79	18.98
OPTION INV_28-CONV_29-CF1	15.94	16.47	17.00	17.53	18.06	18.59	19.12	19.65	21.24

Source: Author's calculation

Figure A-II- 5 Deferral values with CF=1.2 and varying EF (2029 Ammonia conversion)

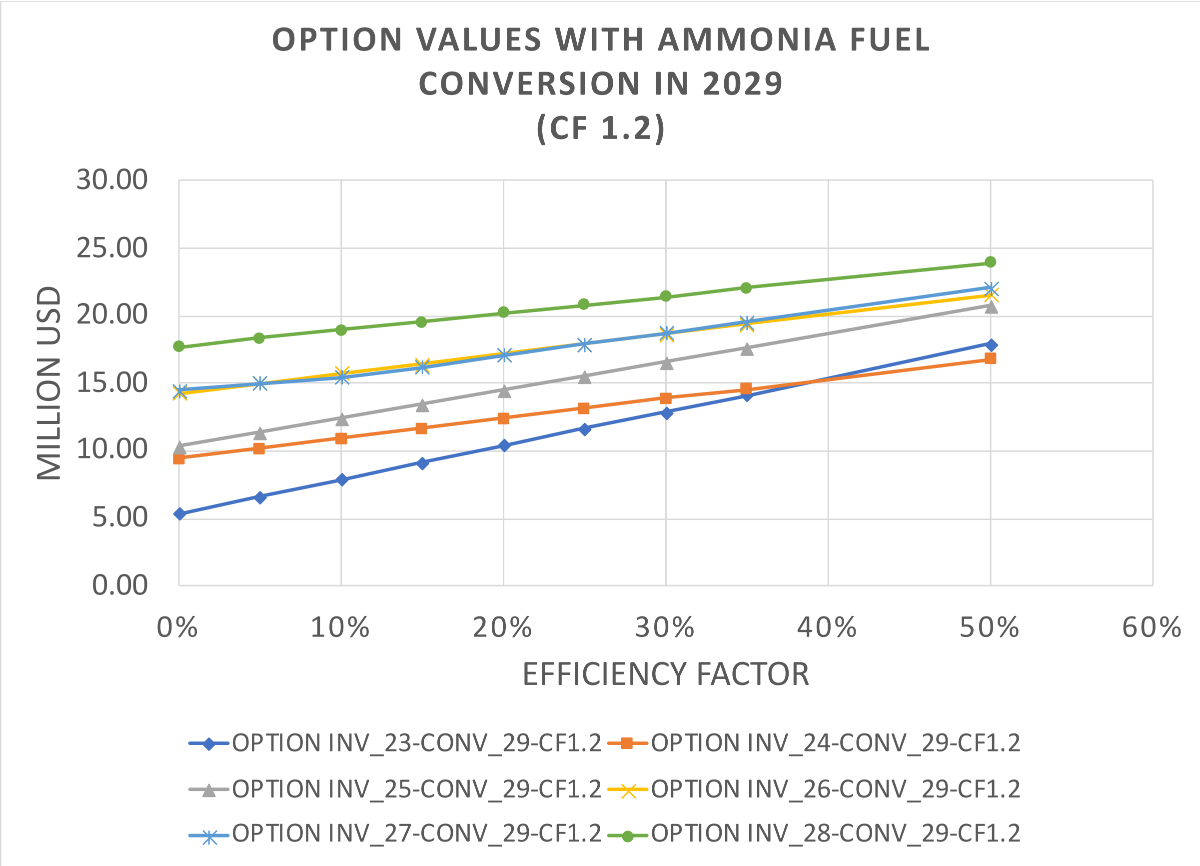


Table A-II- 5 Deferral values with CF=1.2 and varying EF (2029 Ammonia Conversion)

