Economic Analysis on Ship Investment and Management Strategy of Dry Bulk Shipping

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ECONOMIC ANALYSIS ON SHIP INVESTMENT AND MANAGEMENT STRATEGY OF DRY BULK SHIPPING

ドライバルクシッピングにおける船舶投資と船舶管理の経済分析

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Biography

Emrah Bulut is born in Elazig, Turkey in 1981. He attended Balak Gazi High school in Elazig, Turkey. He received his bachelor degree from the department of Maritime Transportation and Management Engineering at Istanbul Technical University in 2006. He worked at Server shipping company as an operation manager for six months and then worked on the product tanker ship as a third and second officer. After that, he attended the Istanbul Technical University where he received a MEng. in ship investment decision making. In 2008, Emrah was accepted as a graduate student in the department of Graduate School of Maritime Science at Kobe University. He graduated with a MSc. in September 2010.

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"*History must be the light of the future, not to be a mirror.*"

Chapter 1

Introduction

Maritime transportation is undoubtedly one of the most fascinating industries in the world transportation systems and it goes back to as early as 45,000 years ago. From that time to the present, maritime transportation has been developed and modified in accordance with technological development, new sailing route, different cargo type, and capacity. Since the demand of raw materials has increased particularly after the industrial revolution in the 19th century, maritime transportation has been more indispensable to transport it from one point to another. In the last few decades, shipping market has arrived about 80 billion dollars per year for financing new building alone and there exists more than 30,000 worldwide shipping companies in the shipping industry (Unctad, 2010).

Maritime transportation plays a much more important role in the global economy. It is also influenced by the economic and political factors that regulate shipping supply and demand. Four important players, shipowners, shippers or charterers, bankers, and various regulatory authorities, affect the supply and demand equilibriums of ships. Ship owners make a decision whether to order new ships or second hands, or sell their ships. Shippers influence the cargo volume and their transportation by ships. Bankers play a financial role as lenders to purchase the ships. Transportation authority organizes the fleet capacity by environmental regulation (Lun, Lai, & Cheng, 2010).

At the demand side, political factors, world economy, seaborne trade, average haul, and transport cost might be considered as determinants of demand in shipping business. In the shipping market, supply and demand intersect at the equilibrium price that determines freight rates (Figure 1.1).

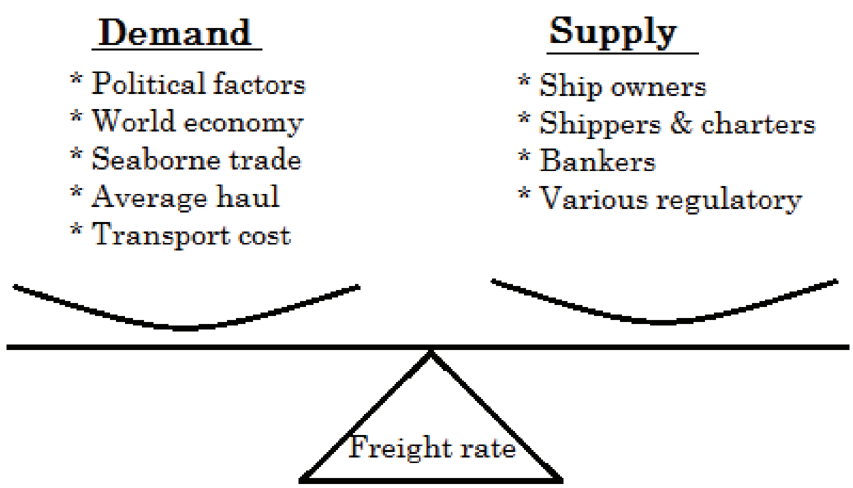

Figure 1.1 Supply – Demand equilibrium.

Incapability of ship size and the different cargo type caused the emergence of larger and different type of ships such as dry bulk, tanker, chemical, container, RoRo, and cruise ships, that are grouped Handy size, Panamax, Aframax, VLCC, Capsize and so on. The efficient ship management becomes distinct for each type of ships and it should be considered different professional perspective and skills by ship owners. Generally, they tend to be specialized the same type of ships in ship management for the risk aversion of ship operation, while big shipping companies such as NYK, Kline, and Maersk, have different professional ship management departments for each type of ships (Stopford, 2009).

Shipping industry is extremely volatile and highly cyclical business, where making the right decision in good time that allows the owners to grow their company, while the wrong decision causes the total loss and high risk. By having an extensive understanding of the way the shipping market and its components work, we can generate a better decision support system for shipping investor (Lun, et al., 2010). For this purpose, entrepreneurs or ship owners are expected to analyze the alternatives of the ship investment and management in shipping market to make an effective decision for the investment strategy. Before entering the shipping market, three major and significant decisions, namely, the market entry-exit decision (asset play), ship investment decision (the type of ship and size), and the proper ship management strategy decision, should be considered (Figure 1.2). The empirical study is based on the entrepreneurs' own ships and it does not consider the time charter ship and its different period selection.

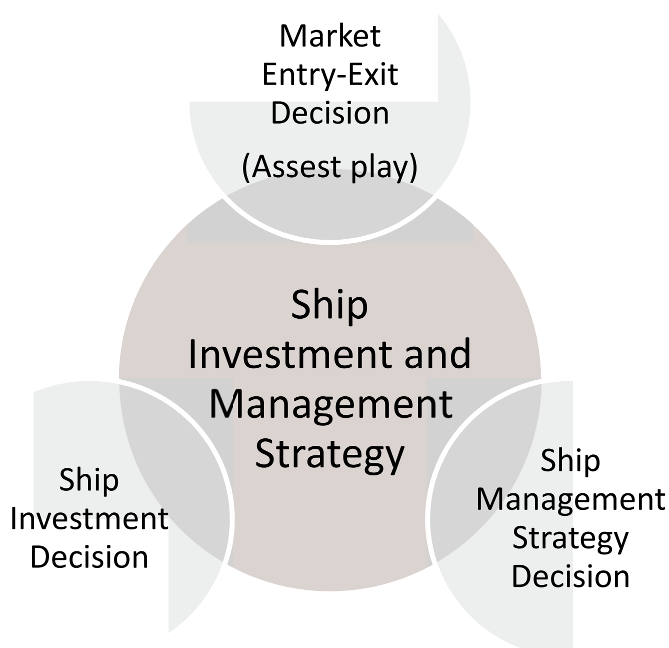

Figure 1.2 Ship investment and management strategy decisions.

In the existing literature, a limited number of studies investigate the shipping investment and management strategy for the entrepreneur in the shipping industry. In order to close this gap, in this dissertation, the model that is based on economic and financial tools is developed to allow us to understand the dynamics of ship investment decisions under uncertainty. The developed models and the valuation methods with fuzzy analytic hierarchy process (FAHP) model are used in order to increase the probability of success and improve the decision making for the ship owners.

1.1 Historical transition in ship investment and management

During the World War II, the private equity was the major source for the shipping finance. The world economy has recovered itself and the growth after the World War II, and the need for the larger cargo capacities was increased. Then, the shipping finance instruments have evolved in compatibility with the different market demand because only the private equity could not cover the amount of requisite capital investment (Harwood, 2006). Until the 1950s, retained earnings supplied the new investment in shipping industry for the owners. Between the 1950s and the 1960s, the private equity or cash could no longer meet large corporations with growing cargo volumes which clearly needed bigger ships. Ship owners used the long term charter contracts and mortgage as security to finance new buildings. The shipping market became extremely volatile after the 1950s and the financial mechanism has been diversified to complicated and sophisticated including different debt and equity sources such as ship yard credit, corporate loan, and bond issue (Grammenos, 2010).

Consequently, the alternative ship financing structures and sources of debt funding for the shipping markets have begun to be available and important especially after the Suez canal effect in 1957 and oil companies' crises in 1970 (Table 1).

Nowadays, three main principle sources are mostly used for the capital requirements in shipping finance (Brealey, Myers, & Allen, 2008; McConville & Leggate, 1999);

Equity Finance which includes owner's cash reserves or outside equity finance and there are no fixed payments to capital.

Bank Finance is the most used source for the shipping finance. There are four main types of loans available to shipowners: mortgage loan, corporate loan, shipyard credit, and mezzanine finance. The bank loan is widely preferred source of financing for shipping companies with the major perceived advantages of low cost, easy access, and relatively flexible terms and conditions.

Capital Markets is defined in the late 1990s and it is based on the bond market. The amount of loan in this type of debt is much more than others and it is generally used for offshore oil, gas, and LNG ships.

Table 1. Three different options for shipping finance.

Equity Finance	Own Funds Private Investment
Bank Finance	Mortgage-Backed Loan Corporate Loan Ship yard Credit Mezzanine Finance Private Placement
Capital Markets	Public Offering Bond Issue

According to the conventional ship management, many duties should be carried out by ship owners and their function plays a critical role in the organizational chart of conventional ship management. By the late 1980s, the significant recovery in shipping industry has brought with the transformation of ship management from an in-house function of the ship owners to special ship management organization (Sletmo, 1989). The ship management outsourcing has grown and different types of ship management outsourcing became a strategic choice and alternatives for the owners. Increasing running cost, limitation of crew resources, many environmental and safety rules, achieving competition, and shipping market volatility have made the shipping management difficult for the conventional management structure. All these criteria influenced the cost-efficiency and companies' profitability and they should be considered and analyzed to make decision for the alternatives of shipping management.

1.2 Literature review

1.2.1 Ship investment

In the last decade, the ship investment strategy selection is one of the most attractive study fields. The earliest studies go back to the beginning of the 20th century and they are basically based on the economic analysis of shipping market and freight rates (Eulenburg, 1932; Isserlis, 1938; Matsumoto, 1929; Tinbergen, 1931). One of the first indications in the classical econometric analysis for ship investment is Koopmans' study which investigated the deterministic factor of freight rates in terms of a supply and demand model (Koopmans, 1939).

Beenstock & Vergotis (1989a, 1989b) stated a theoretical model where freight markets and ship building markets have high correlation and which is applied to analyze the dry bulk cargo market and the tanker market.

Marcus et al. (1991) proposed an estimator of relative price level for general ship based on the net present value (NPV) method to compare market price with a cost-based nominal price and thus identified relative highs and lows in a bulk shipping market. In other words, they compared the nominal and actual price to determine the purchasing and selling of bulk carriers. They defined two different measures of relative ship price to use as investment signals in the spreadsheet. First is the ratio between actual price and nominal price. When the ratio is positive, the nominal price is greater than the actual price and the ship could be construed as "under-valued." Thus it's time to consider adding a ship to the investment portfolio. Conversely, a negative ratio signal indicates an "overvalued" ship and therefore suggests it's time to consider selling. Second one is related to the change signal of current ratio. When the change signal is positive, ships are becoming more attractive. When the change signal is negative, ships are becoming less attractive.

Study of Merikas and Koutroubousis (2008) investigated the relative price ratio of second-hand price over the new building price (SH/NP) to define the investment timing. They investigated the determinants of this ratio across different ship sizes in the tanker sector and showed that it can be used as an effective tool in investment decision as well as in ship appraisal.

Alizadeh and Nomikos (2003, 2007) investigated the performance of trading strategies based on the combination of technical trading rules and fundamental analysis in the sale and purchase market for dry bulk ships. The authors studied the existence of a long-run cointegration relationship between ship price and earning and use this relationship as an indicator of investment or divestment timing decisions in the dry bulk shipping sector by using a sample of ship price and charter rates over the period between 1976 and 2004. Their results reveal that trading strategies based on earnings–price ratios significantly out-perform buy and hold strategies in the second-hand market, especially for larger ships, due to higher volatility in these markets.

NPV method has long been advocated as the applicable theoretical support for maritime investments (Evans, 1984; Gardner, Goss, & Marlow, 1984). However, the limitations of the financial and econometric methods are also well known, while their results are practical to use for a confirmatory role (Grammenos, 2010; Trigeorgis, 1995). There are also some significant factors that influence ship investment decision making and they are not clearly financial or cannot be easily quantified in financial terms (H. Bendall & Stent, 2003; Rousos & Lee, 2012). In order to close existing gap, several studies applied the different methods, such as multi criteria decision making and real option analysis, from classical economic approaches, not only for ship investment analysis but also for different markets (H. B. Bendall & Stent, 2007; Bulut, Duru, Keçeci, & Yoshida, 2012; Chou & Liang, 2001; Dimitras, Petropoulos, & Constantinidou, 2002; Lyridis, Zacharioudakis, Mitrou, & Mylonas, 2004).

1.2.2 Ship management

Management is extremely significant in the volatile and competitive shipping industry (D. K. Mitroussi, 2003). The origin of today's professional ship management company model can be traced back to the time after the World War II, consciously to develop commercial activities of the old family-owned ship management companies (Sletmo, 1986). In the mid-1960s, the demand for the professional ship management considerably increased by major oil companies which employed third party ship management companies for their ships (Panayides & Gray, 1997). The BIMCO standard ship management document, called BIMCO Shipman, was established in 1988 and revised to constitute standard and principle of ship management.

In the existing literature, the limited number of studies investigates the ship management to determine factors and criteria which influence a making decision for the selection of the type of ship management and develop the ship management model for the shipping companies. Panayides and Cullinane (2002) investigated to define the dimensions in ship manager selection and evaluation. They used personnel interview and questionnaire as a research method to identify the choice selection and evaluation criteria as used by the ship managers. The study was specified as follows;

- *To identify ship manager's perceptions with respect to ship manager selection and service evaluation criteria,*
- *To identify the importance attached to each criterion by ship managers;*
- *To identify the criteria (dimensions) actually used by shipowners (clients) in selecting ship management companies and evaluating the service provided;*
- *To identify the importance attached to each criterion by the shipowners (clients); and*
- *To identify any perceptual gap which exists between the perspective of ship managers and shipowners and to analyze the implications of this.*

The result of their study showed that the price/cost variable is important but not at the expense of quality. Hence, the price/cost ratio might be considered as the deterministic variable when all other things are equal. However, if service quality is low that customers assume acceptable, the price will not be much in attracting particular customer to the ship manager. Experience, qualifications and the technical ability of personnel also are considered to be selected as a criteria agenda. The cost-effectiveness in ship operation and the trust between parties were found as a particular importance for the ship marketing strategy. In the study of Mitroussi (2003; 2004a), the revolution of third party ship management is analyzed. They outlined some of the basic factors that contribute to the separation of ownership and management in the modern business system. These factors can be considered instrumental in the decision of a ship-owning firm to employ third party ship management. He found that issues like the size, type and age of the company can have a major influence on the separation of ownership and management. One of the other study of Mitroussi (2004b) investigates the comparison of two traditional maritime centers, Greece and the UK, to look into the ship owner's view point on a number of key issues for the analytical examination of the ship management.

Cariou and Wolff (2011) analyzed 45,456 ships belonging to 9580 different ship-owners to investigate the extent of outsourcing in shipping and to identify the key factors affecting the likelihood of outsourcing. According to their results, ship-owners' decisions to outsource are explained by the characteristics of the ships in question (age, type and size) and the characteristics of the ship-owner (country of domiciliation and number of ships).

In the study for the ship management companies in UK and Cypriot, Panayides and Gray (1999) point out the different perspective of ship management for co-operation and long-term customers relationship that achieve a competitive advantage or reduce the risk of losing.

Each study in the literature as mentioned above investigated the part of the ship management, not all of the structure of the shipping business management from first step to last one. However, all parts, such as management department, investment department, chartering department, and crew department of shipping business, should be considered for the ship investment and management analysis. In this study, we handled all these issues of shipping business to investigate the economic analysis on the ship investment and management strategy decision for the dry bulk shipping market.

1.3 Motivation and scope of work

In this study, three major shipping investment decisions that are clearly interrelated with each other are investigated (Figure 1.3). The first one is related with market entry-exit decision from the point of business cycles in the dry cargo shipping. One of the critical problems of the shipping business is based on the market entry-exit decision and the investment timing for ship allocation. There are many indicators which define the investment climate in the shipping business and the optimized market entry may extremely contribute to the cumulative financial results of a shipping asset (i.e. vessel). A number of indicators are investigated under the business cycle perspective and the fluctuations of the return on equity (here after ROE) is figured out in the long-run framework. The fluctuations of ship prices and ROE indicate that the ship investor tends to place the investment at the time of peaks of ship prices (new building or second hand) which extremely causes the loss of ROE rates in the long-run. The statistical significance is tested and the market entry decision is investigated according to the maximum ROE constraint (Bulut, Duru, & Yoshida, 2013).

The second is the decision on the ship investment of different type of ships in new building, or second hand ships. Particularly in the rapid growth of the world economy, shipping capacity is more important and a certain size of ship has advantages on employment and profit margins. An investor is basically asked to define characteristics of his ships. The ship size is one of the critical dimensions of ship investment. Investors have three optional entry strategies: a new building ship, purchasing a second hand hull or hiring an existing ship for a period of time. In practice in the shipping business, charterers of ships are large-scale industry players or their intermediaries. A shipping investor usually tends to purchase a new construction or an existing ship (Duru, Bulut, & Yoshida, 2012).

The ship management decision is another focus of the present study. When a ship owner purchases a merchant ship, management of the fleet is another problematic point of the ship management process. The owner may prefer to manage the fleet by himself; management outsourcing is another option. An experienced investor may choose to manage his fleet by senior managers of the corporation or if the investor is an entrepreneur, management outsourcing can be a reasonable solution. Depending on the size of the fleet, it may be feasible to establish management at the headquarters, or through third party management companies (Bulut, et al., 2012).

The remainder of this dissertation is organized as follows: Chapter 2 investigates the market entry-exist decisions and irrationality problem on shipping asset play. In Chapter 3, the several criteria are defined to analyze the type and size of ships for the investment. Next, Chapter 4 proposes the model that investigates the ship management strategy selection to maximize the return and minimize the risk.

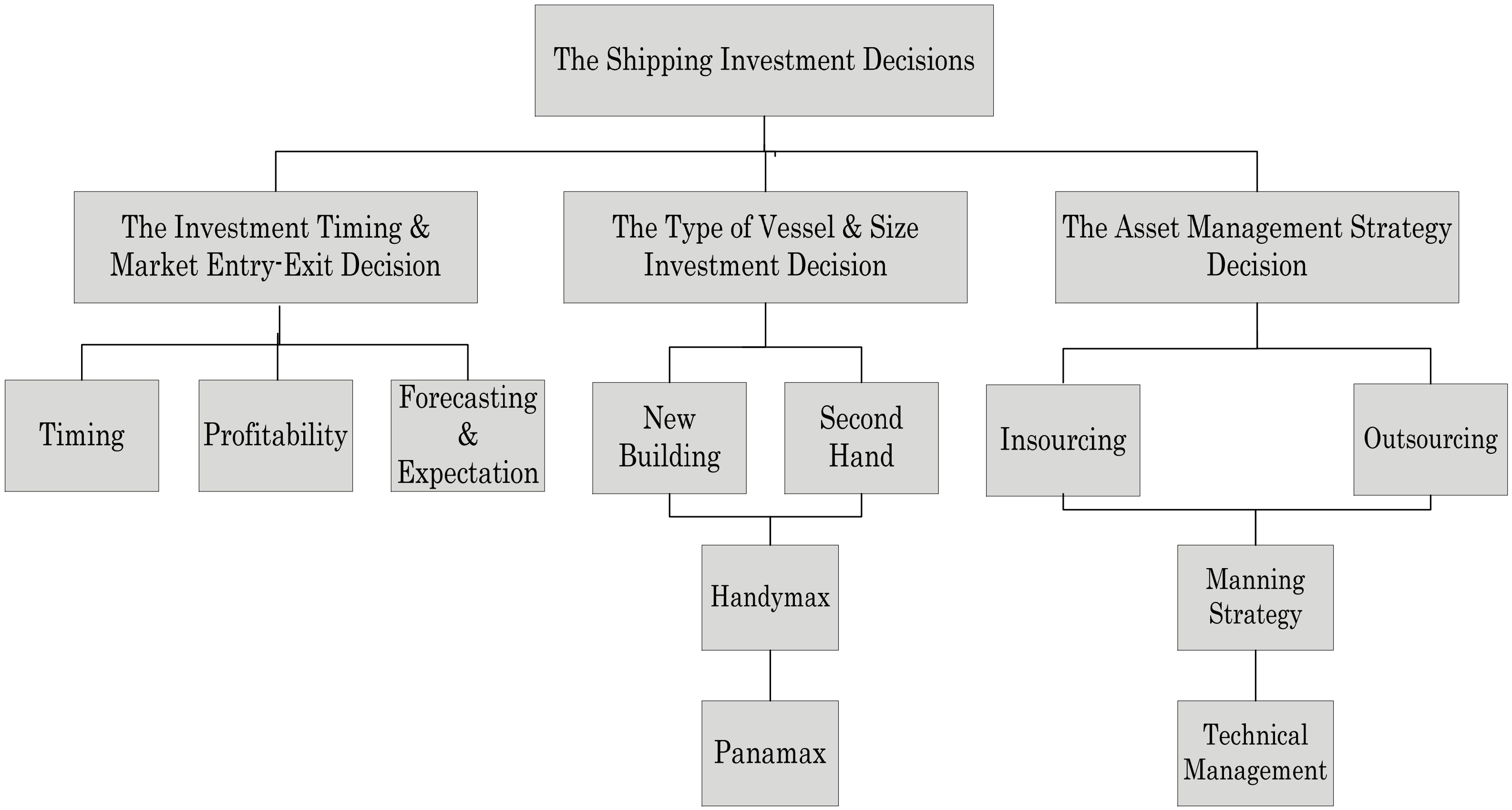

Figure 1.3 The shipping investment decisions and its components.

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Chapter 2

Market Entry-Exit Decision

One of the most major processes in shipping management is asset (i.e. ship/vessel) management that refers to the long term planning for the profit maximization and the related activities to ensure company growth (Bulut et al., 2012). Particularly the market entry-exit decision (sale & purchase of ships) is critical to obtain desired financial outcome. In addition, the ship management is a process between the sale and purchase of ship to ensure long term competitiveness in the shipping service industry. In case of ship management process, the market switching decision between period and spot markets is an important debate since it defines the level of employment risk, opportunity risk, and business reputation. Although a vast number of studies discuss the ship management and the market switching problem, the literature on ship management is limited. The ship management studies deal with a highly complicated business environment and the lack of proper data is a substantial problem.

The ship prices, interest rates, freight market, and return on equity (ROE), which is the profitability ratio used to measure the firm's return on its investment, have their own cycles that may have higher correlations among each other. It is very common that the shipping asset prices may dramatically change in a few months which wipe out the ship operation returns of a few years. Such business anomalies make the shipping one of the most volatile industries and it is quite difficult to ensure financial sustainability and competitiveness of an enterprise.

Therefore, the investment timing is the most important and critical part of the shipping business.

The characteristic feature of traditional behaviour of ship investor is illustrated with the peak market purchases and the slump market sales. The existing statistics on the contracting of sale & purchasing explicitly indicate the investment anomalies. According to the empirical results, ship investment is based on typically impatient capital behaviour with asymmetric incentives. The ROE results show that the governance of ships is unskilled and misguided in the last few decades. Herd behaviour, asymmetric motivation, and irrational exuberance, as the term used by Alan Greenspan (former chairman of Federal Reserve Bank, U.S.) trigger the shipping investor and they are stumbled by the cash surplus.

This Chapter of dissertation contributes to the literature by investigating the ROE ratio among the last few decades, and discusses whether the analogy indicates an investment timing signal for future prospects. By a number of regression models, the significance of the ship price factor and its lead-lag durations are tested. Since the ROE series consist of negative numbers, logarithmic transformation could not be applied.

For the empirical study, the monthly data sets between January 1980 and December 2010 (360 data) are collected to analyze ROE for the new building (NB) for Panamax (PM) and Handymax (HM) dry bulk carriers, respectively. In this study, variables for the calculation of ROE, such as time charter (TC) rate, new building ship price, second hand ship price, and London interbank offered rate (LIBOR), are investigated to define the direction of the relationship between them and how they influence each others.

2.1 Irrationality problem on ship management

Since the shipping markets are influenced by both political and economic random factors, the investment analysis in shipping is greatly difficult and it plays a significant role to make a decision before starting investment in shipping as in different industries. In the existing literature, therefore, many colleagues investigate it by using some different methods. The net present value (NPV) is one of the most applied methods for investment analysis and it is also attracted as the applicable for theoretical support in maritime investments (Evans, 1983; Gardner and Gross, 1984). Revenko and Lapkina (1997) investigated the important investment strategy techniques, as well as the factors that influence buying and selling of ships, and they defined the model for the investment policy analysis for a shipping company. In their study, they proposed some different methods which are based on the NPV method for the prediction value of ship and critical time charter rate to recoup the operation cost. However, they did not investigate the accuracy of their proposed method.

In addition, Lun and Quaddus (2009) investigated four different markets in shipping and they explained how these markets affect one another by empirically testing the relationship among the key variables of bulk shipping, such as prices of ships, fleet size, freight rate, and seaborne trade.

After making an investment decision, there may be some alterations that may influence the investment decision because of the dynamic structure of the maritime sector. In order to make those uncertainties more elastic for an investor, Bendall and Stent (2003) suggested the application of Real Option Analysis (ROA) method. In the existing literature, many studies investigate the shipping market for the selection of corporate strategies by using forecasting modelling (Goulielmos and Plomaritou, 2009; Goulielmos et al., 2012).

The irrationality of investors has a growing attention in the economic literature and it is an existing debate for many product and service markets. Irrationality has several forms of existence such as asset stock pricing. Asset (i.e. vessel) price is one of the critical topics of shipping business research and it has a number of contributions to the ship management. Among these implications, the investment timing and market entry/exit decisions are the most important issue since the ship prices vary enormously, which may dramatically change the feasibility of the project. In case of rationality assumption, investors are expected to follow the cycle and place orders recession-downturn period relatively low vessel prices. Then, a market exit can be scheduled for the peak market with a high sale option since the major reason is the high correlation (around 0.80), that indicates the co-trending behaviour between the freight market and the vessel prices (both new building and second hand vessels).

On the other hand, the existing investment sentiments differ from the long term co-trending dynamics (Duru, 2012). Figure 2.1 indicates how the new building contracts dead weight (DWT) are placed with the peak market conditions for Panamax bulk carriers. Herd behaviour exists and the vast number of investors prefers to be in line with the competitors, while placing huge amount of funds with a high level of business risk of losing the value in the short-term. The correlation coefficient between the percentage changes of new building Handymax bulker prices and the time charter rates is over 0.80. The massive downturns are resulting on the loss of asset value.

Figure 2.2 and 2.3 show the relationship between annual percentage changes of vessel prices (NB) and TC rates in Handymax and Panamax size bulkers. In most cases, vessel prices and TC rates have the identical variations, while the latest freight market bubble is more influential in Handymax market.

Figure 2.1 New building ship prices and the number of Panamax size bulk carrier contracting statistics (annual data between 1983 and 2008) (Duru, 2012).

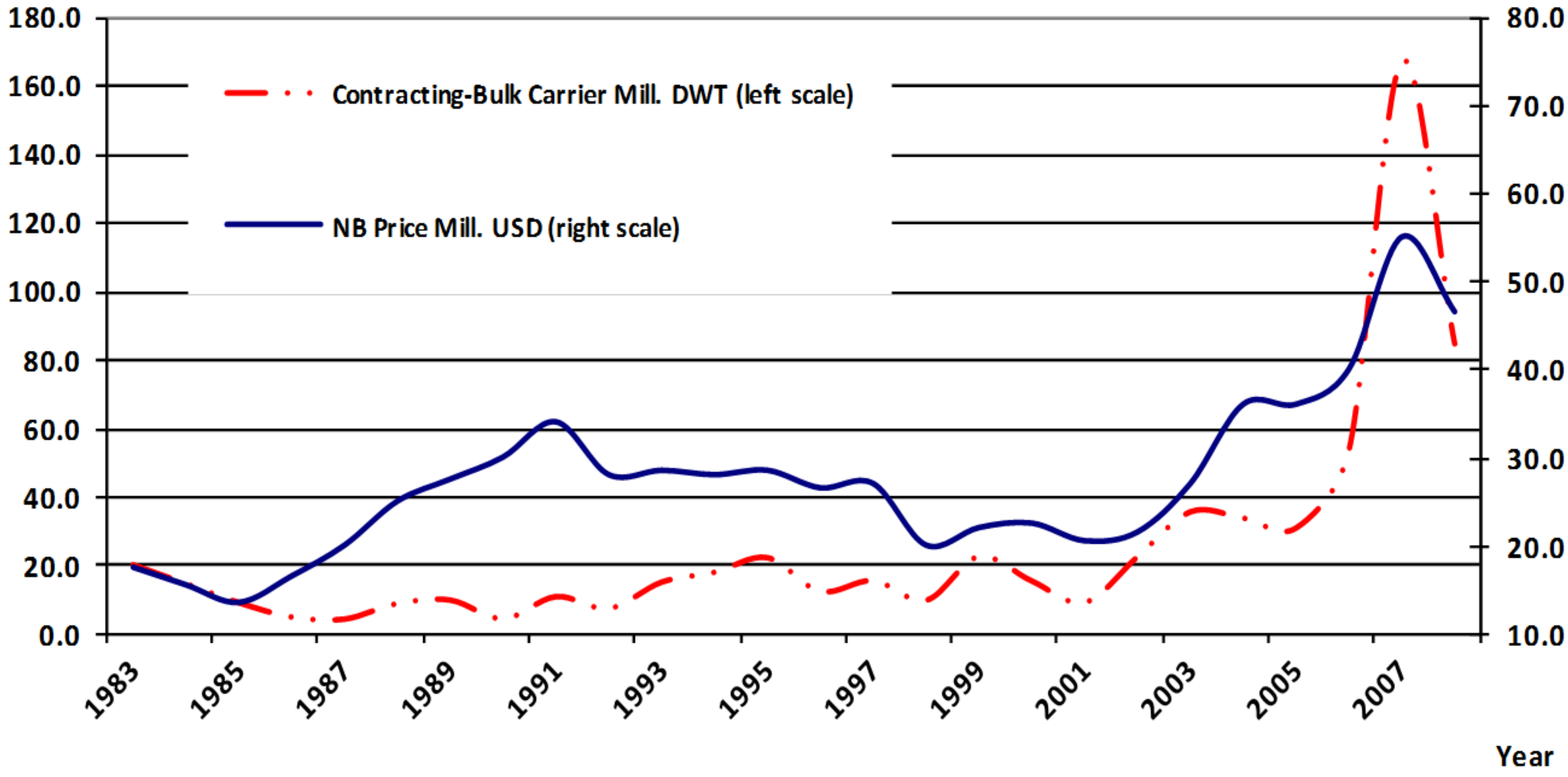


Figure 2.2 Annual percentage changes of new building ship prices and time charter rates in Handymax dry bulkers.

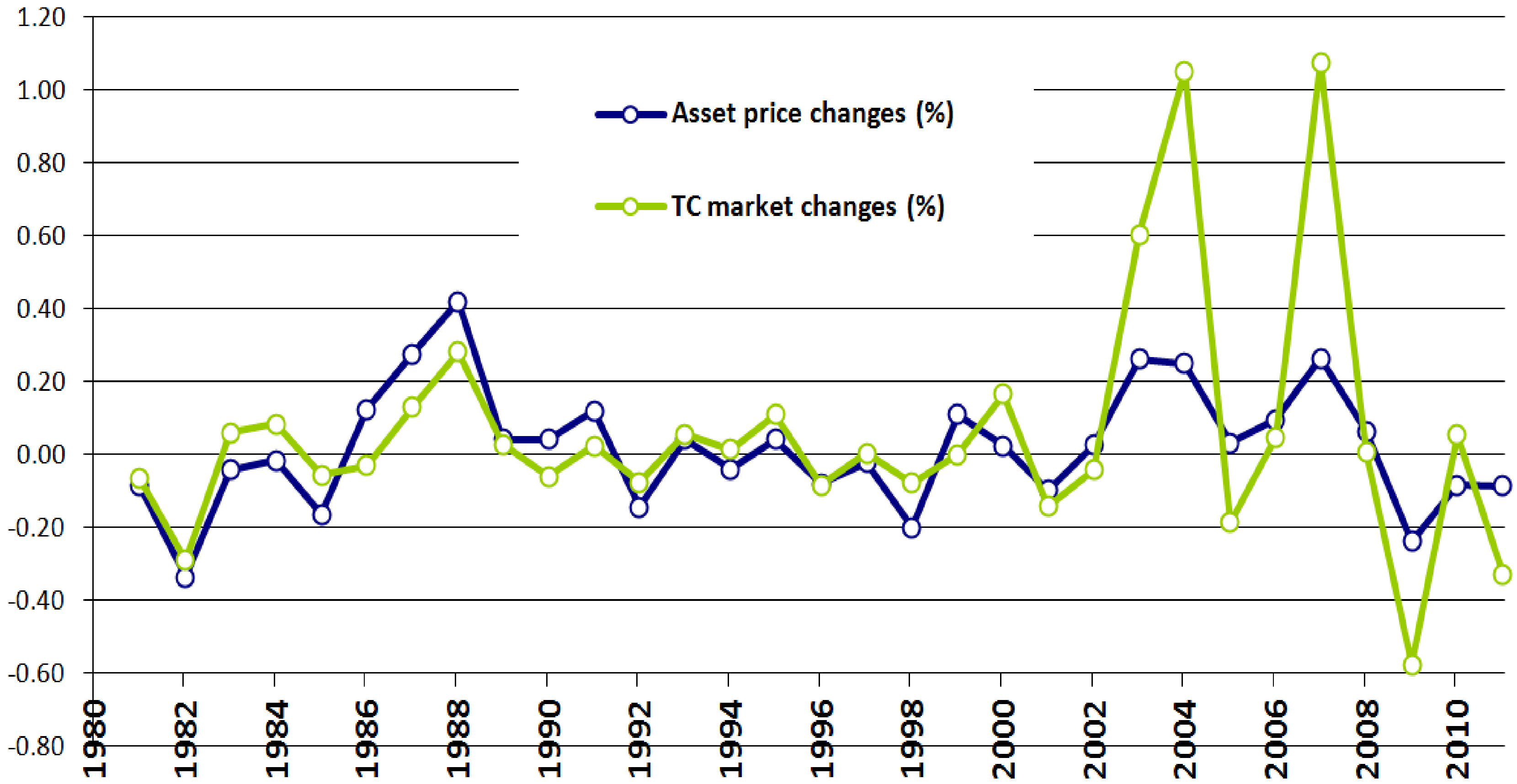
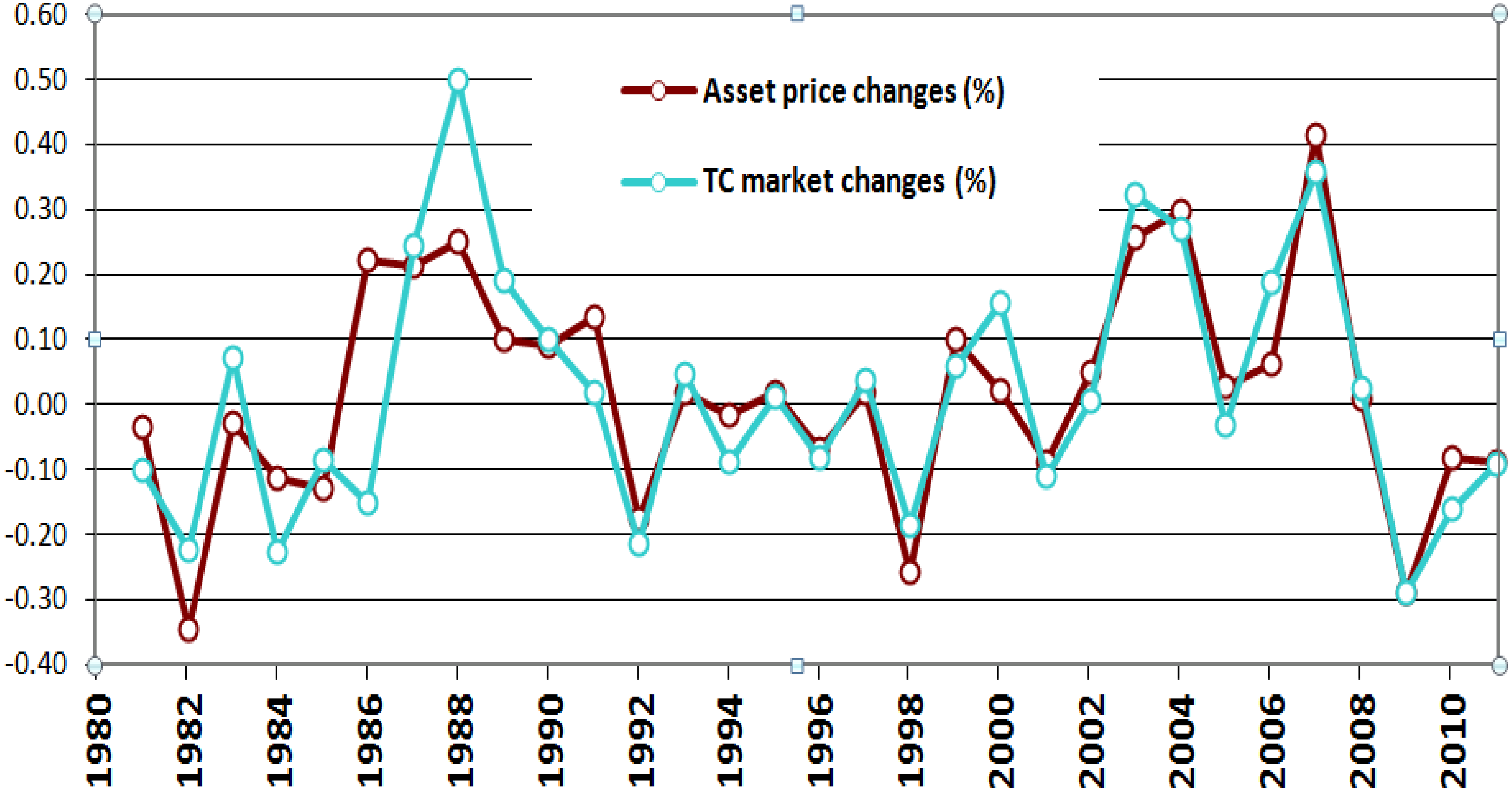


Figure 2.3 Annual percentage changes of new building ship prices and time charter rates in Panamax dry bulkers.



The following Table 2.1 presents the correlation coefficients between contracting volume and ship prices and also TC rates. There is a clear indication that the contracting volume and the presented series are positively correlated and the degree of correlation is over 0.85 in many cases. Both graphical and numerical investigations indicate that the investors are irrational to the existing market record and led by some other factors, such as cash abundance, convenience of commercial loans, low interest rates, and herd behaviour.

Table 2.1 Correlation matrix between contracting volume, ship prices and T/C rates (1980-2011).

	Contracting Volume	
	Handymax	Panamax
New building	0.79	0.74
Second hand 5 yrs	0.85	0.85
Second hand 10 yrs	0.81	0.87
Second hand 15 yrs	0.85	0.88
Time charter rates	0.87	0.86

For eliciting the particulars of irrational behaviour, the time lags of ship price factor are investigated under the variety of ROE projections by maximising R-square value (minimising AIC correspondingly).

2.2 Methodology

The particulars of irrational behaviour and significance of the time lag between the profitability ratio and ship prices are tested in a number of models. The ROE value is calculated according to the assumptions for funding, delivery, operating term, and cost structure. The intended procedure is indicated in three phases:

2.2.1 Phase 1: Scenario assignment

In the prepared scenario, an empirical study is performed by considering two different projects based on two different candidate ships, Panamax (75.000-DWT) new building dry bulk carrier, Handymax (50.000 DWT) new building dry bulk carrier. One cycle in the shipping market is usually completed itself every ten or less than ten years (Stopford, 2009). In this study, however, the duration of project, ω, is considered in different periods from four to sixteen years because the entrepreneur can operate his/her ship less or more than the circle period. The new order for ships is assumed to be two years early before delivery.

Reference Leverage of bank financing is assumed at 70% for all scenarios and the owner's equity would be 30% (Revenko & Lapkina, 1997; Stopford, 2009). For the new building ships, the scheduling owner's contribution is divided in two steps. First one is considered to pay after contracting and remaining amount of equity would be paid before delivery. The owner is also responsible for the additional costs, such as the brokers' commission, initial supply of the ship before operating, and other purchasing costs. They are considered 10% of asset value.

For the NPV calculation, the average of the LIBOR in duration of project is assumed as a discounting rate and its rate of each year with 1% risk premium is calculated for a loan amortization (average ratio between 2% and 5%) (Botosan & Plumlee, 2005). For the duration of project more than eight years, the credit of bank financing including identical settlements and an interest is refunded in 8 years using semi-annually payment schedule after delivery. However, if the vessel is planned to resale before completing the loan amortisation, it is considered that the owner completes all loan amortisation before reselling of vessel. The monthly data sets between January 1980 and December 2010 are collected to analyze ROE by using several data sources such as Clarkson Shipping Review and Outlook, and Fearnleys weekly report.

2.2.2. Phase 2: Method for ROE calculation

In the shipping finance, operating profits are provided from time-charter or spot market. In the spot market, the owner is responsible for all expenses, while the operating cost in the time charter does not include the voyage cost, such as bunkers, port dues, and commission. In this paper, we use time charter rates as an indicator of profits for two reasons. First, time-charter rates represent the net earnings from chartering activities of the vessel. Second, time-charter rates can display information about future earnings of the ship because they are used for a particular period for hiring (Alizadeh & Nomikos, 2007; Kavussanos & Alizadeh-M, 2002). In general, the ship cannot be operated (off hire) 10 or 20 days because of periodic maintenance per year; hence, the calculation of operation cost is based on the assumption that the ship is available for 350 days a year.

In the financial assessment of an investment project, the NPV method is one of the most applied methods to compute the cumulative profit which is gained from all operations. An overall profit plays a significant role for the investor to compare all investments with each other but the NPV method cannot display a rate of profitability. Therefore, a Return on Equity (ROE) that is the ratio of net profit is principally used for accounting how much investment project generates a profit from the initial capital (Bulut et al., 2012). The calculation of ROE is as follows;

$$ROE = \frac{NPV}{E} \qquad \text{(eq.2.1)}$$

where E is owner's equity and the calculation of NPV for the ship investment is as follows;

$$NPV = \sum_{t=1}^{\omega} \frac{CF_t + SH_t - G_t - E_t}{(1+i)^t} \qquad \text{(eq.2.2)}$$

where CF_t is the cash flow from the ship operating in year t: SH_t is the second hand selling price: G_t is the remaining loan amortisation before reselling ship: i is the discount rate which is calculated as an average of the LIBOR rate in the duration of project and ω is the operating life of ship. If the duration of project is less than a refunded period (eight years) of loan amortisation, it is assumed that the owner already completes all loan amortisation before the resale of ship.

$$CF_t = TC_t - P_t - C_t \qquad \text{(eq.2.3)}$$

where TC_t is time-charter rates; P_t is the operation cost and C_t is the capital expenses.

$$C_t = \sum_{t}^{n} \left[\left(\frac{0.7NB}{16}\right) + (L_t * i_t) \right] \quad (t=1, 2, 3, ..., n) \qquad \text{(eq.2.4)}$$

where NB is new building ship price and L_t is the loan amount that is 70% of ship value.