DEFERRAL OPTION VALUES (CONVERSION 2029, CF =1.2)									
	EFFICIENCY FACTOR								
	0%	5%	10%	15%	20%	25%	30%	35%	50%
OPTION INV_23-CONV_29-CF1.2	5.37	6.62	7.88	9.13	10.38	11.64	12.89	14.14	17.90
OPTION INV_24-CONV_29-CF1.2	9.46	10.19	10.93	11.66	12.40	13.13	13.87	14.60	16.80
OPTION INV_25-CONV_29-CF1.2	10.33	11.37	12.42	13.46	14.50	15.55	16.59	17.64	20.77
OPTION INV_26-CONV_29-CF1.2	14.27	15.00	15.73	16.46	17.18	17.91	18.64	19.37	21.55
OPTION INV_27-CONV_29-CF1.2	14.49	14.98	15.47	16.24	17.07	17.90	18.73	19.56	22.06
OPTION INV_28-CONV_29-CF1.2	17.71	18.33	18.95	19.57	20.19	20.81	21.43	22.05	23.91

Source: Author's calculation

Figure A-II- 6 Deferral values with CF=1.5 and varying EF (2029 Ammonia conversion)

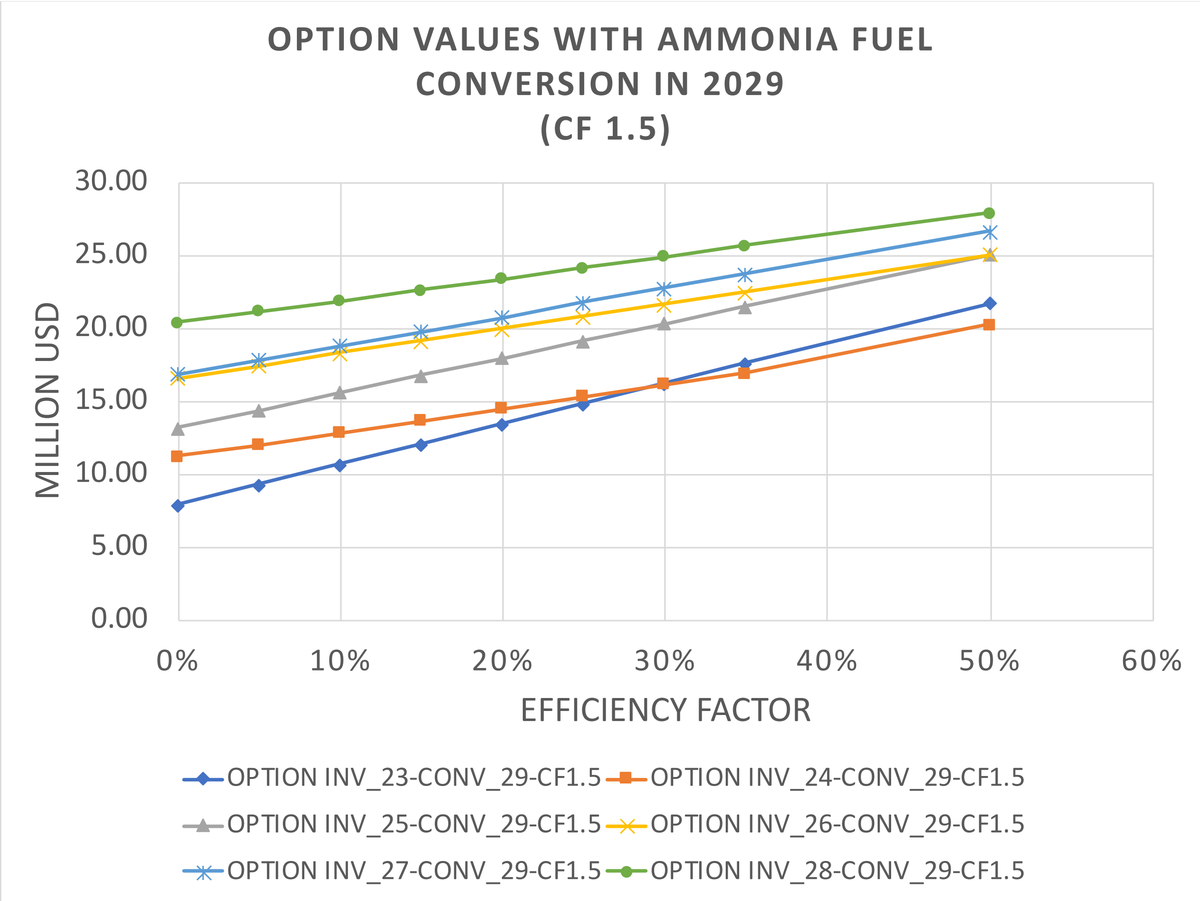


Table A-II- 6 Deferral values with CF=1.5 and varying EF (2029 Ammonia Conversion)