2.2.3 Phase 3: Model estimation

This study is based on the hypothesis which is related to define entry and exit decision for the dry bulk shipping market. The ROE is one of the best indicators for the owner whether to enter market or not, and it is calculated according to the scenario as mentioned above.

The ROE, therefore, is the dependent variable in the regression model and its correlation between other variables (TC rate, NB price, SH price for five and ten years old Handymax and Panamax ships, order-book volume (OV), and contracting volume (CV)) is investigated to define independent variable(s). Table 2.2 and Table 2.3 display that the correlations between almost all variables are higher than 0.80. If two explanatory variables are highly (or nearly so) correlated, multicollinearity problem has occurred in a regression model. The coefficient estimations may change erratically in response to small changes in the model (Farrar & Glauber, 1967) and the stability of the regression coefficients is affected unstably and unreliably by multicollinearity (Makridakis et al., 1998). Multicollinearity is not a problem unless either (i) the individual regression coefficients are of interest, or (ii) the regression model is isolated by the contribution of one explanatory variable to dependent variable, without the influence of other explanatory variables.

Table 2.2 Correlation between variables for Panamax.

	ROE	NB	SH5yrs	SH 10yrs	TC	OV	CV
ROE	1	<u>**0.78**</u>	0.73	0.46	0.60	0.16	0.31
NB		1	0.95	0.94	0.89	0.84	0.74
SH-5yr			1	0.95	0.95	0.92	0.85
SH10yr				1	0.94	0.90	0.87
TC					1	0.95	0.86
OV						1	0.88
CV							1

Table 2.3 Correlation between variables for Handymax.

	ROE	NB	SH5yrs	SH 10yrs	TC	OV	CV
ROE	1	<u>**0.55**</u>	0.52	0.43	0.34	0.20	0.13
NB		1	0.96	0.95	0.88	0.82	0.79
SH-5yr			1	0.98	0.94	0.91	0.85
SH10yr				1	0.95	0.94	0.81
TC					1	0.96	0.85
OV						1	0.87
CV							1

The new building price data set that has higher significance than other variables is used as the independent variable to preclude from muticollinearity problem and the equations of regression model are as follows:

$$RH_{\omega} = \alpha H_{t-\gamma} + u_{RH,t} \qquad \text{(eq.2.5)}$$

$$RP_{\omega} = \alpha P_{t-\gamma} + u_{RP,t} \qquad \text{(eq.2.6)}$$

where RH is the ROE of HM ship; H is the Handymax new building price; RP is the ROE of PM ship; P is the Panamax new building price; γ represents the time lag when the R-sqrd value is higher than other operation period and u is the white noise error term.

The iteration of time lag (γ) from γ=2 to γ=12 of independent variable is analysed to find the highest R-sqrd value and the lowest Akaike information criterion (AIC), and it is computed for each project duration (ω). For instance, Fig. 2.4 shows that the time lag γ=11 is found for the highest R-sqrd and the lowest AIC for ω=4 in Panamax size.

Figure 2.4 Instance of the highest R-qrd (right-hand side) and the lowest AIC (left-hand side) (ω=4).

The unit root test based on Augmented Dickey-Fuller (Dickey & Fuller, 1979) is used for raw data to ensure to be stationary and it is seen that the raw data of NBP and all ROE series are stationary. Table 2.4 displays the stationary test for data set of NBP and ROE of HM and PM ships.

Table 2.4 Unit root test for data set of ROE and NBP of HM and PM (01M1980 – 12M2010).

	Handymax Levels		Panamax Levels	
	ROE	NBP	ROE	NBP
t-statistics (*)	-4.65 (*0.00*) *	-4.53 (*0.00*) *	-6.15 (*0.00*) *	-7.33 (*0.00*) *
1% level	-4.46	-4.33	-4.46	-4.32
5% level	-3.64	-3.58	-3.64	-3.58
10% level	-3.26	-3.22	-3.26	-3.22
**p*-value.				

2.3 Empirical results and discussion

The value of ROE is calculated for 13 different projections (between 4 and 16 years of operation) and the models are estimated to ensure maximum R-square value. Descriptive variable is the new building ship price and the time lag structure is based on maximum R-square value of significant models*.

There are two particular points of the empirical results. First, there is a time lag between new building prices and the ROE, and the coefficient of new building price is positive which indicates that the conventional market entry estimations are significantly out of the statistical evidence. Since ship-owners tend to place orders on high prices (peak market conditions), the existing tradition cannot be confirmed with

* In some cases, significance can not be ensured, then the most significant estimation is presented (e.g. w=4 and w=5 year ROE in Handymax bulk carrier).

the market analogies of the last few decades. It is clear that the demand for new ships (contracting volume) and ship prices are closely related, and prices are based on the existing demand. On the other hand, ship-owners still tend to place orders, while market is already at peak. Such irrational perceptions are also addressed for other product markets, and particularly the cash abundance triggers the over-supply and impatience.

Another result of this study is the period of prepositive time lag. Shimojo (1979) developed a model for the freight market fixtures and first used the term "prepositive term" to state the impacts of time lag between contracting time and the shipment. In this study, the prepositive term is found for market entry by the assessment of new building prices and the ROE. The empirical results point two prepositive terms of market entry: around 10 years for 6 years of operation periods and 4 years for 12 years of operation periods (Table 2.5 and 2.6). The differences between these indications are based on the existing market cycles of shipping business. Six years-operation is based on an order at low price and a sale of ship at high price of the subsequent peak market. On the other hand, 12 years-operation is oriented for an order at low price holding the vessel till the next peak market. These interpretations are based on the average cycle terms (Stopford, 2009). It is considered that the results indicate the market entry according to the new building price of few years ago. The time lags of new building prices state that ship-owner should follow the asset prices and be patient till the market declines completely. Once the market declines, then an investor can easily define the peak point (high ship price) and the prepositive term by adding related time lag (10 years or 4 years according to the projection of ship operation). As seen in Figure 2.5 and 2.6, these time lags usually point the time of lower vessel prices for contracting, and the corresponding projection term points to the optimum time market exit (6 or 12 years after the contract. Delivery is estimated in two years).

The proposed approach investigates the lead-lag relationships between ROE and the new building price, and it does not deal with other possible explanatory variables. Therefore, the presented results will be based on the maximum R-sqrd value among different lag structures, even if it is found very low at maximum. For example, maximum R-sqrd value is 0.23 in Fig. 4. Such kind of results may indicate that the model needs additional explanatory variables, while the structure of new building price is found as presented. For future research, one may estimate models with other potential indicators. On the other hand, the existing results are still proper for investigation of irrationality on investment timing. Since the mainstream investors prefer peak market for purchasing vessels, the estimation results indicate that the traditional perspective is not rational, which is not expected for profit maximisation.

Figure 2.5 The highest *R*-sqrd and the lowest AIC for each operation period of Handymax.

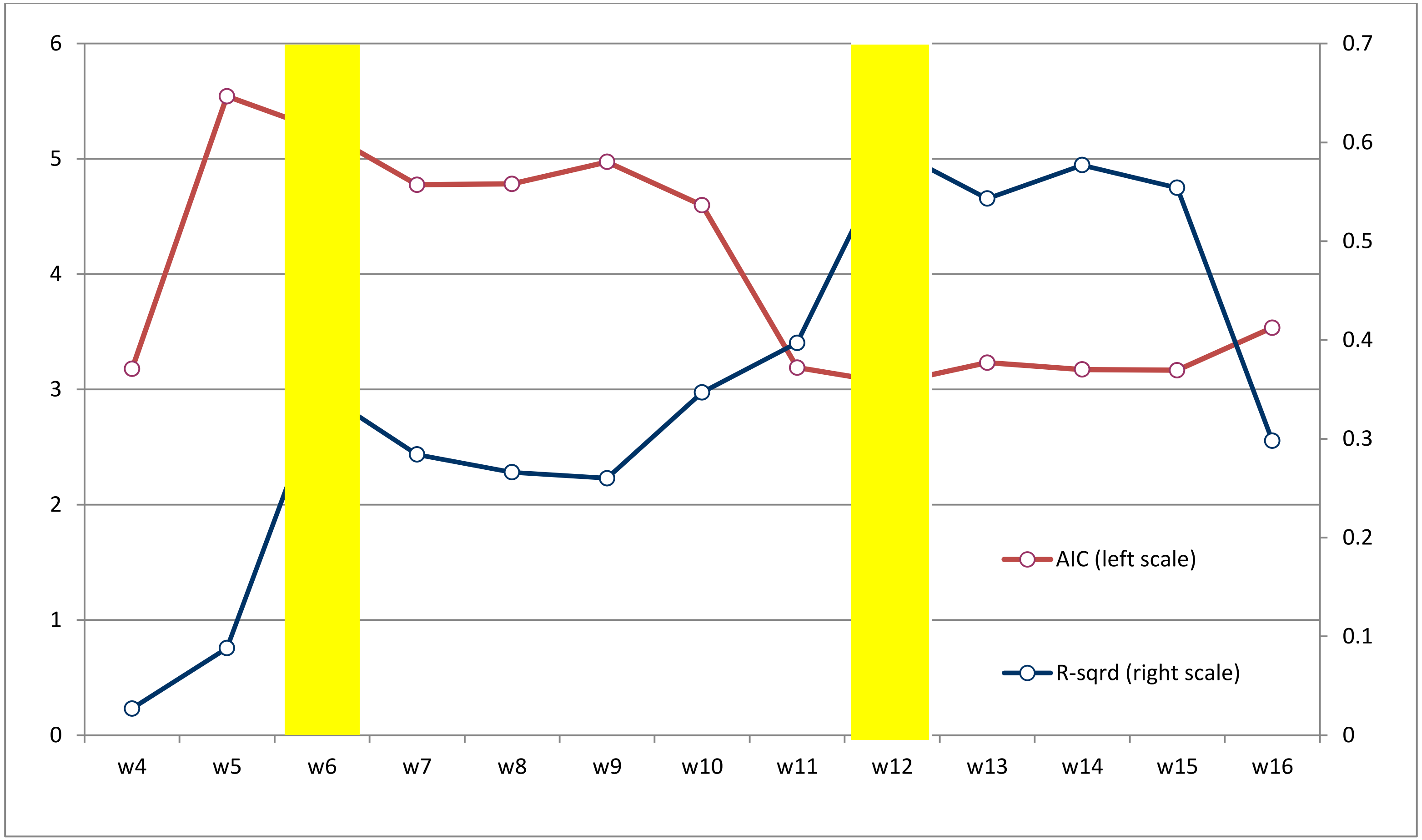


Figure 2.6 The highest *R*-sqrd and the lowest AIC for each operation period of Panamax.

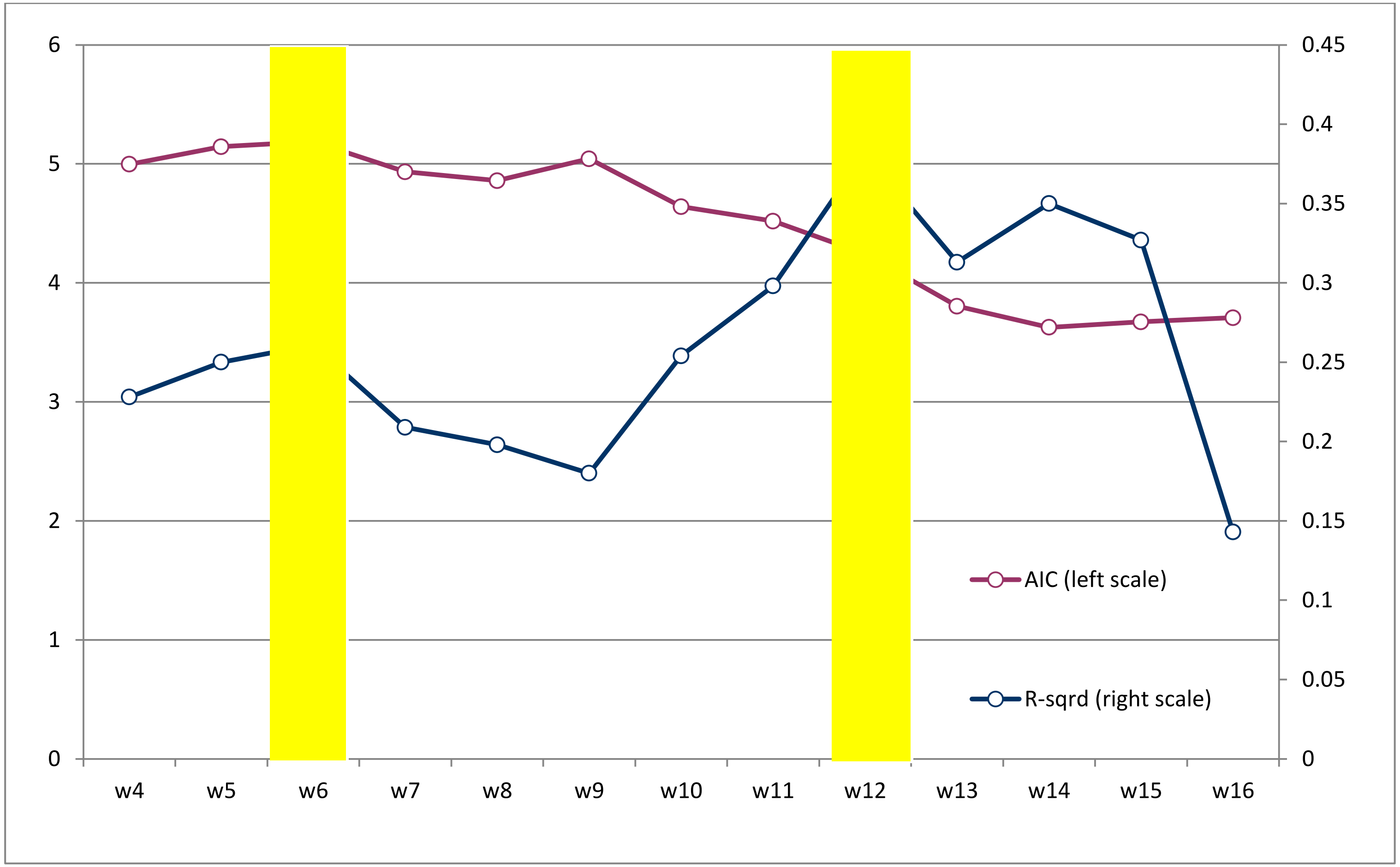


Table 2.5 The investment timing assessment on different ROE projections – Handymax.

$$RH_{\omega} = \alpha H_{t-\gamma} + u_{RH,t}$$

	ω =4 γ=5	ω=5 γ=5	ω=6 γ=10	ω=7 γ=9	ω=8 γ=8	ω=9 γ=9	ω=10 γ=5	ω=11 γ=4	ω=12 γ=4	ω=13 γ=4	ω=14 γ=4	ω=15 γ=3	ω=16 γ=3
α	0.017*	0.143*	0.212*	0.156*	0.140*	0.149*	0.145*	0.088*	0.143*	0.105*	0.138*	0.167*	0.176*
S.E.	0.016	0.037	0.037	0.033	0.032	0.036	0.026	0.015	0.018	0.017	0.015	0.015	0.019
t-stat	1.060	3.776	5.744	4.701	4.372	4.069	5.473	5.565	7.950	6.188	9.202	11.07	9.242
P-value	0.305	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.027	0.088	0.347	0.284	0.266	0.260	0.347	0.397	0.593	0.543	0.577	0.554	0.298
S.E.	1.150	3.795	3.265	2.573	2.583	2.842	2.354	1.156	1.312	1.242	1.148	1.143	1.371
Log-likelihood	-24.42	-71.06	-61.94	-49.13	-49.21	-51.22	-47.26	-24.51	-26.54	-25.66	-25.96	-24.33	-25.50
DW[a]	0.379	0.344	0.316	0.290	0.378	0.340	0.154	0.651	0.628	0.794	0.767	0.850	0.755
AIC[b]	3.177	5.543	5.245	4.775	4.782	4.973	4.597	3.189	3.052	3.232	3.172	3.166	3.534
SIC[c]	3.226	5.591	5.294	4.824	4.832	5.023	4.646	3.238	3.121	3.281	3.221	3.215	3.581
J-B Normality[d]	0.993	15.06	6.744	5.065	5.466	3.639	3.581	1.160	2.459	2.748	1.207	0.340	0.657
p-value	0.608	0.000	0.034	0.079	0.065	0.162	0.166	0.559	0.292	0.253	0.546	0.843	0.719
LM test[e] (F-test)	10.50	27.05	28.06	26.11	24.41	17.71	49.09	4.499	6.910	5.220	2.793	2.152	3.235
p-value	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.009	0.217	0.095	0.155	0.075
ARCH[f] (F-test)	3.212	8.987	4.378	38.67	6.983	1.481	34.32	0.012	4.054	0.167	0.002	0.000	0.005
p-value	0.096	0.006	0.048	0.000	0.016	0.239	0.000	0.912	0.065	0.689	0.958	0.994	0.941

* Significant at the 1% level.
[a] Durbin-Watson statistics (1950).
[b] Akaike Information Criterion (1974).
[c] Schwarz Bayesian Information Criterion (1978).
[d] J-B Normality is the Jarque-Bera (2004) normality test, with probability values in square brackets.
[e] Serial Correlation LM test (Breusch, 1978; Godfrey, 1978).
[f] ARCH is the Engle's (1982) *F* test for Autoregressive Conditional Heteroskedasticity.

Table 2.6 The investment timing assessment on different ROE projections – Panamax.

$$RP_{\omega} = \alpha P_{t-\gamma} + u_{RP,t}$$

	ω=4 γ=11	ω=5 γ=11	ω=6 γ=10	ω=7 γ=9	ω=8 γ=8	ω=9 γ=7	ω=10 γ=5	ω=11 γ=5	ω=12 γ=4	ω=13 γ=4	ω=14 γ=4	ω=15 γ=4	ω=16 γ=3
α	0.109*	0.132*	0.138*	0.104*	0.093*	0.088*	0.095*	0.104*	0.121*	0.073*	0.083*	0.110*	0.110*
S.E.	0.025	0.027	0.028	0.027	0.025	0.027	0.022	0.021	0.019	0.015	0.015	0.016	0.016
t-stat	4.223	4.761	4.888	3.766	3.616	3.197	4.325	4.838	6.357	4.660	5.504	6.815	6.629
P-value	0.000	0.000	0.000	0.001	0.001	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.228	0.250	0.261	0.209	0.198	0.180	0.254	0.298	0.382	0.313	0.350	0.327	0.143
S.E.	2.884	3.105	3.170	2.786	2.684	2.944	2.408	2.262	1.968	1.577	1.44	1.472	1.495
Log-likelihood	-58.96	-60.73	-61.23	-50.80	-50.02	-51.96	-47.74	-44.19	-39.31	-33.23	-29.82	-28.38	-26.80
DW[a]	0.354	0.333	0.277	0.241	0.346	0.345	0.127	0.371	0.289	0.445	0.485	0.576	0.353
AIC[b]	4.997	5.144	5.186	4.933	4.859	5.043	4.641	4.519	4.243	3.804	3.626	3.672	3.707
SIC[c]	5.046	5.193	5.235	4.983	4.909	5.093	4.691	4.569	4.293	3.853	3.675	3.721	3.754
J-B test[d]	10.07	7.178	6.220	12.63	10.34	9.334	4.842	6.803	8.049	2.756	1.984	2.109	1.463
p-value	0.006	0.027	0.044	0.001	0.005	0.009	0.088	0.033	0.017	0.251	0.370	0.348	0.481
LM test[e] (F-test)	21.27	25.01	27.58	31.26	23.95	16.02	54.55	16.43	17.28	8.075	6.236	4.874	8.206
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.011	0.026	0.005
ARCH[f] (F-test)	5.147	6.582	3.254	82.24	8.428	1.320	40.62	2.391	3.002	0.018	0.227	0.000	3.862
p-value	0.033	0.018	0.085	0.000	0.009	0.265	0.000	0.140	0.102	0.893	0.640	0.988	0.072

* Significant at the 1% level.
[a] Durbin-Watson statistics (1950).
[b] Akaike Information Criterion (1974).
[c] Schwarz Bayesian Information Criterion (1978).
[d] J-B Normality is the Jarque-Bera (2004) normality test, with probability values in square brackets.
[e] Serial Correlation LM test (Breusch, 1978; Godfrey, 1978).
[f] ARCH is the Engle's (1982) F test for Autoregressive Conditional Heteroskedasticity.

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Chapter 3

Ship Investment Decision

Transportation is of prime importance in the world trading activities and maritime transportation has a special niche in the transport industry. In recent figures, maritime transport is around 90% of import-export transportation. For example, the most important industrial product of the world, steel, is provided of two major raw materials, iron ore and coal. Both raw materials are mainly transferred from several exporting countries by dry bulk ships. Economic growth and increase of shipping services are parallel issues since most of the world's surface is covered by waterways. Therefore, maritime transportation is a critical part of global economy.

The cost of maritime transport named freight rate is included in the price of the products and the shipping price fluctuations directly affect retail price levels. In the period 2003-2008, the enormous upturn of freight rates was caused by the limited shipping fleet under the rapid development in the financial climate. The price of a single route shipment increased ten times over prices of the year of 2003. In conventional economic analysis, shipping price plays a critical role and is used as a leading indicator ("Hurting the real economy", *The Economist*, October 15th, 2008; Israely, 2009).

Particularly in the rapid growth of the world economy, shipping capacity is more important and a certain size of ship has advantages on employment and profit margins. An investor is basically asked to define the characteristics of his ship. The ship size is one of the critical dimensions of ship investment. Investors have three optional entry strategies: building a new vessel, purchasing a second hand hull or hiring an existing vessel for a period of time. In practice in the shipping business, charterers of ships are large-scale industry players or their intermediaries. A shipping investor usually tends to purchase a new construction or an existing vessel. A new building option has a long delivery procedure and prices will be higher. Conversely, a second hand ship can be purchased in a reasonable term with cheaper prices. Differences between prices and delivery dates are composed of the main concern of the ship selection problem in the shipping industry.

Shipping services are classified as either dry cargo shipments or wet cargo shipments. Dry cargoes are carried by dry bulk carriers; container ships, etc., while wet cargoes are transferred by tanker ships. The concern of the present study is the dry bulk shipping industry and sample projects are selected from the dry bulk vessel. According to potential cargo sizes, routes, and service capabilities, dry bulk carriers are classified by their tonnage capacities. Tonnage classes are usually divided as follows: Capesize bulker (over 80,000 deadweight-DWT), Panamax bulker (around 80,000-60,000 DWT), Handymax bulker (60,000-45,000 DWT), and Handysize bulker (45,000-10,000 DWT). Sample projects are selected from Panamax and Handymax size vessels. The reason for this selection is based on convenience of data collection, interactions of similar cargoes (competitiveness exists to some degree), and closeness of vessel prices, among others.

3.1 Definition of the criteria and alternatives

Under the fuzzy analytic hierarchy process (FAHP) framework, several criteria and alternatives are defined by an expert consultation and the industrial survey. Table 3.1 shows the major criteria which have selective capabilities (Duru, Bulut, & Yoshida, 2012). These criteria can be classified into two groups: Financial features and technical features.

Table 3.1 The criteria for the ship asset selection and their symbols.

Criterion of the ship asset selection	Symbols of each criterion
Return on equity	*RE*
Loss probability (FMC)	*LP*
Fuel consumption	*FC*
Loaded draught	*LD*
Ship's speed	*SS*
Cargo crane existence	*CE*

An extended discussion of the ship investments and the criteria for the vessel selection are performed in Bulut *et al.* (2012) and Duru *et al.* (2012). In the financial assessment of an investment project, one of the most used indicators is the return rate of the invested equity. Every investment project has its own profit expectations and a marginal return on equity is required over the risk free alternatives of the capital markets. Return on equity (ROE) is the ratio of net profit/deficit over the invested equity except financial aids, loans etc. The calculation of ROE is based on the scenario stated in Chapter 2. Another financial indicator is the loss probability of the project under the Monte Carlo Bayesian simulation model. Duru *et al.* (2010) first developed the fuzzy-Monte Carlo simulation method and applied it to the assessment of shipping assets and their financial support particulars. One of the outcomes of that study is the loss probability value that is the ratio of deficits in the simulation. Fuel consumption is a financial concern, but it is also partly a technical feature. Since the majority of the operational cost of a merchant ship is based on its fuel consumption, it is usually included in the subjective assessment of the vessel.

Three attributes are involved in the assessment of technical features: loaded draught, navigating speed of the ship, and the availability of a cargo transfer crane. Draught is the vertical height of the underwater part of the ship which differs accordingly loaded or cargo-free. The maximum level of the draught exists in the loaded condition and it defines whether the ship can be accepted at a port or it is limited for specific depth waterways. Speed of the ship defines its service time and cargo crane existence defines whether the ship can operate cargo transfers using its own facilities.

Ship assets are identified in four ways: A new building and a second hand of Panamax size dry bulk carrier, a new building and a second hand of Handymax size dry bulk carrier. Table 3.2 indicates alternative ship projects and their corresponding symbols. The final structure of the FAHP hierarchy is designed as in Figure 3.1.

Table 3.2 The alternatives for the ship selection and their symbols.

Alternatives for the ship investment	Symbols
Panamax new building	*PNB*
Handymax new building	*HNB*
Panamax second hand	*PSH*
Handymax second hand	*HSH*

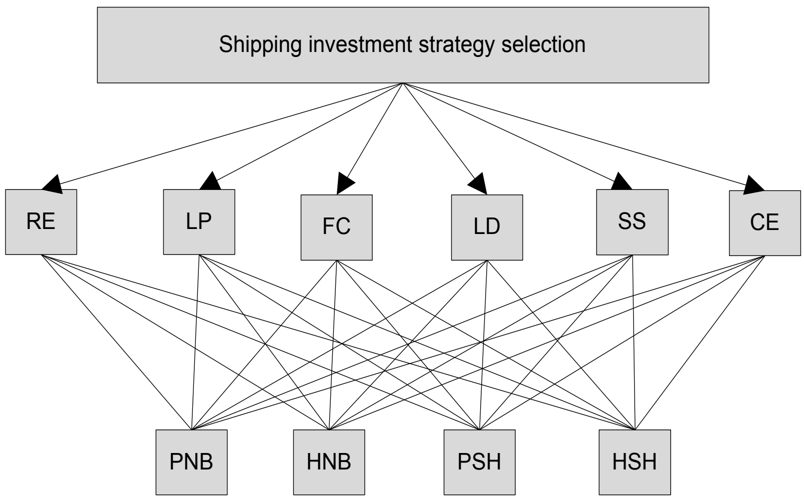

Figure 3.1 Decision hierarchy of ship selection problem.

3.2 Methodology

3.2.1 Fuzzy sets and triangular fuzzy numbers (TFNs)

The fuzzy set theory is developed to cope with the extraction of the principal outcome from a variety of information distantly and roughly (Zadeh, 1965). It is an effective instrument for modeling in the lack of comprehensive and accurate information. The fuzzy set theory is particularly applied in complex business, finance, and management problems. A triangular fuzzy number is a particular fuzzy set Ã, and its membership function $\mu_{\tilde{A}}(x)$ is a continuous linear function. These basic definitions will be used throughout the paper otherwise stated.

Definition 1: Let X be universe of discourse, $\tilde{A}$ is a fuzzy subset of X such that for all x∈X. $\mu_{\tilde{A}}$(x) ∈ [0,1] which is assigned to stand for the membership of x to $\tilde{A}$, and $\mu_{\tilde{A}}(x)$ is called the membership function of fuzzy set $\tilde{A}$.

Definition 2: A fuzzy number $\tilde{A}$ is a convex and normalized fuzzy set of $X \subseteq \mathbb{R}$.

Definition 3: A triangular fuzzy number (TFN) is defined by its basic particulars which is

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < a, \\ (x-a)/(b-a), & a \le x < b, \\ 1, & x = b, \\ (c-x)/(c-b), & b < x \le c, \\ 0, & c < x. \end{cases} \qquad \text{(eq. 3.1)}$$

where a and c are the lower and upper bounds of the fuzzy number $\tilde{A}$, respectively, and b is the midpoint (Fig. 3.2).

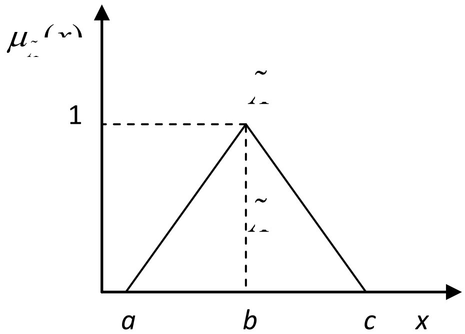

Figure 3.2 A triangular fuzzy number Ã.

The triangular fuzzy numbers (TFNs) are indicated as $\tilde{A}=(a,b,c)$. Consider two TFNs $\tilde{A}_1$ = (a_1, b_1, c_1) and $\tilde{A}_2$ = (a_2, b_2, c_2). Their operational law is as follows (A. Kaufmann & Gupta, 1991):

Fuzzy number addition ⊕:

$$\tilde{A}_1 \oplus \tilde{A}_2 = (a_1,b_1,c_1) \oplus (a_2,b_2,c_2) = (a_1+a_2, b_1+b_2, c_1+c_2) \qquad \text{(eq. 3.2)}$$

Fuzzy number subtraction ⊖:

$$\tilde{A}_1 \ominus \tilde{A}_2 = (a_1,b_1,c_1) \ominus (a_2,b_2,c_2) = (a_1 - c_2, b_1 - b_2, c_1 - a_2) \qquad \text{(eq. 3.3)}$$

Fuzzy number multiplication ⊗:

$$\tilde{A}_1 \otimes \tilde{A}_2 = (a_1,b_1,c_1) \otimes (a_2,b_2,c_2) = (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2) \text{ for the } a_i>0,\ b_i>0,\ c_i>0 \qquad \text{(eq. 3.4)}$$

Fuzzy number division ⊘:

$$\tilde{A}_1 \oslash \tilde{A}_2 = (a_1,b_1,c_1) \oslash (a_2,b_2,c_2) = (a_1/c_2, b_1/b_2, c_1/a_2) \text{ for the } a_i>0,\ b_i>0,\ c_i>0 \qquad \text{(eq. 3.5)}$$

3.2.2 Fuzzy analytic hierarchy process (FAHP)

In order to overcome the deficiency of the fuzziness during decision making, the fuzzy analytical hierarchy process (FAHP) was developed for solving the decision making problems. Laarhoven & Pedrycz (1983) have evolved the AHP into the FAHP by adapting the triangular fuzzy number of the fuzzy set theory the pairwise comparison matrix of the AHP.

Many scholars proposed the FAHP methods for various decision making problems. Leung & Cao (2000) proposed a fuzzy consistency definition with consideration of a tolerance deviation. The fuzzy ratios of relative importance are formulated as constraints on the membership values of the local priorities. The fuzzy local and global weights are determined via the extension principle. The alternatives are ranked on the basis of the global weights by the application of max-min set ranking method. Buckley (1985) determined trapezoidal fuzzy numbers to express the priorities of comparison ratios. Chang (1996) used triangular fuzzy membership value for pairwise comparison and introduced a new approach for handling the FAHP, named "extent synthesis analysis". Lee et al. (1999) reviewed the basic ideas behind the AHP, introduced the concept of comparison interval, and proposed a methodology based on stochastic optimization to achieve global consistency and accommodate the fuzzy nature of the comparison process. Weck et al. (1997) presented a method for evaluating different production cycle alternatives by adding the mathematics of fuzzy logic to the classical AHP.

In the present study, the extent synthesis method of Chang (1996) is preferred as the base method, and the proposed design is developed by supporting consistency control, expert prioritization, and ranking for direct numerical valuations.

Chang (1996) introduced the extent synthesis method as follows:

Let $X=\{x_1, x_2, \ldots, x_n\}$ be an object set and $U=\{u_1, u_2, \ldots, u_m\}$ be a goal set. According to the method of extent analysis, each object is taken and extent analysis for each goal is performed, respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M_{g_i}^1, M_{g_i}^2, \ldots, M_{g_i}^m, \quad i=1, 2, \ldots, n, \qquad \text{(eq. 3.7)}$$

where all the M_g^j ($j=1,2,\ldots,m$) are TFNs.

The steps of Chang's extent analysis can be given as the following:

Step 1: The value of fuzzy synthetic extent with respect to the *i*th object is defined as

$$S_i \sum_{j=1}^{m} M_{g_i}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} \qquad \text{(eq. 3.8)}$$

To obtain $\sum_{j=1}^{m} M_{g_i}^{j}$, the fuzzy addition operation of *m* extent analysis values for a particular matrix is performed such as:

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j , \sum_{j=1}^{m} m_j , \sum_{j=1}^{m} u_j \right) \qquad \text{(eq. 3.9)}$$

And to obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1}$, the fuzzy addition operation of $M_{g_i}^{j}$ *(j=1, 2,…, m)* values is performed such as:

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{i=1}^{m} l_j , \sum_{i=1}^{m} m_j , \sum_{i=1}^{m} u_j \right) \qquad \text{(eq. 3.10)}$$

and then the inverse of the vector in Eq. (3.10) is computed such as:

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i} , \frac{1}{\sum_{i=1}^{n} m_i} , \frac{1}{\sum_{i=1}^{n} l_i} \right). \qquad \text{(eq. 3.11)}$$

Step 2: The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as

$$V(M_2 \geq M_1) = \sup_{y \geq x} \left\lfloor \min(\mu_{M_1}(x), \mu_{M_2}(y)) \right\rfloor \qquad \text{(eq. 3.12)}$$

and can be expressed as follows:

$V(M_2 \geq M_1) = hgt\,(M_1 \cap M_2)$

$$= \mu_{M_2}(d) = \begin{cases} 1, & if \quad m_2 \geq m_1, \\ 0, & if \quad l_1 \geq u_2, \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise. \end{cases} \qquad \text{(eq. 3.13)}$$

Fig. 3.3 illustrates Eq. 3.13 where d is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2}. To compare M_1 and M_2, we need both the values of V $(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.

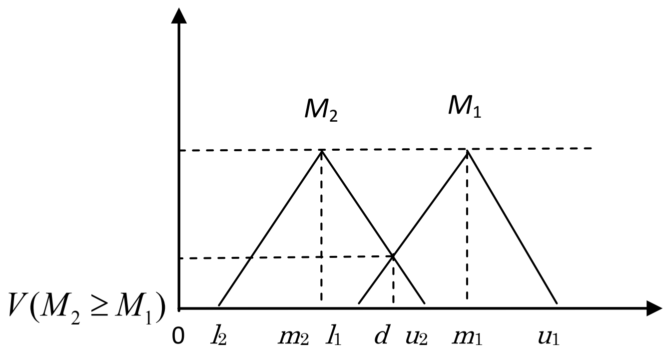

Figure 3.3 The intersection between M_1 and M_2.

Step 3: The degree possibility for a convex fuzzy number to be greater than k convex fuzzy $M_i\,(i=1,2,\ldots,k)$ numbers can be defined as:

$$V(M \geq M_1, M_2, \ldots, M_k) = V[(M \geq M_1) \; and \; (M \geq M_2) \; and \ldots and \; (M \geq M_k)]$$
$$= \min \; V(M \geq M_i),\ i=1,2,3,\ldots,k. \qquad \text{(eq. 3.14)}$$

Assume that $d(A_i) = \min V(S_i \geq S_k)$ for $k=1,2,\ldots,n; k\neq i$.. Then the weight vector is given by:

$$W' = (d'(A_1), d(A_2),\ldots,d(A_n))^T \quad \text{(eq. 3.15)}$$

where A_i ($i=1, 2,\ldots, n$) are n elements.

Step 4: Via normalization, the normalized weight vectors are

$$W = (d(A_1), d(A_2),\ldots,d(A_n))^T, \quad \text{(eq. 3.16)}$$

where W is a non-fuzzy number.

Figure 3.4 presents the evaluation scale for the linguistic comparison terms, and Table 3.3 indicates their equivalent fuzzy numbers in this paper (Bulut, et al., 2012; Dağdeviren & Yüksel, 2008; Duru, et al., 2012).

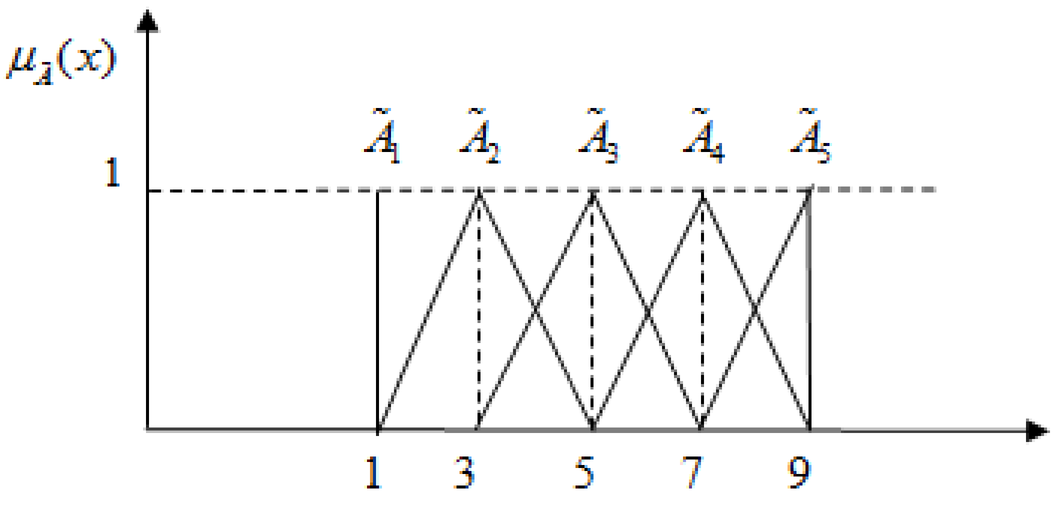

Figure 3.4 Fuzzy number of linguistic variable set.

Table 3.3 Membership function for the TFNs.

Fuzzy number	Linguistic scales	Membership function	Inverse
$\tilde{A}_1$	Equally important	(1,1,1)	(1,1,1)
$\tilde{A}_2$	Moderately important	(1,3,5)	(1/5,1/3,1)
$\tilde{A}_3$	More important	(3,5,7)	(1/7,1/5,1/3)
$\tilde{A}_4$	Strongly important	(5,7,9)	(1/9,1/7,1/5)
$\tilde{A}_5$	Extremely important	(7,9,9)	(1/9,1/9,1/7)

3.2.3 Design of proposed method (RS-FAHP)

The present study proposes a novel FAHP procedure named regime switching FAHP (RS-FAHP), by extending the conventional method with centric consistency index control, prioritization of expert contribution and providing a ranking method for the use of numerical inputs without expert consultation (Bulut, et al., 2012; Duru, et al., 2012). The proposed method is applied to both the ship investment strategy selection in this chapter and the ship management and crew strategy problem in the next chapter (Chapter 4). In Figure 3.5, the procedure of the RS-FAHP method is indicated in the stepwise progress.

The motives for the development of RS-FAHP are based on a number of drawbacks existing in the traditional AHP and the former FAHP procedures. First, the classical AHP method is unable to execute uncertain consultations and requires a unique, single and crisp valuation for each pairwise priority choice. The FAHP is previously proposed to deal with the decision uncertainty and the individual bias on the execution of minor increments (Chang, 1996). Priority scale clustering in the FAHP ensures the elimination of such drawbacks.

Second, the conventional use of the FAHP is not intending the distinction of expertise. Chiclana et al. (1998) suggested individual priority segmentation and construction of an aggregated decision matrix by a weighting algorithm. The RS-FAHP originally combines a decision maker weighting algorithm (*lambda* coefficient) and the classical FAHP as the proposed method.

Third, both the classical AHP and the fuzzy extended version is not investigated and improved for direct numerical inputs. In many selection problems, the analyst has some numerical measurements, and some qualitative factors also exist. Therefore, the analyst tends to use the AHP to investigate selection under qualitative aspects of the problem. However, numerical indications have their specific importance and both numeric and non-numeric factors are a part of the whole problem.

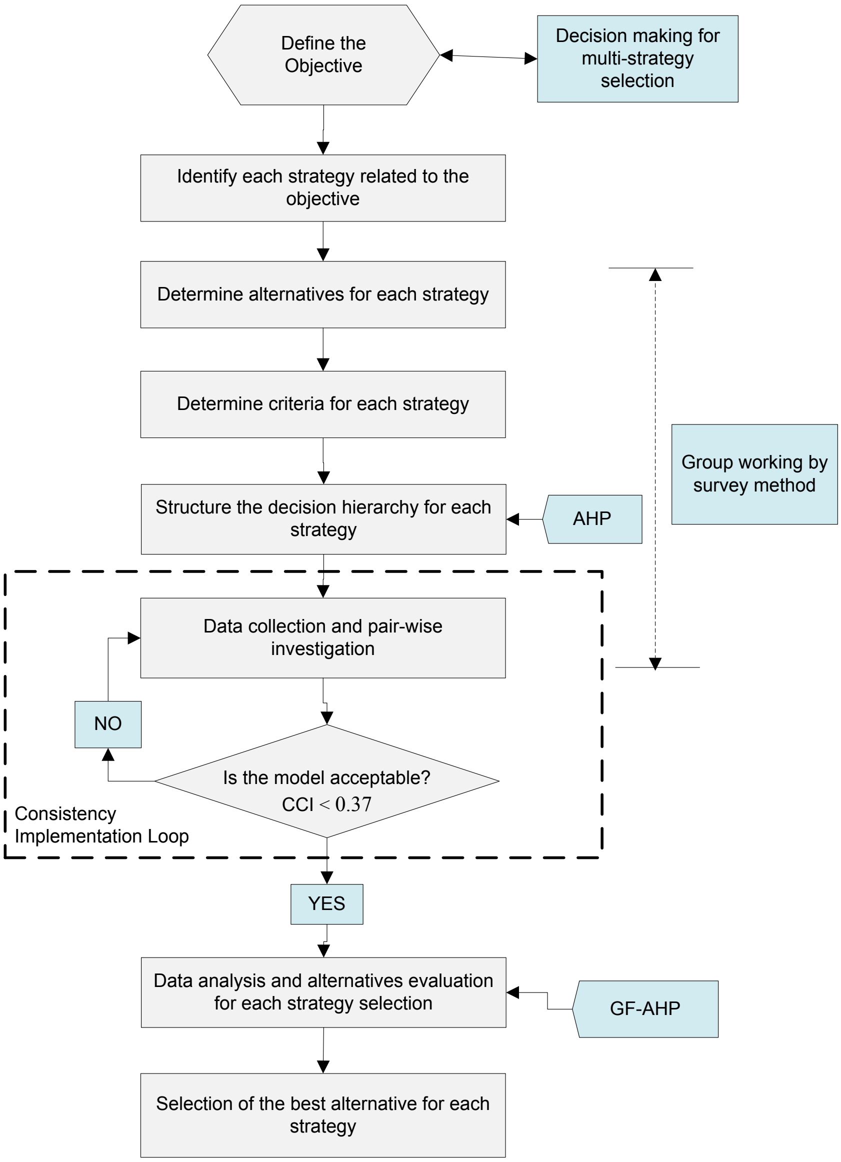

Figure 3.5 RS-FAHP procedure.