DEFERRAL OPTION VALUES (CONVERSION 2029, CF =1.5)									
	EFFICIENCY FACTOR								
	0%	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**	**35%**	**50%**
OPTION INV_23-CONV_29-CF1.5	**7.92**	**9.30**	**10.68**	**12.06**	**13.44**	**14.83**	**16.21**	**17.59**	**21.73**
OPTION INV_24-CONV_29-CF1.5	**11.20**	**12.02**	**12.84**	**13.66**	**14.48**	**15.30**	**16.12**	**16.94**	**20.24**
OPTION INV_25-CONV_29-CF1.5	**13.20**	**14.38**	**15.57**	**16.76**	**17.94**	**19.13**	**20.32**	**21.51**	**25.07**
OPTION INV_26-CONV_29-CF1.5	**16.59**	**17.44**	**18.28**	**19.13**	**19.97**	**20.82**	**21.66**	**22.51**	**25.04**
OPTION INV_27-CONV_29-CF1.5	**16.83**	**17.81**	**18.80**	**19.78**	**20.77**	**21.75**	**22.74**	**23.72**	**26.68**
OPTION INV_28-CONV_29-CF1.5	**20.38**	**21.13**	**21.88**	**22.64**	**23.39**	**24.14**	**24.89**	**25.65**	**27.91**

Source: Author’s calculation

Figure A-II- 7 Deferral values with CF=1.0 and varying EF (2030 Ammonia conversion)