A hybrid solution is an inclusion of numeric criteria in the AHP design. Saaty (2008) referred to the ranking method as an alternative for pairwise comparisons. Rather than expert consultation, the RS-FAHP method proposes to use the ranking method for numeric estimations. The result of a ranking process is adequate as a priority indication. An extended discussion is inserted in section 4.1.

Fourth, many FAHP studies do not report any control of consistency on decision matrices. However, Saaty (1980) presented the AHP with its fundamental consistency measure. Since the validity and robustness of decision are raison d'être for decision science, consistency control is a very critical part of the whole process and cannot be omitted from any AHP study. A brief discussion on the lack of consistency exists in section 3.3.1. In the RS-FAHP model, a novel consistency index method called centric consistency (CCI) is proposed which is an extended version of geometric consistency index (GCI).

The procedure of the RS-FAHP consists of all these novel contributions. After the definition of the problem and intended strategies, an expert survey is conducted. The survey does not cover just pairwise choices, but also involves particulars of experience in the field of the shipping business. Subjects are required to submit their business background in a specific division of industry and the time spent in their professional career. As an objective indication of expertise, the duration of a professional career is considered in their priority ratings.

In the AHP method, the individual matrix can be aggregated in the different ways. Two of the methods that have been found to be the most useful are the aggregation of individual judgment (AIJ) and the aggregation of individual priorities (AIP) (Forman & Peniwati, 1998) .

In the AIJ method, the aggregated judgment matrix is obtained by using arithmetic or geometric means of all individual matrices.

In the AIP method, the individual judgment matrix is subject to an expertise prioritization before the aggregation process. The aggregation of individual judgments is provided by a priority weighted algorithm. Ramanathan & Ganesh (1994) indicated that the AIJ violates the Pareto principal of social choice theory and suggested using the AIP in the AHP group decision making. For the proposed RS-FAHP method, aggregation of individual matrices is conducted by expert priority multiplier, named *lambda* coefficient.

Let $A=(a_{ij})_{n\times n}$, where $a_{ij}>0$ and $a_{ij}\times a_{ji}=1$, be a judgment matrix. The prioritization method refers to the process of deriving a priority vector of criteria w = $(w_1, w_2,..., w_n)^T$, where $w_i\geq 0$ and $\sum_{i=1}^{n} w_i = 1$, from the judgment matrix A.

Let $D = \{d_1, d_2,..., d_m\}$ be the set of decision makers, and $\lambda_k = \{\lambda_1, \lambda_2,..., \lambda_m\}$ be the priority vector of decision makers. The priority vector of decision makers (λ_k) is the normalized I_k for the group of experts which is calculated as follows:

$$I_k = \frac{1}{CCI_k} \qquad \text{(eq. 3.17)}$$

where I_k is the inverse of the CCI normalization,

$$\lambda_k = \frac{I_k}{\sum_{k=1}^{m} I_k} \qquad \text{(eq.3.18)}$$

where $\lambda_k>0$, $k = 1,2,...,m$, and $\sum_{k=1}^{m} \lambda_k = 1$.

Let $A^{(k)} = (a_{ij}^{(k)})_{n\times n}$ be the judgment matrix provided by the decision maker d_k.

$w_i^{(k)}$ is the priority vector of criteria for each decision maker calculated by

$$w_i^{(k)} = \frac{\left(\prod_{j=1}^{n} a_{ij}\right)^{1/n}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} a_{ij}\right)^{1/n}} \qquad \text{(eq. 3.19)}$$

The aggregation of individual priorities is defined by

$$w_i^{(w)} = \frac{\prod_{k=1}^{m} (w_i^{(k)})^{\lambda_k}}{\sum_{i=1}^{n}\prod_{k=1}^{m} (w_i^{(k)})^{\lambda_k}} \qquad \text{(eq. 3.20)}$$

where $w_i^{(w)}$ is the aggregated weight vector. After the aggregation process, the extent synthesis methodology of Chang (1996) is applied to the subsequent choice selection.

In the case of non-judgmental criteria, numerical inputs are capable of indicating relative importance among the intended alternatives. Direct numerical inputs (DNI) of the RS-FAHP are based on ranking-and-assignment scale. Table 3.4 presents sample scales of five alternative and four alternative cases for the DNI purpose. A pairwise comparison between alternatives *i* and *j* on criterion, *C*, is defined by

$$a_{ij}^{c} = \frac{A_r^i}{A_r^j} \qquad \text{(eq. 3.21)}$$

where A_r^i is the rank valuation set of alternative *i*.

The comparative priority is defined by cross fractions. For example, if the rank valuation of alternative *i* is A_3^i and alternative *j* is A_1^j, then the pairwise comparison value is (3/7, 5/9, 7/9). Since the posterior process is based on a normalized matrix, a use of a specific scale matrix does not deteriorate the entire procedure. For the loss probability sets, the pairwise comparisons are similarly based on the cross fractions between the intended alternatives without any transformations to the standard scale.

Table 3.4 The scale of the DNI.

Scale for five alternatives			**Scale for four alternatives**		
Rank A_r	Linguistic variable	TFNs	Rank A_r	Linguistic variable	TFNs
A_1	Very high	(7,9,9)	A_1	Very high	(7,9,9)
A_2	High	(5,7,9)	A_2	High	(5,7,9)
A_3	Medium	(3,5,7)	A_3	Medium	(3,5,7)
A_4	Low	(1,3,5)	A_4	Low	(1,3,5)
A_5	Very low	(1,1,3)			

For the ship investment problem, DNIs are converted to fuzzy priority sets according to their numerical superiority (Table 3.5).

Table 3.5 Direct numerical input for the result of ROE.

Project	Result of ROE	Linguistic variable	TFNs
PNB	-12.5%	Low	(1,3,5)
HNB	28.0%	Medium	(3,5,7)
PSH	183.1%	High	(5,7,9)
HSH	355.4%	Very high	(7,9,9)

The regime switching algorithm of the FAHP method is defined by alternating priority matrices of each regime. The final priority matrix is defined by

$$\rho_j = w_c^R \times w_j^R \qquad \text{(eq. 3.22)}$$

where ρ_j is the final priority value of alternative j and c is the criteria. $R \to (P,H)$ is the regime of alternative and criteria (P-Panamax, H-Handymax).

The rule-based process is based on the IF-THEN framework as follows:

Program.

1. IF the alternative j is a Panamax tonnage project, THEN the final priority of alternative j is $\rho_j = w_c^P \times w_j^P$,

2. IF the alternative j is a Handymax tonnage project, THEN the final priority of alternative j is $\rho_j = w_c^H \times w_j^H$.

The procedure of the RS-FAHP is completed by the final consistency control. The following section refers to consistency control and CCI for the RS-FAHP applications.

3.2.4 Consistency control and centric consistency index (CCI)

Saaty (1980) first presented the consistency index as a component of the AHP process. Several reasons may cause individual bias on the AHP surveys and in such situations; a facilitator may decide whether the survey responses are robust. Otherwise, the survey should be replaced to provide a robust solution of the objective. Therefore, consistency control is a unique and routine part of every AHP study.

In the existing literature, many studies applied the FAHP method to multi-attribute decision making problems. The algorithm of Chang (1996) is often used in the FAHP studies and the extent synthesis method has a particular popularity in the field of expert aided selection. However, most of these studies ignore or does not report consistency control including the study of Chang (1996) itself.

Saaty (1980) proposed the consistency ratio (CR) method as defined by calculating the fraction between the consistency index based on the principal eigenvector and the random consistency index. The random consistency index is calculated by a random response simulation and it is reported by Saaty (1980) for several dimensions of a decision matrix.

The present study extends geometric consistency index (GCI) for the FAHP and proposes the centric consistency index (CCI). GCI is formalized from the row geometric mean method (RGMM) proposed by Crawford & Williams (1985) (Aguarón & Moreno-Jiménez, 2003). For the classical AHP method, GCI is suggested to measure the individual consistency of judgment matrices. The centric consistency index (CCI) is applied to the calculation of consistency in the aggregated matrices.

Let $A=(a_{Lij},a_{Mij},a_{Uij})_{n\times n}$ be a fuzzy judgment matrix, and let $w=[(w_{L1},w_{M1},w_{U1}),(w_{L2},w_{M2},w_{U2}),\ldots,(w_{Ln},w_{Mn},w_{Un})]^{T}$ be the priority vector derived from A using the RGMM. The centric consistency index (CCI) is computed by eq. 3.23.

$$CCI(A) = \frac{2}{(n-1)(n-2)} \sum_{i<j} (\log(\frac{a_{Lij} + a_{Mij} + a_{Uij}}{3}) - \log(\frac{w_{Li} + w_{Mi} + w_{Ui}}{3}) + \log(\frac{w_{Lj} + w_{Mj} + w_{Uj}}{3}))^2 \quad \text{(eq. 3.23)}$$

When $CCI(A)=0$, we consider A fully consistent. Aguarón et al. also provide the thresholds ($\overline{GCI}$) as $\overline{GCI}=0.31$for $n=3$; $\overline{GCI}=0.35$ for $n=4$ and $\overline{GCI}=0.37$ for $n>4$. When $CCI(A) < \overline{GCI}$, it is considered that the matrix A is sufficiently consistent. Since the CCI is a fuzzy extended version of GCI, thresholds remain identical.

3.2.5 Fuzzy Monte Carlo simulation

The fuzzy Monte-Carlo (FMC) simulation method is previously used for fault tree analysis (Arnold Kaufmann, Gupta, & Kaufmann, 1985) and health risk assessment (A. Kaufmann & Gupta, 1991). Originally this study improves the FMC for financial assessment purposes. The FMC is developed for random variable selection and Bayesian process design. Rather than the classical Monte-Carlo method, fuzzy extension provides data clusters and reduces data noise. These clusters are based on fuzzy intervals, and their corresponding discrete probabilities are used for random selection of income-cost inputs. Fuzzy Monte-Carlo simulation is designed in six steps (Fig. 3.6). The process is simply commencing with fuzzification of all simulation inputs, and then simulations are carried out. Finally, the net results of financial period are calculated over fuzzy inputs, and a fuzzy output will be produced for all iterations. The fuzzy output is transformed in to a crisp result by calculating the centre of gravity.

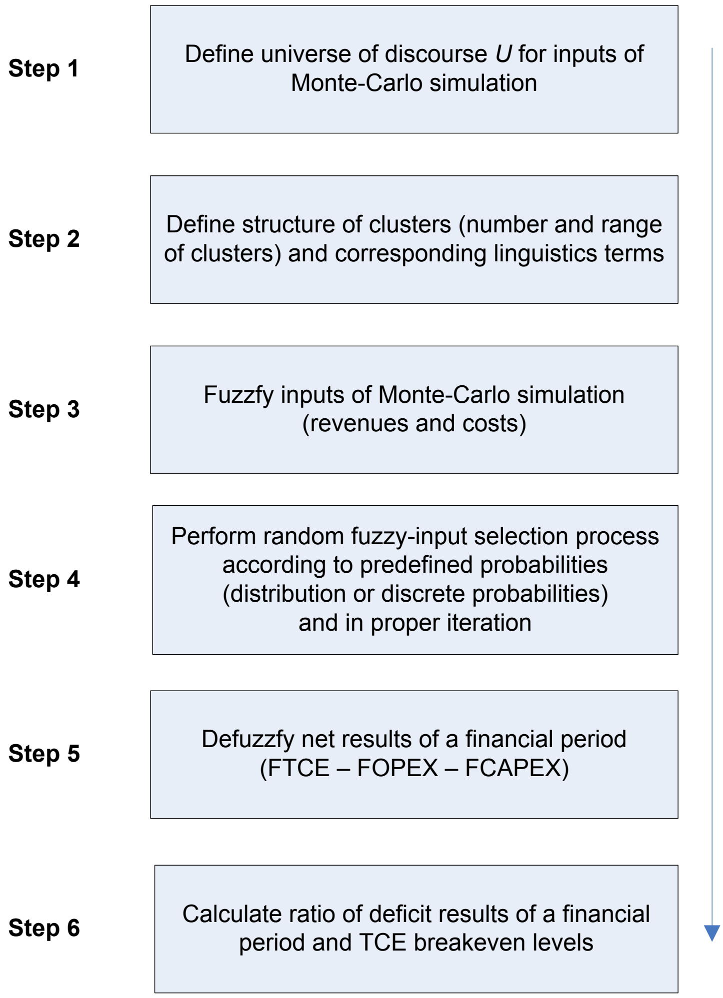

Figure 3.6. The process of FMC simulation.

Step 1 & 2. Inputs of the simulation are fuzzified according to the defined fuzzy intervals. The number of clusters and their intervals are generally based on the judgmental decisions which should be predetermined by the practitioner. In the example of ship investment, four sample projects are used in the empirical works. Samples are selected for a Panamax and a Handymax bulk carrier with different characteristics. Table 3.6 shows particulars of the projects which have different purchasing prospects, but with the same risk premiums. For the cost inputs and revenue inputs

(TCE), fuzzification maps are defined as in Fig. 3.7. Datasets are divided into five fuzzy intervals which have corresponding linguistic terms, such as very low, low, moderate, high, and very high (u_1, u_2, u_3, u_4, and u_5 respectively). Their corresponding fuzzy sets are A_1, A_2, A_3, A_4, and A_5 respectively.

Step 3. The operating cost, LIBOR (London Interbank Offer Rate), and TCE base income are transformed into fuzzy sets. The operating cost (OPEX-Operating Expense) means the fixed cost of a ship which does not include the cost of the voyage (bunkers, port dues, commisions etc.). Since the income is based on TCE base, voyage costs are out of scope for the current study. Another important fixed cost is the capital cost which arises from the project financing. One of the critical and volatile criterias of financial deal is the rate of interest (conventionally LIBOR rate plus a risk premium based on the risk perception by the lender). According to the LIBOR rate, capital cost of a financial period differs. As a cost input, LIBOR rate is also fuzzified, and a predetermined spread of risk premium is applied over the random selection of fuzzy-LIBOR rate.

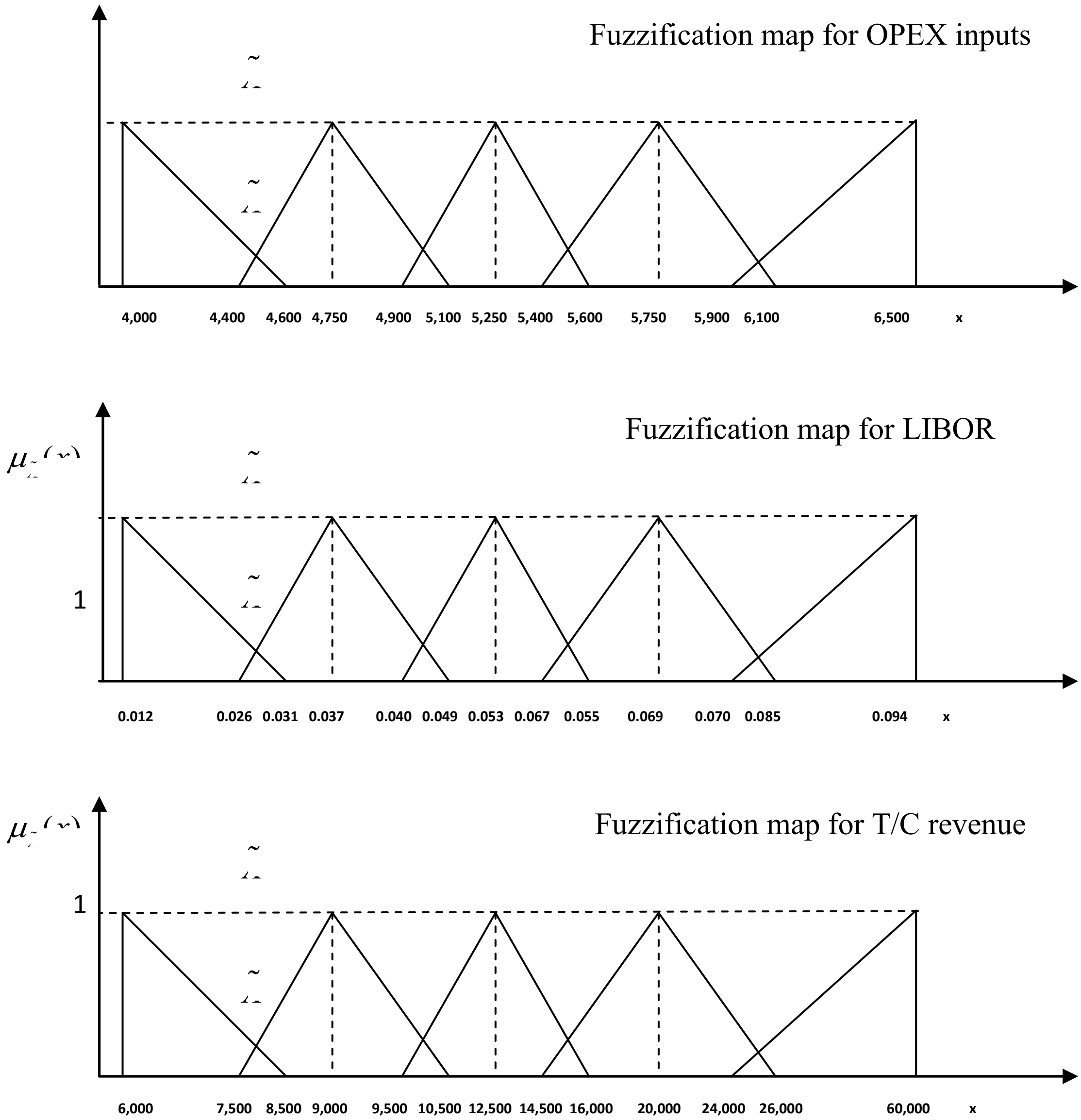

Figure 3.7 Fuzzification maps of the FMC simulation inputs.

Table 3.6 Particulars of empirical ship investment projects.

Code of project	Ship type & size	Loan amount	Term structure & interest
PNB	Panamax New building (2 yrs) (post-delivery finance)	26,950,000 USD	LIBOR base 1% Spread for risk premium. Paid in 8 years, semi-annually.
HNB	Handymax New building (2 yrs) (post-delivery finance)	23,450,000 USD	LIBOR base 1% Spread for risk premium. Paid in 8 years, semi-annually.
PSH	Panamax Second hand	23,100,000 USD	LIBOR base 1% Spread for risk premium. Paid in 10 years, semi-annually.
HSH	Handymax Second hand	18,900,000 USD	LIBOR base 1% Spread for risk premium. Paid in 10 years, semi-annually

Step 4. Inputs of the FMC simulation are selected randomly in a thousand iteration according to the scenario characteristics. Since the intended simulation is not performed for an optimization, the higher number of iteration is just for smoothing. Scenarios are based on historical densities, Gaussian densities (normally distributed), lower case and higher case. Table 3.7 shows the probability character of inputs based on historical record. OPEX data are collected from Drewry Shipping Cost Annual reports for 2000-2009 term on the annual average base. The LIBOR rate series include monthly averages between 1990 and 2009. T/C rates of Panamax and Handymax bulkers are supplied by Clarkson Shipping Co. for 1987-2009 period. Probabilities that are presented in Table 3.7 are calculated from the historical probability distribution.

For every scenario, a thousand iteration of input is performed and the result of output fuzzy sets is transformed into crisp numbers by calculating the centre of gravity of triangle fuzzy numbers.

Table 3.7 Historical probabilities of the FMC simulation inputs.

	OPEX	LIBOR	T/C Rate
u_1	0.10	0.21	0.18
u_2	0.35	0.20	0.18
u_3	0.35	0.39	0.32
u_4	0.15	0.15	0.14
u_5	0.05	0.05	0.18

Step 5. The net result of a financial period (semi-annual in the present empirical work) is calculated by substracting Fuzzy-OPEX and Fuzzy-CAPEX (Capital Expense) from Fuzzy-TCE as follows:

$$\text{Profit/Loss} = \text{FTCE} - \text{FOPEX} - \text{FCAPEX} \qquad \text{(eq. 3.24)}$$

where TCE refers to time charter equivalent income from operations, OPEX is the expenses of operation, and CAPEX is the expenses of the capital. CAPEX is based on straight line principals rather than straight line payments. Therefore, term payments decrease by the declining interest payment.

Substracting process is a fuzzy arithmetic operation which is proposed by Zadeh (1965). The final crisp result is defined by the calculating the centre of gravity point on X-axis.

Step 6. The ratio of deficit results and deficits less than 5% of equity invested is recorded for every candidate project. Fuzzy interval of loss probability is bounded by these indications, and the average value is the mid-point of the fuzzy set. Table 3.8 presents the calculated sets of loss probabilities. The loss probability sets are direct numerical inputs (DNI) which are used for calculating cross fractions to define comparative priorities in the FAHP process.

Table 3.8 Loss probability sets.

Code of project	Lower-bound	Mid-point	Upper-bound
PNB	0.379	0.462	0.545
HNB	0.539	0.583	0.626
PSH	0.154	0.267	0.379
HSH	0.316	0.400	0.484

3.3 Application and results

The fuzzy pairwise comparison matrix relevant to the goal is presented in Table 3.9 and Table 3.10. Lambda (λ) coefficients correspond to the expert priority ratio.

Table 3.11 and Table 3.12 present the result of the individual fuzzy priority vectors and the aggregated weight vector of Handymax and Panamax regimes respectively. As seen in Table 3.13, the coefficient of return on equity has the considerable contribution to the final outcome with its 0.40 value and the lost probability (0.28) has the second major contribution on the final outcome. Fuel consumption, crane existence, ship speed and loaded draught have the remaining contributions of 0.17, 0.07, 0.05, and 0.03, respectively.

For the Panamax ship, the aggregated weight of each criterion is different from the Handymax contribution of criteria (Table 3.14). Returns on equity and loss probability have the major contribution to the aggregated weight vector for both Panamax and Handymax regimes.

However, the ranking of the remaining criteria in the Panamax regime is quite different from the aggregated weight matrix of the Handymax regime. The contributions of fuel consumption, loaded draught, ship speed, and crane existence in the Panamax regime are 0.16, 0.09, 0.06, and 0.03 respectively.

The aggregated fuzzy judgment matrix (AFJM) for the criteria of the Handymax regime (see Table 3.13) is formed from Table 3.9 and Table 3.11. For the Panamax regime (see Table 3.14), it is based on the individual fuzzy judgment matrix of the Panamax ship and Table 3.12. In this study, there are two different mean aggregated weights (MAW) for the Handymax and Panamax regimes, which comprise Table 3.11 and Table 3.12, respectively.

AFJM is found consistent since the CCI is less than the threshold of 0.37. By the extent analysis method for the Handymax and Panamax, the computation is performed for the ship investment strategy decision problem as follows:

Via normalization, the priority weights of the main attributes for the Handymax (H) and Panamax (P) are calculated as follows:

$$d(H) = (0.40,0.33,0.26,0,0,0.01)$$
$$d(P) = (0.37,0.31,0.22, 0.10,0,0)$$

After the calculation of weight for the Handymax and Panamax, the aggregated fuzzy judgment matrix for the alternatives under each criterion is computed from the individual fuzzy judgment matrix of decision makers (Table 3.15).

The results of the priority weights of the alternatives are as follows:

$$d(RE) = (0.00,0.20,0.36,0.44)$$
$$d(LP) = (0.31,0.50,0.00,0.19)$$
$$d(FC) = (0.32,0.53,0.00,0.16)$$

$$d(LD) = (0.00,0.50,0.00,0.50)$$

$$d(SS) = (0.43,0.54,0.00,0.03)$$

$$d(CE) = (0.03,0.53,0.02,0.43)$$

The results by the regime switching analytic hierarchy process (RS-FAHP) for the ship investment decision problem are summarized in Table 3.16. The priority weights of alternatives, PNB, HNB, PSH, and HSH are 0.17, 0.39, 0.13, and 0.29, respectively. As seen in Table 3.16, the priority weight of the Handymax new building is superior to other alternatives.

Table 3.9 The individual fuzzy judgment matrix for criteria of Handymax ship investment strategy.

DM_1 λ=0.13	RE	LP	FC	LD	SS	CE
RE	(1,1,1)	(1,1,1)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)
LP	(1,1,1)	(1,1,1)	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)
FC	(1/7,1/5,1/3)	(1/9,1/7,1/5)	(1,1,1)	(3,5,7)	(3,5,7)	(1,3,5)
LD	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(1/5,1/3,1)
SS	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(1,1,1)
CE	(1/7,1/5,1/3)	(1/5,1/3,1)	(1/5,1/3,1)	(1,3,5)	(1,1,1)	(1,1,1)
CCI = 0.05						
DM_2 λ=0.17	RE	LP	FC	LD	SS	CE
RE	(1,1,1)	(1,3,5)	(3,5,7)	(5,7,9)	(5,7,9)	(3,5,7)
LP	(1/5,1/3,1)	(1,1,1)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)
FC	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(5,7,9)	(3,5,7)	(1,3,5)
LD	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1,1,1)	(1/5,1/3,1)	(1/7,1/5,1/3)
SS	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,3,5)	(1,1,1)	(1/5,1/3,1)
CE	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/5,1/3,1)	(3,5,7)	(1,3,5)	(1,1,1)
CCI = 0.04						
DM_3 λ=0.11	RE	LP	FC	LD	SS	CE
RE	(1,1,1)	(1,3,5)	(3,5,7)	(7,9,9)	(5,7,9)	(3,5,7)
LP	(1/5,1/3,1)	(1,1,1)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)
FC	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(5,7,9)	(3,5,7)	(3,5,7)
LD	(1/9,1/9,1/7)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)
SS	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,3,5)	(1,1,1)	(1,1,1)
CE	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,3,5)	(1,1,1)	(1,1,1)
CCI = 0.06						
DM_4 λ=0.24	RE	LP	FC	LD	SS	CE
RE	(1,1,1)	(1,1,1)	(3,5,7)	(7,9,9)	(7,9,9)	(5,7,9)
LP	(1,1,1)	(1,1,1)	(1,1,1)	(7,9,9)	(5,7,9)	(3,5,7)
FC	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(5,7,9)	(3,5,7)	(3,5,7)
LD	(1/9,1/9,1/7)	(1/9,1/9,1/7)	(1/9,1/7,1/5)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)
SS	(1/9,1/9,1/7)	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1,3,5)	(1,1,1)	(1,1,1)
CE	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,3,5)	(1,1,1)	(1,1,1)
CCI = 0.03						
DM_5 λ=0.14	RE	LP	FC	LD	SS	CE
RE	(1,1,1)	(3,5,7)	(5,7,9)	(7,9,9)	(7,9,9)	(7,9,9)
LP	(1/7,1/5,1/3)	(1,1,1)	(1,3,5)	(5,7,9)	(5,7,9)	(3,5,7)
FC	(1/9,1/9,1/7)	(1/5,1/3,1)	(1,1,1)	(5,7,9)	(3,5,7)	(3,5,7)
LD	(1/9,1/9,1/7)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)
SS	(1/9,1/9,1/7)	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1,3,5)	(1,1,1)	(1,1,1)
CE	(1/9,1/9,1/7)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,3,5)	(1,1,1)	(1,1,1)
CCI = 0.05						
DM_6 λ=0.20	RE	LP	FC	LD	SS	CE
RE	(1,1,1)	(1,3,5)	(1,3,5)	(5,7,9)	(3,5,7)	(3,5,7)
LP	(1/5,1/3,1)	(1,1,1)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)
FC	(1/5,1/3,1)	(1/5,1/3,1)	(1,1,1)	(3,5,7)	(3,5,7)	(3,5,7)
LD	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(1/5,1/3,1)
SS	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(1/5,1/3,1)
CE	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,3,5)	(1,3,5)	(1,1,1)
CCI = 0.04						

Table 3.10 The individual fuzzy judgment matrix for criteria of Panamax ship investment strategy.

DM$_1$ λ=0.1	RE	LP	FC	LD	SS	CE
RE	(1,1,1)	(1,3,5)	(3,5,7)	(3,5,7)	(5,7,9)	(7,9,9)
LP	(1/5,1/3,1)	(1,1,1)	(1,3,5)	(3,5,7)	(3,5,7)	(5,7,9)
FC	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1,3,5)	(3,5,7)	(5,7,9)
LD	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1,3,5)	(5,7,9)
SS	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(3,5,7)
CE	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1,1,1)
CCI = 0.05						
DM$_2$ λ=0.1	RE	LP	FC	LD	SS	CE
RE	(1,1,1)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(5,7,9)
LP	(1/7,1/5,1/3)	(1,1,1)	(1,3,5)	(3,5,7)	(3,5,7)	(7,9,9)
FC	(1/9,1/7,1/5)	(1/5,1/3,1)	(1,1,1)	(3,5,7)	(1,1,1)	(5,7,9)
LD	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(3,5,7)
SS	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/5,1/3,1)	(1,1,1)	(1,1,1)	(3,5,7)
CE	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)
CCI = 0.04						
DM$_3$ λ=0.00	RE	LP	FC	LD	SS	CE
RE	(1,1,1)	(1,1,1)	(1,3,5)	(3,5,7)	(3,5,7)	(5,7,9)
LP	(1/5,1/3,1)	(1,1,1)	(1,3,5)	(3,5,7)	(3,5,7)	(7,9,9)
FC	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(3,5,7)	(1,1,1)	(5,7,9)
LD	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(3,5,7)
SS	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(1,1,1)	(3,5,7)
CE	(1,1,1)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)
CCI = 0.06						
DM$_4$ λ=0.1	RE	LP	FC	LD	SS	CE
RE	(1,1,1)	(1,1,1)	(3,5,7)	(3,5,7)	(7,9,9)	(7,9,9)
LP	(1,1,1)	(1,1,1)	(3,5,7)	(3,5,7)	(3,5,7)	(7,9,9)
FC	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(5,7,9)	(3,5,7)	(5,7,9)
LD	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/9,1/7,1/5)	(1,1,1)	(3,5,7)	(5,7,9)
SS	(1/9,1/9,1/7)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(3,5,7)
CE	(1/9,1/7,1/5)	(1/9,1/9,1/7)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1,1,1)
CCI = 0.03						
DM$_5$ λ=0.1	RE	LP	FC	LD	SS	CE
RE	(1,1,1)	(1,1,1)	(3,5,7)	(3,5,7)	(7,9,9)	(7,9,9)
LP	(1,1,1)	(1,1,1)	(3,5,7)	(1,3,5)	(5,7,9)	(5,7,9)
FC	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,3,5)	(3,5,7)	(5,7,9)
LD	(1/7,1/5,1/3)	(1/5,1/3,1)	(1/5,1/3,1)	(1,1,1)	(1,3,5)	(5,7,9)
SS	(1/9,1/9,1/7)	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1,1,1)
CE	(1/9,1/9,1/7)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1,1,1)	(1,1,1)
CCI = 0.05						
DM$_6$ λ=0.1	RE	LP	FC	LD	SS	CE
RE	(1,1,1)	(1,3,5)	(1,3,5)	(3,5,7)	(5,7,9)	(7,9,9)
LP	(1/5,1/3,1)	(1,1,1)	(1,1,1)	(3,5,7)	(3,5,7)	(7,9,9)
FC	(1/5,1/3,1)	(1,1,1)	(1,1,1)	(1,3,5)	(3,5,7)	(5,7,9)
LD	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(3,5,7)	(5,7,9)
SS	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(3,5,7)
CE	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1,1,1)
CCI = 0.04						

Table 3.11 The individual fuzzy priority vector of decision-makers and aggregated weight vector for criteria of ship investment Handymax regime.

	RE	LP	FC	LD	SS	CE
DM_1	(0.34, 0.37,0.39)	(0.30, 0.31,0.32)	(0.13,0.14,0.15)	(0.04,0.05,0.05)	(0.05,0.05,0.06)	(0.07,0.08,0.10)
DM_2	(0.31,0.35,0.36)	(0.31,0.34,0.34)	(0.13,0.15,0.17)	(0.03,0.03,0.03)	(0.04,0.04,0.05)	(0.08,0.09,0.12)
DM_3	(0.40,0.42,0.44)	(0.27,0.28,0.29)	(0.15,0.15,0.16)	(0.03,0.03,0.03)	(0.04,0.05,0.05)	(0.06,0.07,0.08)
DM_4	(0.38,0.40,0.40)	(0.26,0.28,0.29)	(0.18,0.19,0.21)	(0.03,0.03,0.04)	(0.05,0.05,0.05)	(0.05,0.05,0.06)
DM_5	(0.46,0.52,0.69)	(0.22,0.24,0.25)	(0.14,0.16,0.17)	(0.02,0.03,0.03)	(0.04,0.05,0.06)	(0.05,0.05,0.06)
DM_6	(0.36,0.37,0.40)	(0.26,0.26,0.27)	(0.18,0.20,0.20)	(0.04,0.04,0.05)	(0.04,0.04,0.06)	(0.07,0.08,0.08)
Agg. Weight	(0.37,0,41,0.41)	(0.28,0.28,0.28)	(0.16,0.16,0.18)	(0.03,0.04,0.04)	(0.05,0.05,0.05)	(0.06,0.07,0.08)

Table 3.12 The individual fuzzy priority vector of decision-makers and aggregated weight vector for criteria of ship investment Panamax regime.

	RE	LP	FC	LD	SS	CE
DM_1	(0.39, 0.44,0.44)	(0.24, 0.25,0.27)	(0.15,0.15,0.16)	(0.09,0.09,0.10)	(0.05,0.06,0.06)	(0.02,0.02,0.03)
DM_2	(0.46,0.51,0.55)	(0.21,0.23,0.24)	(0.12,0.13,0.15)	(0.06,0.06,0.07)	(0.05,0.05,0.06)	(0.02,0.02,0.02)
DM_3	(0.31,0.32,0.33)	(0.32,0.33,0.34)	(0.15,0.15,0.18)	(0.07,0.07,0.07)	(0.09,0.09,0.10)	(0.02,0.03,0.03)
DM_4	(0.34,0.37,0.38)	(0.33,0.33,0.34)	(0.15,0.15,0.17)	(0.08,0.08,0.09)	(0.04,0.04,0.05)	(0.02,0.02,0.02)
DM_5	(0.33,0.38,0.60)	(0.32,0.32,0.44)	(0.14,0.15,0.18)	(0.09,0.12,0.13)	(0.03,0.04,0.06)	(0.03,0.03,0.05)
DM_6	(0.36,0.39,0.41)	(0.22,0.23,0.25)	(0.20,0.20,0.21)	(0.10,0.10,0.11)	(0.05,0.05,0.05)	(0.02,0.02,0.03)
Agg. Weight	(0.37,0,40,0.40)	(0.28,0.29,0.29)	(0.15,0.15,0.17)	(0.08,0.08,0.09)	(0.05,0.06,0.06)	(0.02,0.02,0.03)

Table 3.13 The aggregated fuzzy judgment matrix for criteria of ship investment Handymax regime.

	RE	LP	FC	LD	SS	CE	MAW
RE	(1,1,1)	(1.17,1.78,2.20)	(2.13,4.33,6.39)	(6.26,8.28,9.00)	(4.80,6.89,8.28)	(3.82,5.89,7.70)	(0.40)
LP	(0.46,0.56,0.86)	(1,1,1)	(1.58,2.86,3.92)	(4.57,6.65,8.28)	(3.98,6.02,8.05)	(2.15,4.28,6.32)	(0.28)
FC	(0.16,0.23,0.47)	(0.25,0.35,0.63)	(1,1,1)	(3.86,5.91,7.93)	(3.00,5.00,7.00)	(2.15,4.28,6.32)	(0.17)
LD	(0.11,0.12,0.16)	(0.12,0.15,0.22)	(0.13,0.17,0.26)	(1,1,1)	(0.34,0.48,1.00)	(0.19,0.31,0.83)	(0.03)
SS	(0.12,0.15,0.21)	(0.12,0.17,0.25)	(0.14,0.20,0.33)	(1.00,2.08,2.93)	(1,1,1)	(0.45,0.58,1.00)	(0.05)
CE	(0.13,0.17,0.26)	(0.16,0.23,0.46)	(0.16,0.23,0.46)	(1.21,3.28,5.30)	(1.00,1.71,2.20)	(1,1,1)	(0.07)
CCI = 0.27							

Table 3.14 The aggregated fuzzy judgment matrix for criteria of ship investment Panamax regime.

	RE	LP	FC	LD	SS	CE	MAW
RE	(1,1,1)	(1.14,1.75,2.16)	(2.00,4.19,6.25)	(3.32,5.37,7.22)	(4.84,6.91,8.44)	(6.42,8.44,9.00)	(0.39)
LP	(0.46,0.57,0.88)	(1,1,1)	(1,38,2.89,4.20)	(2.42,4.53,6.56)	(3.52,5.56,7.58)	(5.96,7.98, 9.00)	(0.29)
FC	(0.16,0.24,0.50)	(0.24,0.35,0.73)	(1,1,1)	(1.77,3.95,6.01)	(1.98,3.11,4.09)	(5.00,7.00,9.00)	(0.16)
LD	(0.14,0.19,0.30)	(0.15,0.22,0.41)	(0.17,0.25,0.57)	(1,1,1)	(1.34,2.59,3.62)	(4.13,6.17,8.19)	(0.09)
SS	(0.12,0.14,0.21)	(0.13,0.18,0.28)	(0.24,0.32,0.50)	(0.28,0.39,0.75)	(1,1,1)	(2.42,3.65,4.79)	(0.06)
CE	(0.11,0.12,0.16)	(0.11,0.13,0.17)	(0.11,0.14,0.20)	(0.12,0.16,0.24)	(0.21,0.27,0.41)	(1,1,1)	(0.03)
CCI = 0.29							

Table 3.15 The aggregated fuzzy judgment matrix for alternatives of ship investment under each criterion.

Criteria		PNB	HNB	PSH	HSH	MAW
RE	PNB	(1,1,1)	(0.33,0.60,071)	(0.20,0.43,0.56)	(0.14,0.33,0.33)	0.11
	HNB	(1.40,1.67,3.00)	(1,1,1)	(0.60,0.71,0.78)	(0.43,0.56,0.78)	0.21
	PSH	(1.80,2.33,5.00)	(1.29,1.40,1.67)	(1,1,1)	(0.43,0.78,1.00)	0.29
	HSH	(3.00,3.00,7.00)	(1.29,1.80,2.33)	(1.00,1.29,2.33)	(1,1,1)	0.40
CCI=0.00						
		PNB	HNB	PSH	HSH	MAW
LP	PNB	(1,1,1)	(0.70,0.79,0.87)	(1.44,1.73,2.46)	(1.13,1.16,1.20)	0.27
	HNB	(1.15,1.26,1.42)	(1,1,1)	(1.65,2.19,3.50)	(1.29,1.46,1.71)	0.35
	PSH	(0.41,0.58,0.70)	(0.29,0.46,0.61)	(1,1,1)	(0.49,0.67,0.78)	0.15
	HSH	(0.83,0.87,0.89)	(0.59,0.69,0.77)	(1.28,1.50,2.05)	(1,1,1)	0.23
CCI=0.00						
		PNB	HNB	PSH	HSH	MAW
FC	PNB	(1,1,1)	(0.26,0.34,0.57)	(1.63,3.63,5.49)	(0.94,1.57,2.05)	0.23
	HNB	(1.77,2.90,3.85)	(1,1,1)	(3.84,5.63,7.48)	(1.00,2.88,4.72)	0.48
	PSH	(0.18,0.28,0.61)	(0.13,0.18,0.26)	(1,1,1)	(0.37,0.51,1.00)	0.08
	HSH	(0.49,0.64,1.06)	(0.21,0.35,1.00)	(1.00,1.95,2.67)	(1,1,1)	0.17
CCI=0.01						
		PNB	HNB	PSH	HSH	MAW
LD	PNB	(1,1,1)	(0.14,0.20,0.33)	(1,1,1)	(0.14,0.20,0.33)	0.23
	HNB	(3.00,5.00,7.00)	(1,1,1)	(3.00,5.00,7.00)	(1.00,1.00,1.00)	0.48
	PSH	(1.00,1.00,1.00)	(0.14,0.20,0.33)	(1,1,1)	(0.14,0.20,0.33)	0.08
	HSH	(3.00,5.00,7.00)	(1.00,1.00,1.00)	(3.00,5.00,7.00)	(1,1,1)	0.17
CCI=0.01						
		PNB	HNB	PSH	HSH	MAW
SS	PNB	(1,1,1)	(0.51,0.63,1.00)	(3.47,5.62,7.68)	(1.59,3.40,5.06)	0.34
	HNB	(1.00,1.59,1.97)	(1,1,1)	(4.74,6.77,8.65)	(3.21,5.34,7.34)	0.49
	PSH	(0.13,0.20,0.26)	(0.12,0.15,0.21)	(1,1,1)	(0.29,0.43,0.96)	0.06
	HSH	(0.20,0.29,0.63)	(0.14,0.19,0.31)	(1.04,2.34,3.43)	(1,1,1)	0.11
CCI=0.01						
		PNB	HNB	PSH	HSH	MAW
CE	PNB	(1,1,1)	(0.16,0.22,0.45)	(1.00,1.26,1.41)	(0.18,0.28,0.71)	0.12
	HNB	(2.25,4.45,6.40)	(1,1,1)	(2.90,4.69,6.51)	(1.00,1.30,1.46)	0.45
	PSH	(0.71,0.79,1.00)	(0.15,0.21,0.34)	(1,1,1)	(0.22,0.37,1.08)	0.11
	HSH	(1.42,3.56,5.61)	(0.68,0.77,1.00)	(0.93,2.71,4.52)	(1,1,1)	0.32
CCI=0.02						

Table 3.16 Final assessment of alternatives of ship investment.