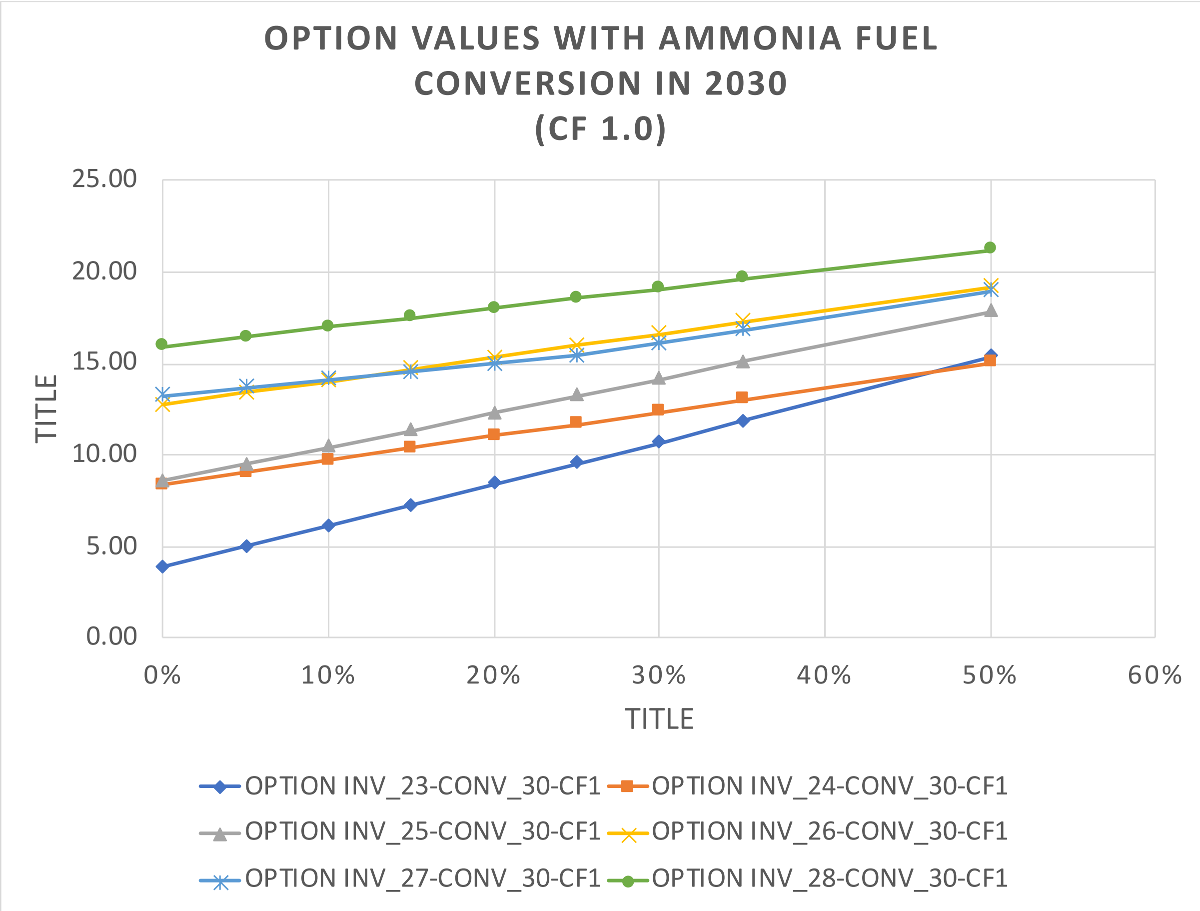


Table A-II- 7 Deferral values with CF=1.0 and varying EF (2030 Ammonia Conversion)

DEFERRAL OPTION VALUES (CONVERSION 2030, CF =1.0)									
	EFFICIENCY FACTOR								
	0%	5%	10%	15%	20%	25%	30%	35%	50%
OPTION INV_23-CONV_30-CF1	3.85	4.99	6.13	7.26	8.40	9.54	10.68	11.81	15.35
OPTION INV_24-CONV_30-CF1	8.36	9.02	9.69	10.36	11.03	11.70	12.36	13.03	15.05
OPTION INV_25-CONV_30-CF1	8.57	9.50	10.43	11.36	12.29	13.21	14.14	15.07	17.86
OPTION INV_26-CONV_30-CF1	12.76	13.40	14.05	14.70	15.34	15.99	16.63	17.28	19.22
OPTION INV_27-CONV_30-CF1	13.26	13.69	14.12	14.55	14.98	15.41	16.11	16.82	18.98
OPTION INV_28-CONV_30-CF1	15.91	16.44	16.97	17.51	18.04	18.57	19.10	19.63	21.22

Source: Author's calculation

Figure A-II- 8 Deferral values with CF=1.2 and varying EF (2030 Ammonia conversion)