	RE	LP	FC	LD	SS	CE	Alternative priority weight
Panamax regime weight	**0.37**	0.31	0.22	0.10	0.00	0.00	
Handymax regime weight	**0.40**	0.33	0.26	0.00	0.00	0.01	
PNB	0.00	0.31	0.32	0.00	0.43	0.03	0.17
HNB	0.20	0.50	0.53	0.50	0.54	0.53	**0.39**
PSH	0.36	0.00	0.00	0.00	0.00	0.02	0.13
HSH	0.44	0.19	0.16	0.50	0.03	0.43	0.29

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Chapter 4

Ship Management Strategy Decision

When an entrepreneur purchases a ship, management of the fleet is another problematic point of the ship management process. The owner may prefer to manage the fleet by himself; management outsourcing (third party ship management) is another option. An experienced investor may choose to manage his fleet by senior managers of the corporation or if the investor is an entrepreneur, third party ship management can be a reasonable solution. Depending on the size of the fleet, it may be feasible to establish management at the headquarters or through third party management companies. Selection of a management service provider is investigated in this chapter.

Once a corporate decides if part of the management task will be outsourced or if the enterprise will take on full management responsibility of ship asset, then some additional critical selection problems exist in the shipping business. One of them is the pattern of crew nationality on board. Nowadays, various crew agencies provide a manning pool that includes native workers or foreigners. Due to the cost of manning, and the quality of on board services etc., nationality pattern selection is inserted in the entire process of the shipping management problem.

By the mentioned definitions, the ship asset management (SAM) problem is identified in three major steps (Fig. 4.1). First, particulars of the ship investment strategy will be defined by an expert aided process, and it is analyzed and concluded in Chapter 3. Second, a management service provider will be selected. Finally, nationality patterns of the crew should be designated. Moreover, if the commercial management of the ship asset is expected to be supplied by corporate itself, then chartering characteristics must be decided between the spot trading and the period trading alternatives.

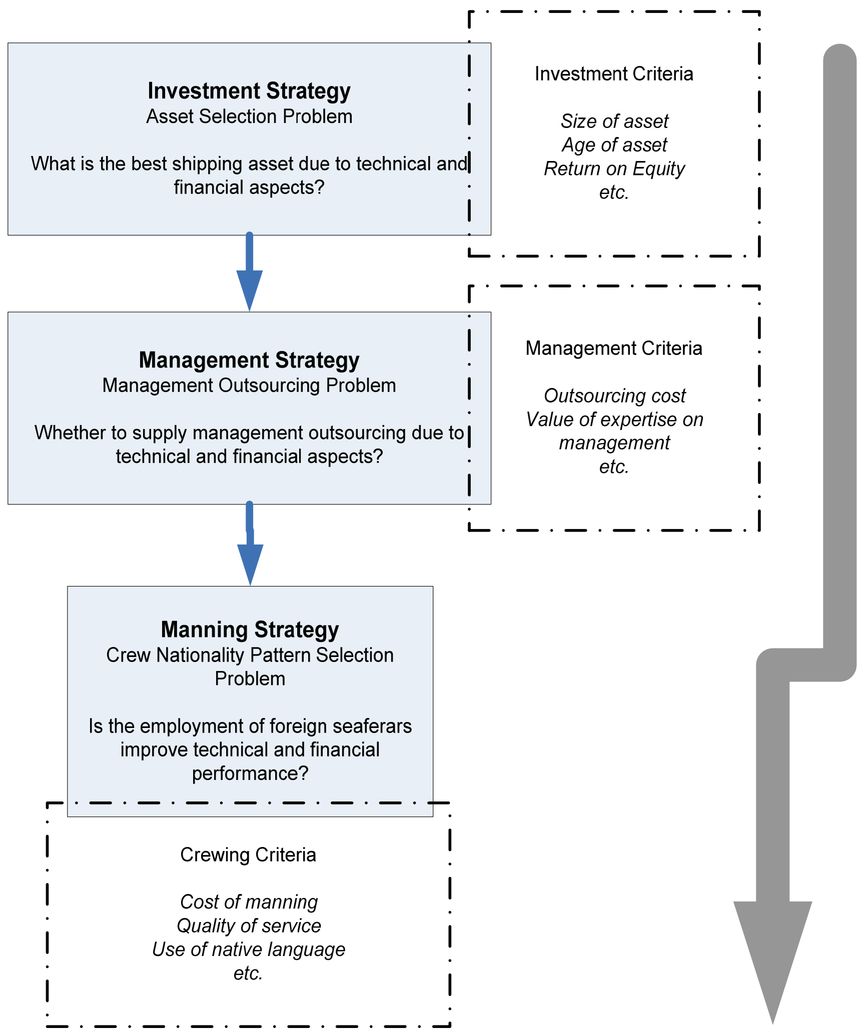

Figure 4.1 The ship asset management process design.

4.1 Design of the management outsourcing decision process

Management of a ship is a problematic point because of differences of cost-benefit particulars for a variety of management options. For a broader size fleet, owner's management can be feasible in both financial and technical performance (MA_1). However, for a limited size fleet, self-management has both financial and technical disadvantages, such as cost of management per ship and cost of implementing technical standards. In case of poor expertise or small fleet size, a complete or partial management outsourcing may have particular advantages.

Ship Management outsourcing in the shipping business has three main forms due to practical use and service design of the third party management companies (Bulut, Duru, Keçeci & Yoshida, 2012). First, a ship owner may prefer to assign a complete management service including technical, operational, and commercial aspects (MA_2). Since a full management service consists of every components of the shipping business (except ship management); no additional management decision processes will be needed in case of preference.

Because of the shortage of crew supply, the crewing task is a troublesome routine in the shipping business. Owners who do not have a larger size fleet may choose to use a crewing service (MA_3). That is classified as a management outsourcing in part. Another local solution is commercial governance. The ship owner may prefer a partial service on commercial management of vessel (MA_4). Ship owners who do not have strong relationships with customers and who are beginners in the business may require an outsourcing service which improves chartering performance of the vessel. Finally, a bundle of technical, operational, and crewing management services would be a useful option for many investors the beginner stage in the market (MA_5). Table 4.1 displays all alternatives for the management strategy.

Table 4.1 The alternatives for the model of ship management and their symbol.

Alternatives	Symbols
Alternatives for the management strategy	MA
The owner's management	MA_1
Full management outsourcing	MA_2
The crew management	MA_3
The commercial management	MA_4
The technical, operational & crew management	MA_5

The criteria for the ship management strategy decision are selected by using the survey and gathering from literature; ship size (MC_1), fleet size (MC_2), owner's experience (MC_3), profitability of management service (MC_4), age of fleet (MC_5), and business network (MC_6). The corresponding hierarchical design is presented in Figure 4.2.

Table 4.2 The criteria for the model of ship management and their symbol.

Criteria	Symbols
Criterion of the management strategy	MC
Ship size	MC_1
Fleet size	MC_2
Owner's experience	MC_3
Profitability of management service	MC_4
Age of fleet	MC_5
Network facility	MC_6

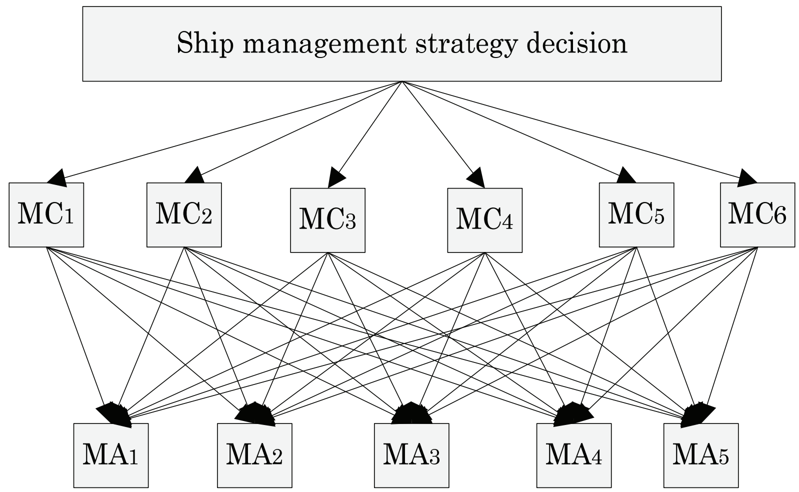

Figure 4.2 The hierarchy of the management outsourcing decision.

4.2 Design of the crew nationality pattern selection process

The cost of a shipping business is the key factor in cash flows and it is particularly fundamental during a period of recession. As an important part of the balance of payments, crewing is indicated to be around 40% of fixed costs (Stopford, 2009). For cost management purposes, crewing should be supplied from cheaper sources according to direct manning. Additionally, quality and safety of on board services are extraordinary components in the recent shipping industry since many ships are exposed to detentions for several days. From an economic perspective, such a termination of service causes unexpected costs and the loss of customer satisfaction.

Borman et al. (1997) and Robertson et al. (2001) review the personnel selection problem and indicate that particular variations including change in organizations, change in work, change in personnel, change in nationality, change of laws, and change in marketing have influential personnel selection task. Application blanks, biodata forms, reference checks, interviews, cognitive ability, personality tests, integrity tests, achievement tests, group exercises, and simulation can be listed for the conventional personnel selection approaches (Devanna, Fombrun, & Tichy, 1981). However, all of them are developed on the basis that static employment characteristics would not be so long sufficient (Lievens, Dam, & Anderson, 2002). In particular, Gargano et al. (1991) combined genetic algorithm and artificial neural networks for the purpose of selecting the personnel to be employed in finance sector . The fuzzy sets theory is suggested for the personnel selection problem by Alliger et al. (1993) and Liang & Wang (1994). The second study for personnel selection with using a fuzzy model was developed by Capaldo and Zollo (2001) to improve the effectiveness of selection processes in major Italian companies. Karsak (2001) presented the model in order to score alternatives by using fuzzy multiple criteria programming and evaluated qualitative and quantitative factors together via membership functions in this model. One of the methods proposed the personnel selection by using fuzzy analytic hierarchy process (FAHP) method, which is one of the multi-criteria decision-making methods. The complexity and importance of crew selection problem call for analytical methods rather than intuitive decisions.

In addition, personnel selection and human research management are also investigated for shipping companies and shipping business in literature. Obando-Rojes et al. (1999) studied to identify the dynamic structure of the officer supply-chain, education of crew in merchant marine by using a system dynamic methodology. Kundu et al. (2007) investigated to assess the human resources (HR) practices in shipping companies by using factor analyzing method. The study proposed that firm's competitive advantage could be generated from HR and firm performance is influenced by a set of effective human research management practices. However, there are still many unclear fields of manning strategy or personnel selection that have not been explored and that might give a better understanding of the maritime manpower system.

Cost and quality balance is the major concern of crew selection. Although every crew has its own individual characteristics, nationality is also a general frame of cost-quality performance. Therefore, the third layer of a shipping investment assessment is designed for selection of crew nationality patterns, which means how different nationalities will be combined. For example, a completely national crewing strategy may have several advantages, such as using an identical language through the directors and crew members (CA_1). Other alternatives can be a joint employment of both national and international crew (CA_2) or a complete foreign crew employment (CA_3) (Table 4.3).

Table 4.3 The alternatives for the crew management and their symbol.

Alternatives for the crew national pattern selection (CA)	Symbols
National employment	CA1
Fully foreigner employment	CA2
The combination of national and foreigner employment	CA3

The criteria for priority preference are defined as language, salary, crew insurance, conflict resolution law/law privilege, overtime working, and service quality according to the survey and the literature (Table 4.4) (Borman et al., 1997; Bulut et al., 2012; Robertson & Smith, 2001). Figure 4.3 shows the corresponding hierarchical design of the crew nationality pattern selection problem.

Table 4.4 The criteria for the crew management and their symbol.

Criteria of the crew national pattern selection	*Symbols*
Language	CC_1
Salary	CC_2
Crew insurance	CC_3
Conflict resolution law	CC_4
Overtime working	CC_5
Service quality	CC_6

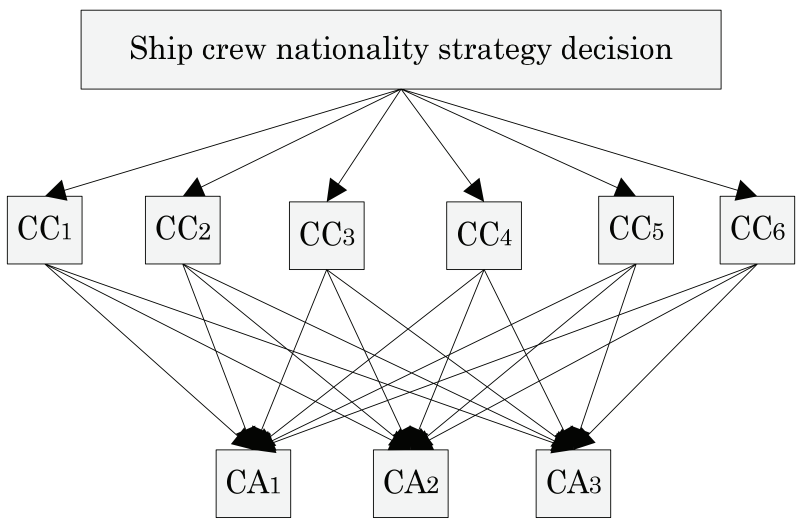

Figure 4.3 The hierarchy of the crew nationality pattern selection.

4.3 Methodology and empirical study

As mentioned before, the algorithm of proposed method in Chapter 3 is also applied to define the strategy for the ship management problem. The weight of same criteria for each alternative might differ from each other for the ship investment strategy. Therefore, the regime should be changed for each alternative, that means the weight of each criterion is re-calculated for different type of each alternative in ship investment problem in Chapter 3. In this Chapter, however, the weight of criteria is no needed to re-calculate for each alternative since the regime is constant. The consistency control is also computed for each decision matrix by using the centric consistency index method.

The empirical study is designed in two layers of the decision process. The first layer defines whether the owner should contract a management outsourcing service in part or completely. In the second layer, it is designed for further management decisions. According to the results of the second layer, crew management decisions are subject to the account of the ship owner, and the corresponding nationality issue is investigated in the subsequent process.

There are five criteria and five alternatives for the ship management strategy selection, and six criteria and three alternatives for the crew national strategy selection (Table 4.1, 4.2, 4.3, 4.4). The criteria and alternative selection are based on a pre-survey among the sample group from the field of shipping business, and latter surveys are also performed with a group of business professionals. For an extended discussion on criteria and alternative, please refer to sections 4.1 and 4.2. The main selection criterion for expertise is the minimum three years of duration in shipping business, and corporate board members are preferred as well. For example, in the case of crew nationality pattern selection, the crewing office directors of two of the top shipping companies of Turkey participated in the survey.

4.4 Application and results

Table 4.5 presents the individual fuzzy judgment matrix for the weight calculation of the criteria of the ship management strategy decision. A lambda (λ) coefficient is related with expert priority ratio, which is calculated by considering the value of each decision maker's matrix.

Table 4.6 displays the result of the aggregated fuzzy judgment matrix and the priority weights for criteria. Table 4.7 indicates the aggregated fuzzy judgment matrix for alternatives of the ship management outsourcing decision. The weight of the age of fleet is found superiority than others and the second important contribution is the profitability of the management service. The owner's experience, network facility, ship size, and fleet size have the remaining contribution of 0.12, 0.11, 0.08, and 0.05, respectively.

Final assessment is introduced in Table 4.8 and the priority weights for criteria are calculated as follows;

$d(MC) = (0.07,0.00,0.14,0.22,0.28,0.28)$.

Then, the priority weights of the alternatives will be determined under each criterion separately.

$d(MA_1) = (0.22,0.19,0.15,0.29,0.16)$
$d(MA_3) = (0.42,0,0.30,0.17,0.11)$
$d(MA_4) = (0.18,0.14,0.28,0.23,0.16)$
$d(MA_5) = (0.09,0.24,0.24,0.22,0.21)$
$d(MA_6) = (0.08,0.27,0.25,0.24,0.17)$
$d(CC) = (0.35,0.33,0.06,0.03,0.12,0.12)$

A partial outsourcing of crew management is selected for further analysis of the process. This type of management, called traditional ship management model, leads the shipping companies to retain the absolute control of shipping business at the strategic and operational management, i.e. technical and commercial management, except the crew management. This traditional management model is well accepted by shipping companies in many countries around the world, such as Greece, Italy, Turkey, and Japan.

Table 4.5 The individual fuzzy judgment matrix for criteria of ship management strategy decision.

DM_1 λ=0.09	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1	(1,1,1)	(3,5,7)	(1,3,5)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1,3,5)
MC_2	(1/7,1/5,1/3)	(1,1,1)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/9,1/7,1/5)	(1/7,1/5,1/3)
MC_3	(1/5,1/3,1)	(3,5,7)	(1,1,1)	(1/7,1/5,1/3)	(1/9,1/7,1/5)	(1,1,1)
MC_4	(1,3,5)	(3,5,7)	(3,5,7)	(1,1,1)	(1/5,1/3,1)	(1,3,5)
MC_5	(3,5,7)	(5,7,9)	(5,7,9)	(1,3,5)	(1,1,1)	(3,5,7)
MC_6	(1/5,1/3,1)	(3,5,7)	(1,1,1)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1,1,1)
DM_2 λ=0.13	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1	(1,1,1)	(1,1,1)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/5,1/3,1)
MC_2	(1,1,1)	(1,1,1)	(1/7,1/5,1/3)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1,1,1)
MC_3	(1,3,5)	(3,5,7)	(1,1,1)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,3,5)
MC_4	(3,5,7)	(1,3,5)	(3,5,7)	(1,1,1)	(1,1,1)	(1,3,5)
MC_5	(1/9,1/7,1/5)	(1/5,1/3,1)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1,1,1)	(5,7,9)
MC_6	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1/9,1/7,1/5)	(1,1,1)
DM_3 λ=0.04	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1	(1,1,1)	(1,3,5)	(1,3,5)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1/5,1/3,1)
MC_2	(1/5,1/3,1)	(1,1,1)	(1/5,1/3,1)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/5,1/3,1)
MC_3	(1/5,1/3,1)	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1,1,1)
MC_4	(1,3,5)	(5,7,9)	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1,3,5)
MC_5	(3,5,7)	(5,7,9)	(3,5,7)	(1,3,5)	(1,1,1)	(3,5,7)
MC_6	(1,3,5)	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1,1,1)
DM_4 λ=0.13	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1	(1,1,1)	(1,3,5)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)
MC_2	(1/5,1/3,1)	(1,1,1)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1/9,1/7,1/5)	(1/7,1/5,1/3)
MC_3	(3,5,7)	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1,1,1)
MC_4	(3,5,7)	(3,5,7)	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1,1,1)
MC_5	(3,5,7)	(5,7,9)	(1,3,5)	(1,3,5)	(1,1,1)	(3,5,7)
MC_6	(1,1,1)	(3,5,7)	(1,1,1)	(1,1,1)	(1/7,1/5,1/3)	(1,1,1)
DM_5 λ=0.17	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1	(1,1,1)	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1/5,1/3,1)
MC_2	(1/5,1/3,1)	(1,1,1)	(1/5,1/3,1)	(1/7,1/51/3)	(1/9,1/7,1/5)	(1/5,1/3,1)
MC_3	(1,1,1)	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1,1,1)
MC_4	(1,3,5)	(3,5,7)	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1,3,5)
MC_5	(1,3,5)	(5,7,9)	(1,3,5)	(1,3,5)	(1,1,1)	(1,3,5)
MC_6	(1,3,5)	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1,1,1)
DM_6 λ=0.11	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1	(1,1,1)	(3,5,7)	(1,3,5)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1/5,1/3,1)
MC_2	(1/7,1/5,1/3)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1/5,1/3,1)
MC_3	(1/5,1/3,1)	(1,3,5)	(1,1,1)	(1,1,1)	(1/5,1/3,1)	(1,1,1)
MC_4	(1,3,5)	(1,3,5)	(1,1,1)	(1,1,1)	(1/5,1/3,1)	(1,3,5)
MC_5	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)	(1,1,1)	(3,5,7)
MC_6	(1,3,5)	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1,1,1)
DM_7 λ=0.21	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1	(1,1,1)	(1,3,5)	(1,1,1)	(1,3,5)	(1/5,1/3,1)	(1,1,1)
MC_2	(1/5,1/3,1)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1/5,1/3,1)
MC_3	(1,1,1)	(1,3,5)	(1,1,1)	(1,1,1)	(1/5,1/3,1)	(1,1,1)
MC_4	(1/5,1/3,1)	(1,3,5)	(1,1,1)	(1,1,1)	(1/5,1/3,1)	(1,3,5)
MC_5	(1,3,5)	(3,5,7)	(1,3,5)	(1,3,5)	(1,1,1)	(3,5,7)
MC_6	(1,1,1)	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1,1,1)

Table 4.6 The aggregated fuzzy judgment matrix for criteria of ship management.

	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6	MAW
MC_1	(1,1,1)	(1.16,2.53,3.69)	(0.40,0.70,1.20)	(0.18,0.28,0.61)	(0.15,0.22,0.41)	(0.38,0.57,1.14)	0.08
MC_2	(0.27,0.39,0.86)	(1,1,1)	(1.18,0.29,0.72)	(0.15,0.22,0.43)	(0.12,0.16,0.23)	(0.25,0.35,0.67)	0.05
MC_3	(0.83,1.44,2.49)	(1.39,3.49,5.53)	(1,1,1)	(0.21,0.32,0.72)	(0.17,0.26,0.57)	(1,1.27,1.42)	0.12
MC_4	(1.65,3.60,5.61)	(2.33,4.52,6.59)	(1.39,3.16,4.77)	(1,1,1)	(0.28,0.42,1)	(1,2.19,3.15)	0.24
MC_5	(2.45,4.55,6.58)	(4.27,6.31,8.32)	(1.75,3.92,5.98)	(1,2.36,3.52)	(1,1,1)	(2.85,4.99,7.03)	0.40
MC_6	(0.88,1.77,2.62)	(1.50,2.85,3.98)	(0.70,0.79,1)	(0.32,0.46,1)	(0.14,0.20,0.35)	(1,1,1)	0.11
CCI = 0.01							

Table 4.7 The aggregated fuzzy judgment matrix for alternatives of ship management under each criterion.