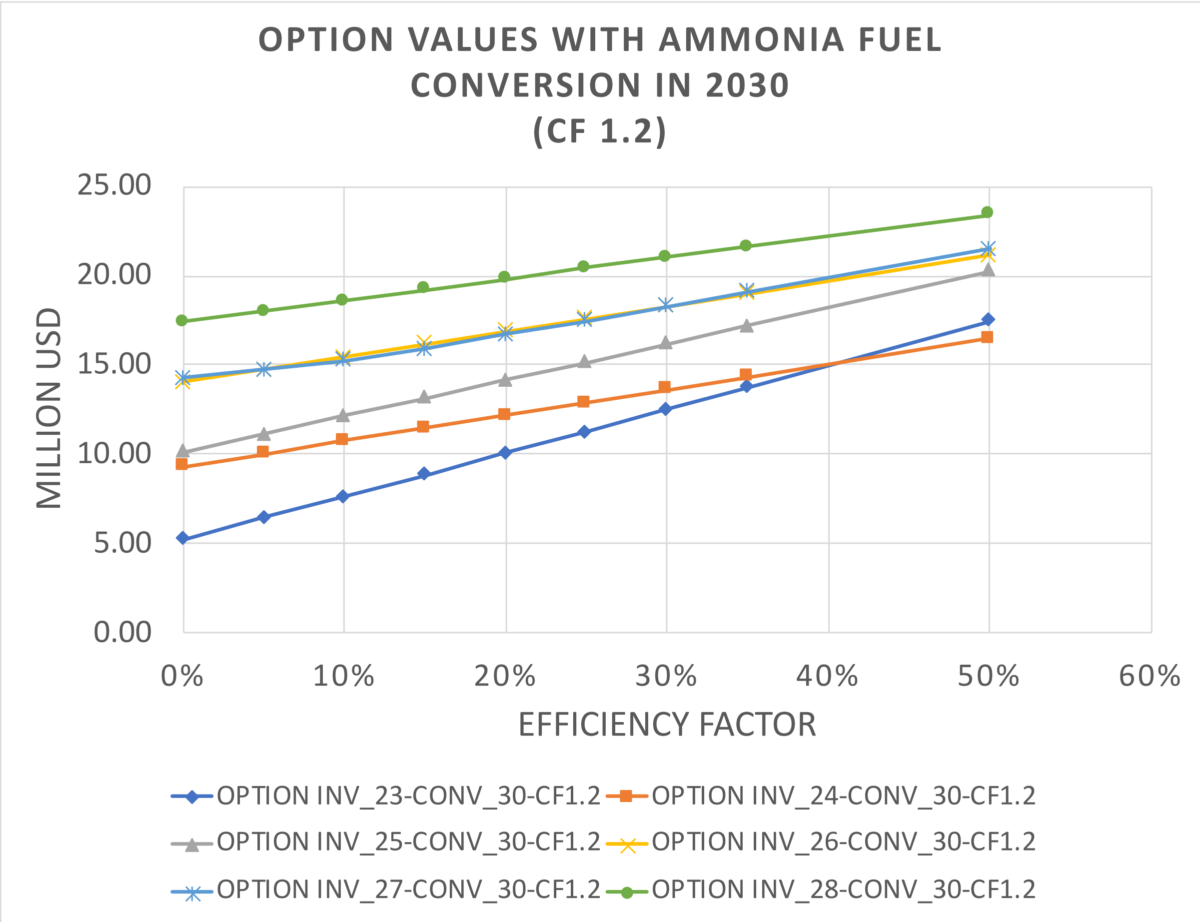


Table A-II- 8 Deferral values with CF=1.2 and varying EF (2030 Ammonia Conversion)

DEFERRAL OPTION VALUES (CONVERSION 2030, CF =1.2)									
	EFFICIENCY FACTOR								
	0%	5%	10%	15%	20%	25%	30%	35%	50%
OPTION INV_23-CONV_30-CF1.2	5.23	6.44	7.64	8.85	10.06	11.26	12.49	13.74	17.50
OPTION INV_24-CONV_30-CF1.2	9.31	10.02	10.74	11.46	12.17	12.89	13.60	14.32	16.50
OPTION INV_25-CONV_30-CF1.2	10.13	11.14	12.14	13.15	14.16	15.16	16.17	17.18	20.26
OPTION INV_26-CONV_30-CF1.2	14.04	14.75	15.46	16.17	16.88	17.59	18.30	19.01	21.14
OPTION INV_27-CONV_30-CF1.2	14.27	14.75	15.24	15.89	16.69	17.50	18.30	19.10	21.51
OPTION INV_28-CONV_30-CF1.2	17.39	18.00	18.60	19.21	19.81	20.42	21.02	21.63	23.44

Source: Author’s calculation

Figure A-II- 9 Deferral values with CF=1.5 and varying EF (2030 Ammonia conversion)