Criteria		MA_1	MA_2	MA_3	MA_4	MA_5	MAW
MC_1	MA1	(1,1,1)	(0.43,0.65,1.35)	(0.56,1.06,2.02)	(0.28,0.43,0.87)	(1.73,3.60,5.60)	0.19
	MA2	(0.74,1.54,2.31)	(1,1,1)	(0.56,1.01,2.15)	(0.32,0.53,1.10)	(0.69,1.42,2.67)	0.19
	MA3	(0.49,0.95,1.79)	(0.46,0.99,1.79)	(1,1,1)	(0.26,0.47,1.24)	(0.27,0.48,1.27)	0.14
	MA4	(1.16,2.35,3.63)	(0.91,1.88,3.10)	(0.81,2.12,3.86)	(1,1,1)	(2.16,4.36,6.42)	0.36
	MA5	(0.18,0.28,0.58)	(0.37,0.70,1.45)	(0.79,2.08,3.72)	(0.16,0.23,0.46)	(1,1,1)	0.12
CCI=0.05							
		MA_1	MA_2	MA_3	MA_4	MA_5	MAW
MC_3	MA1	(1,1,1)	(4.15,6.27,8.31)	(0.62,0.80,1)	(1.32,2.82,4.12)	(4.39,6.43,8.45)	0.38
	MA2	(0.12,0.16,0.24)	(1,1,1)	(0.19,0.31,0.88)	(0.46,0.59,1)	(0.18,0.29,0.73)	0.07
	MA3	(1,1.25,1.62)	(1.13,3.18,5.20)	(1,1,1)	(1.04,2.53,3.83)	(2.30,2.97,3.55)	0.30
	MA4	(0.24,0.35,0.76)	(1,1.70,2.17)	(0.26,0.40,0.96)	(1,1,1)	(1.32,3.12,4.78)	0.15
	MA5	(0.12,0.16,0.23)	(1.36,3.47,5.51)	(0.28,0.34,0.43)	(0.21,0.32,0.76)	(1,1,1)	0.09
CCI=0.06							
		MA_1	MA_2	MA_3	MA_4	MA_5	MAW
MC_4	MA1	(1,1,1)	(0.41,0.81,1.93)	(0.31,0.43,0.70)	(0.74,1.40,2.83)	(0.89,1.40,2.28)	0.18
	MA2	(0.52,1.22,2.44)	(1,1,1)	(0.34,0.47,1)	(2.28,0.53,1.40)	(0.26,0.39,0.92)	0.13
	MA3	(1.42,2.32,3.26)	(1,2.11,2.98)	(1,1,1)	(1.04,2.40,3.56)	(1.28,3.41,5.45)	0.35
	MA4	(0.35,0.71,1.34)	(0.72,1.90,3.58)	(0.28,0.42,0.96)	(1,1,1)	(1.95,3.83,5.50)	0.21
	MA5	(0.44,0.71,1.12)	(1.09,2.55,3.82)	(0.18,0.29,0.78)	(0.18,0.26,0.51)	(1,1,1)	0.13
CCI=0.07							
		MA_1	MA_2	MA_3	MA_4	MA_5	MAW
MC_5	MA1	(1,1,1)	(0.26,0.36,0.69)	(0.19,0.30,0.78)	(0.26,0.34,0.54)	(0.19,0.32,0.90)	0.09
	MA2	(1.45,2.79,3.90)	(1,1,1)	(0.75,1.32,2.11)	(0.51,1.21,2.57)	(0.65,1.42,2.57)	0.26
	MA3	(1.29,3.37,5.40)	(0.47,0.76,1.33)	(1,1,1)	(0.76,1.62,2.67)	(0.86,1.07,1.27)	0.24
	MA4	(1.86,2.92,3.81)	(0.39,0.83,1.95)	(0.38,0.62,1.32)	(1,1,1)	(1,1.64,2.06)	0.22
	MA5	(1.11,3.14,5.16)	(0.39,0.70,1.53)	(0.79,0.94,1.16)	(0.49,0.61,1)	(1,1,1)	0.20
CCI=0.02							
		MA_1	MA_2	MA_3	MA_4	MA_5	MAW
MC_6	MA1	(1,1,1)	(0.16,0.24,0.53)	(0.16,0.25,0.55)	(0.30,0.41,0.80)	(0.45,0.58,1)	0.09
	MA2	(1.90,4.13,6.21)	(1,1,1)	(0.80,1.13,1.50)	(0.67,1.56,2.87)	(0.76,1.70,2.87)	0.29
	MA3	(1.83,4.06,6.14)	(0.67,0.88,1.25)	(1,1,1)	(0.40,0.87,2.02)	(0.86,1.07,1.27)	0.23
	MA4	(1.26,2.43,3.38)	(0.35,0.64,1.50)	(0.50,1.15,2.48)	(1,1,1)	(1,2.05,2.87)	0.23
	MA5	(1,1.72,2.22)	(0.35,0.59,1.32)	(0.79,0.94,1.16)	(0.35,0.49,1)	(1,1,1)	0.16
CCI=0.01							

Table 4.8 Final assessment of alternatives of ship management.

	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6	Alternative
priority							
Weight	0.07	0.00	0.14	0.22	0.28	0.28	weight
MA_1	0.22		0.42	0.18	0.09	0.08	0.16
MA_2	0.19		0.00	0.14	0.24	0.27	0.19
MA_3	0.15		0.30	0.28	0.24	0.25	**0.25**
MA_4	0.29		0.17	0.23	0.22	0.24	0.23
MA_5	0.16		0.11	0.16	0.21	0.17	0.17

In crew management outsourcing, many service providers give an option to decide the nationality of the crew on board. Therefore, the following process corresponds to how crew nationality patterns should be placed on ship management. Table 4.9 shows the individual fuzzy judgment matrix for criteria of crew management decision strategy. Table 4.10 formed from Table 4.9 defines the aggregated fuzzy criteria matrix. According to the final results, order of importance is language, salary, service quality, overtime working regime, conflict resolution law and crew insurance respectively. First of all, conflict resolution and crew insurance criteria have very small contribution to final result because of their low weights. The criteria matrix indicates that language (0.27), salary (0.26) and service quality (0.23) have particular importance in the selection of nationality groups. Although, crew managers endeavor to improve quality of on board services, cost of operation is still the major concern because of the fiscal objectives.

Using same language between company and crew and among the crew members is found to be crucial factor. In case of national crew employment, this objective will be broadly implemented. However, there are several shipping companies which are managed by a group of various nationalities. Use of English is common practice in such organizations and that ensures advantages of using same language too. However, it is quite distinct that same nationality will have unique benefits due to language concerns. Increasing efficiency of relationships, safety procedures and other communication based activities will be benefited from this issue.

Quality of service on board may depend on the educational background of crew and wealth of origin country. It is quite perceptible that crew from developed countries can maintain higher quality of service since their personal quality perceptions are higher than equivalents. The level of educational institutions is another possible content of this criterion.

Overtime working and pricing overtime duties is another important subject. This criterion has two inferences. First, the additional cost of manning other than basic pay has similar influences on fiscal objectives like salary. Another inference is capacity for overtime employment particularly in case of unrated overtime regime.

In Table 4.11, priority of alternatives among the criteria is presented. Fully national crew employment is explicitly preferable according to all factors except the salary requirement of the crew (CC_2). The final result in Table 4.12 indicates national crew selection is superior and recommended for the crew strategy decision in ship management. In addition, the all decision makers who attended the questionnaire for this part of study are from Turkey; therefore, this result could be proposed strongly for the Turkish shipping society.

The priority weights of the criteria are calculated as follows (Table 4.12):

$d(\mathrm{CC}) = (0.35,0.33,0.06,0.03,0.12,0.12)$

Then, the weights for alternatives could be determined under each of criterion separately (Table 4.12).

$d(CC_1) = (0.52,0.33,0.15)$

$d(CC_2) = (0.35,0.40,0.25)$

$d(CC_3) = (0.53,0.27,0.20)$

$d(CC_4) = (0.61,0.18,0.21)$

$d(CC_5) = (0.72,0.14,0.14)$

$d(CC_6) = (0.52,0.30,0.18)$

Table 4.9 The individual fuzzy judgment matrix for criteria of crew management decision strategy.

DM_1	$\lambda=0.13$	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1		(1,1,1)	(1,3,5)	(3,5,7)	(5,7,9)	(5,7,9)	(1,1,1)
MC_2		(1/5,1/3,1)	(1,1,1)	(1,3,5)	(3,5,7)	(3,5,7)	(1/5,1/3,1)
MC_3		(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1,3,5)	(1,3,5)	(1/7,1/5,1/3)
MC_4		(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1/5,1/3,1)	(1/7,1/5,1/3)
MC_5		(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1,1,1)	(1/5,1/3,1)
MC_6		(1,1,1)	(1,3,5)	(3,5,7)	(3,5,7)	(1,3,5)	(1,1,1)
DM_2	$\lambda=0.17$	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1		(1,1,1)	(1/5,1/3,1)	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)
MC_2		(1,3,5)	(1,1,1)	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)
MC_3		(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1
)MC_4		(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)
MC_5		(1/5,1/3,1)	(1/5,1/3,1)	(1,3,5)	(1,3,5)	(1,3,5)	(1,1,1)
MC_6		(1/5,1/3,1)	(1/5,1/3,1)	(1,3,5)	(1,3,5)	(1,3,5)	(1,1,1)
DM_3	$\lambda=0.09$	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1		(1,1,1)	(1/5,1/3,1)	(3,5,7)	(3,5,7)	(1,1,1)	(1,3,5)
MC_2		(1,3,5)	(1,1,1)	(3,5,7)	(3,5,7)	(1,1,1)	(1,3,5)
MC_3		(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,3,5)	(1/5,1/3,1)	(1/5,1/3,1)
MC_4		(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1/7,1/5,1/3)	(1/5,1/3,1)
MC_5		(1,1,1)	(1,1,1)	(1,3,5)	(3,5,7)	(1,1,1)	(1,3,5)
MC_6		(1/5,1/3,1)	(1/5,1/3,1)	(1,3,5)	(1,3,5)	(1/5,1/3,1)	(1,1,1)
DM_4	$\lambda=0.07$	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1		(1,1,1)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(1/5,1/3,1)
MC_2		(1/5,1/3,1)	(1,1,1)	(1,3,5)	(1,3,5)	(1,3,5)	(1/5,1/3,1)
MC_3		(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1/5,1/3,1)	(1,1,1)	(1/7,1/5,1/3)
MC_4		(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1/7,1/5,1/3)
MC_5		(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1/7,1/5,1/3)
MC_6		(1,3,5)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(1,1,1)
DM_5	$\lambda=0.13$	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1		(1,1,1)	(1/5,1/3,1)	(1,3,5)	(1,3,5)	(1,3,5)	(1/5,1/3,1)
MC_2		(1,3,5)	(1,1,1)	(3,5,7)	(3,5,7)	(3,5,7)	(1,1,1)
MC_3		(1/5,1/3,1)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(1,1,1)	(1/7,1/5,1/3)
MC_4		(1/5,1/3,1)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(1,1,1)	(1/7,1/5,1/3)
MC_5		(1/5,1/3,1)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(1,1,1)	(1/7,1/5,1/3)
MC_6		(1,3,5)	(1,1,1)	(1,3,5)	(3,5,7)	(3,5,7)	(1,1,1)
DM_6	$\lambda=0.12$	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1		(1,1,1)	(1,1,1)	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)
MC_2		(1,1,1)	(1,1,1)	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)
MC_3		(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)
MC_4		(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)
MC_5		(1/5,1/3,1)	(1/5,1/3,1)	(1,3,5)	(1,3,5)	(1,1,1)	(1,1,1)
MC_6		(1/5,1/3,1)	(1/5,1/3,1)	(1,3,5)	(1,3,5)	(1,1,1)	(1,1,1)
DM_7	$\lambda=0.05$	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1		(1,1,1)	(1,3,5)	(3,5,7)	(5,7,9)	(5,7,9)	(1,1,1)
MC_2		(1/5,1/3,1)	(1,1,1)	(1,3,5)	(3,5,7)	(3,5,7)	(1/5,1/3,1)
MC_3		(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1,3,5)	(1,3,5)	(1/5,1/3,1)
MC_4		(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1,1,1)	(1/5,1/3,1)
MC_5		(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1,1,1)	(3,5,7)
MC_6		(1,1,1)	(1,3,5)	(1,3,5)	(1,3,5)	(1/7,1/5,1/3)	(1,1,1)

Table 4.10 The aggregated fuzzy judgment matrix for criteria of crew nationality pattern decision strategy.

	CC_1	CC_2	CC_3	CC_4	CC_5	CC_6	MAW
CC1	(1,1,1)	(0.42,0.86,1.91)	(2.55,4.63,6.66)	(2.70,4.82,6.85)	(1.65,3.17,4.46)	(0.50,1.01,2.06)	0.27
CC2	(0.52,1.16,2.39)	(1,1,1)	(1.93,4.07,6.11)	(2.19,4.32,6.35)	(1.34,2.84,4,14)	(0.52,1.05,2.06)	0.26
CC3	(0.15,0.22,0.39)	(0.16,0.25,0.52)	(1,1,1)	(1,1.37,1.59)	(0.49,0.69,1.20)	(0.17,0.26,0.57)	0.07
CC4	(0.15,0.21,0.37)	(0.16,0.23,0.46)	(0.63,0.73,1)	(1,1,1)	(0.46,0.56,0.83)	(0.17,0.26,0.57)	0.06
CC5	(0.22,0.32,0.61)	(0.24,0.35,0.75)	(0.83,1.44,2.06)	(1.21,1.79,2.18)	(1,1,1)	(0.39,0.58,0.87)	0.11
CC6	(0.49,0.99,2.02)	(0.49,0.95,1.91)	(1.77,3.91,5.95)	(1.77,3.91,5.95)	(1.14,1.73,2.56)	(1,1,1)	0.23
CCI = 0.01							

Table 4.11 The aggregated fuzzy judgment matrix for alternatives of crew nationality pattern selection strategy under each criterion.

Criteria		CA_1	CA_2	CA_3	MAW
CC_1	CA_1	(1,1,1)	(1.04,2.46,4.28)	(0.20,0.33,1)	0.56
	CA_2	(0.23,0.41,0.96)	(1,1,1)	(0.82,1.94,3.15)	0.27
	CA_3	(0.20,0.32,0.55)	(0.32,0.51,1.22)	(1,1,1)	0.17
CCI=0.02					
		CA_1	CA_2	CA_3	MAW
CC_2	CA_1	(1,1,1)	(0.43,0.90,2.07)	(0.79,1.31,2.68)	0.35
	CA_2	(0.48,1.11,2.33)	(1,1,1)	(0.94,2.17,3.48)	0.41
	CA_3	(0.37,0.76,1.27)	(0.29,0.46,1.06)	(1,1,1)	0.23
CCI=0.02					
		CA_1	CA_2	CA_3	MAW
CC_3	CA_1	(1,1,1)	(1.02,1.88,3.72)	(1.22,2.57,4.39)	0.52
	CA_2	(0.27,0.53,0.98)	(1,1,1)	(0.94,1.24,1.54)	0.27
	CA_3	(0.23,0.39,0.82)	(0.65,0.80,1.06)	(1,1,1)	0.22
CCI=0.01					
		CA_1	CA_2	CA_3	MAW
CC_4	CA_1	(1,1,1)	(1.45,3.59,5.64)	(1.21,3.31,5.34)	0.59
	CA_2	(0.18,0.28,0.69)	(1,1,1)	(0.70,0.92,1.25)	0.20
	CA_3	(0.19,0.30,0.82)	(0.80,1.09,1.42)	(1,1,1)	0.21
CCI=0.01					
		CA_1	CA_2	CA_3	MAW
CC_5	CA_1	(1,1,1)	(1.96,4.22,6.32)	(1.89,4.06,6.12)	0.65
	CA_2	(0.16,0.24,0.51)	(1,1,1)	(0.64,1.01,1.59)	0.18
	CA_3	(0.16,0.25,0.53)	(0.63,0.99,1.56)	(1,1,1)	0.18
CCI=0.01					
		CA_1	CA_2	CA_3	MAW
CC_6	CA_1	(1,1,1)	(0.88,1.77,2.62)	(1.67,3.62,5.63)	0.53
	CA_2	(0.38,0.57,1.14)	(1,1,1)	(0.71,1.47,2.43)	0.29
	CA_3	(0.18,0.28,0.60)	(0.41,0.68,1.41)	(1,1,1)	0.19
CCI=0.01					

Tablo 4.12 Final assessment for alternatives of the crew nationality pattern selection strategy.

	CC_1	CC_2	CC_3	CC_4	CC_5	CC_6	Alternative priority weight
Weight	0.35	0.33	0.06	0.03	0.12	0.12	
CA_1	0.52	0.35	0.53	0.61	0.72	0.52	**0.49**
CA_2	0.33	0.40	0.27	0.18	0.14	0.30	0.32
CA_3	0.15	0.25	0.20	0.21	0.14	0.18	0.19

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Chapter 5

Conclusion

Economic growth and increase of shipping services are parallel issues since most of the world's surface is covered by waterways. In the shipping services, there exist many alternatives for the type and size of ships of the ship investment, such as Capsize, Panamax, and Handymax. The decision for several alternatives on the ship investment and management plays a significant role for the owners to maximize their return. For this purpose, one of the significant points is related to the market-entry-exist decision. Investors need to consider several indicators such as new building price and freight rate, and understand these factors how to move before entering ship market. The second one is related to make a good decision for the type of the vessel that is important for the supply of shipping market. The last one could be considered for the third party ship management, which includes owner's management, full management outsourcing, crew, commercial, and technical, operational and crew management.

In this study, firstly, the market entry-exit time or ship investment timing is investigated. It is one of the most significant topics for owners to make a reasonable decision for the profit maximization and shipping company growth. However, their traditional characteristic behaviour displays irrationality that they purchase the ship(s) at the peak of ship market, and it causes dramatic loss of return on equity (ROE) rates the long term. The ROE ratio is one of the widely used indicators for profitability rate based on the invested capital; therefore, the regression model is based on ROE to make a decision for the investment timing in the dry bulk shipping market by evaluating the time lags of new building prices. For this purpose, many indicators related with ROE as mentioned in the previous section are investigated to determine an explanatory variable(s), and most of them are found high correlation with ROE and each other. New building (NB) one is found the highest correlation and it is just selected as an independent variable to prevent from muticollinearity influence. New building prices indicated possible time lags between the peak market and the market entry. The corresponding ROE stated the operation time for intended market entry timing. Two different prepositive terms are found to enter the shipping market based on the operation periods that owner already made a decision before investment. One of them is 10 years for the short operation periods (6 years), and the other is found 4 years for the long operation periods (12 years) after the lowest new building asset prices.

An Entrepreneur is expected to also make a good decision for the selection of the proper type of ship after defining the ship investment time. The analysis of the ship investments consists of various decisions based on the maximizing the profit and minimizing the risk, such as ordering new brand ship or second hand ship. The second Chapter investigates such a ship investment problem for the dry bulk transport industry. Most of the raw materials of the fundamental industries are carried by this type of ships and their cargo size is generally over 30,000 metric tons. Handymax and Panamax size ships have an important role in raw material shipments. In the present study, these two tonnages are selected for the empirical work of the intended shipping asset problem.

The analysis and selection of shipping projects before investment decision are often performed by the evaluation of technical and financial information. Financial assessment is one of the most important ones for the project selection problem; however, technical aspects are another important consideration which directly affects the performance of shipping service and the cost of operation (i.e. fixed costs).

Conventional investment analysis is focused on financial assessment of assets in a predefined period. In the financial approach, net present value (NPV) of investment is frequently used which is a total value of revenues and costs after discounting periodic inflation of currency. However, NPV is a value of cumulative profit which is gained from all operations; it is not a rate of profitability. For that reason, return on equity (ROE) is principally used for accounting how much profit investment generates when comparing to initial contribution to capital. ROE is an efficient and reliable rate of return on contributing to the investment. Second financial indicator is described as the loss probability. In addition, technical criteria are also defined as fuel consumption, loaded draught, ship's speed, and cargo crane existence. The result of the second chapter shows that the Handymax bulk carrier project is the best alternative which makes more profit during the operation periods.

The ship management as a service industry plays a significant role for the shipping companies because the owner needs to cut down operating costs and get the fiscal advantages of economies, and also it is important to get access to new sources of manpower. In the last Chapter, the shipping management problem is handled to define some of the factors that influence the separation of ownership and management in shipping business system. Third party ship management is considered as an instance of the separation of ownership and management. In the existing literature, some papers investigated this hot field to define the factors that affect ship management. This study reveals the most of them as the size, type, and age of ships, as well as owner's experience, profitability of management service and network facility by literature review and practitioner consultation. After analyzing the alternatives of third party ship management, the partial outsourcing of crew management is found for the dry bulk shipping companies. This result also causes the nationality problem for the crew management for the shipping companies to make a decision. For the crew management, a completely national crewing management, a joint employment of both national and international crew, and a complete foreign crew employment could be alternatives for the strategy of shipping companies. The result revealed that the national employment is the best alternative for the crew management of shipping companies.