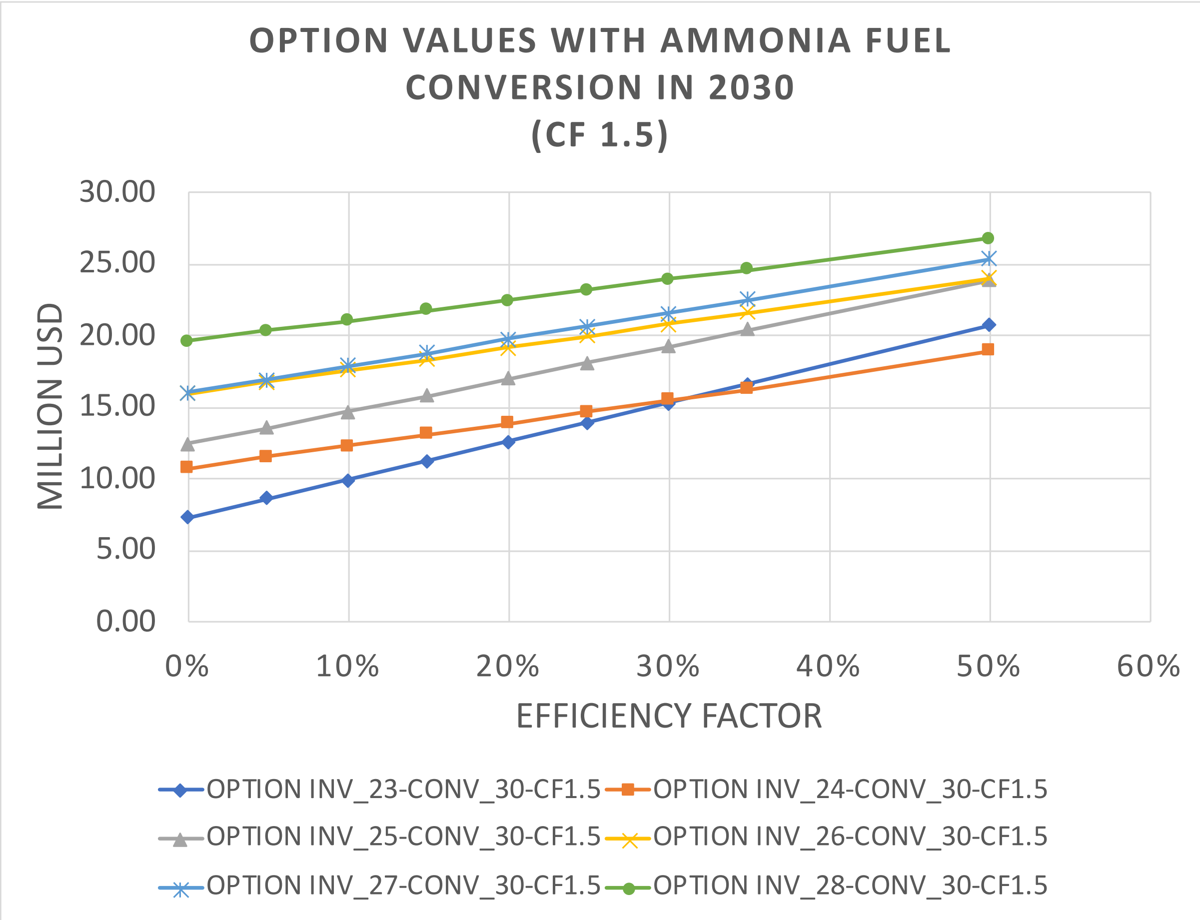


Table A-II- 9 Deferral values with CF=1.5 and varying EF (2030 Ammonia Conversion)

DEFERRAL OPTION VALUES (CONVERSION 2030, CF =1.5)									
	EFFICIENCY FACTOR								
	0%	5%	10%	15%	20%	25%	30%	35%	50%
OPTION INV_23-CONV_30-CF1.5	7.30	8.61	9.92	11.23	12.56	13.92	15.28	16.64	20.72
OPTION INV_24-CONV_30-CF1.5	10.74	11.52	12.31	13.10	13.88	14.68	15.48	16.28	18.92
OPTION INV_25-CONV_30-CF1.5	12.47	13.59	14.72	15.84	16.96	18.10	19.25	20.40	23.86
OPTION INV_26-CONV_30-CF1.5	15.96	16.77	17.57	18.38	19.18	19.99	20.80	21.61	24.05
OPTION INV_27-CONV_30-CF1.5	16.01	16.94	17.87	18.80	19.73	20.66	21.59	22.53	25.35
OPTION INV_28-CONV_30-CF1.5	19.62	20.33	21.05	21.76	22.48	23.19	23.91	24.62	26.77

Source: Author's calculation