İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

A NEW GENERIC METHOD FOR LARGE INVESTMENT ANALYSIS IN INDUSTRY AND AN APPLICATION IN SHIPYARD - PORT INVESTMENT

Ph.D. Thesis by
Burak Ömer SARAÇOĞLU

Department : Naval Architecture

Programme : Naval Architecture

AUGUST 2009

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<u>İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ</u>

BÜYÜK YATIRIM ANALİZLERİNDE YENİ GENEL BİR YÖNTEM VE TERSANE - LİMAN YATIRIMINDA BİR UYGULAMA

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FOREWORD

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"...recognition of the inherent dignity and of the equal and inalienable rights of all members of the human family is the foundation of freedom, justice and peace in the world" Preamble to the Universal Declaration of Human Rights, 1948

"Believe nothing you hear and only half of what you see." Mark Twain

"*Do the right thing. It will gratify some people and astonish the rest."* Mark Twain

"That which does not destroy us makes us stronger." Friedrich Nietzsche

February 2009 Burak Omer SARACOGLU

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ABBREVIATIONS

AGI	:	Adjusted Gross Income
AHP	:	Analytical Hierarchy Process
AI	:	Artificial Intelligence
ANP	:	Analytical Network Process
APV	:	Adjusted Present Value
ARR	:	Accounting Rate of Return
AS	:	Applied Software
AT	:	Applied Techniques
ATOI	:	After Tax Operating Income
B/C (BCR)	:	Benefit Cost Ratio
CAPM	:	Capital Asset Pricing Model
CAR	:	Cumulative Abnormal Return
CBIS	:	Computer Based Information System
CBS	:	Computer Based Systems
CEO	:	Chief Executive Officer
CFPS	:	Cash Flow per Share
CFROI	:	Cash Flow Return on Investment
CMS	:	Cooperation Management Systems
CVA	:	Cash Value Added
DCF	:	Discounted Cash Flow
DDB	:	Double Declining Balance
DDM	:	Dividend Discount Model
DDMO	:	Distributed Decision Making Organization
DM	:	Decision Maker
DME	:	Decision Making Element
DMO	:	Decision Making Organization
DMS	:	Database Management Systems
DOL	:	Degree of Operating Leverage
DS	:	Dialogue Systems
DSS	:	Decision Support Systems
E	:	Expert
EBIAT	:	Earnings Before Interest After Taxes
EBIBAT	:	Earnings Before Interest But After Taxes
EBIT	:	Earnings Before Interest And Taxes
EBITAE	:	Earnings Before Interest, Tax, Amortization and Exceptional Items
EBITDA	:	Earnings Before Tax Interest Depreciation and Amortization
EBITDARM	:	Earnings Before Interest, Taxes, Depreciation, Amortization, Rent and Management Fees
EIS	:	Executive Information Systems
EG	:	Expert Group
ELECTRE	:	Eliminasion et Choix Traduisant la Realité
EMS	:	Electronic Meeting Systems

ES	:	Expert Systems
ESS	:	Executive Support Systems
EU	:	European Union
EUAW	:	Equivalent Uniform Annual Worth
EVA	:	Economic Value Added
FCF	:	Free Cash Flow
FCFE	:	Free Cash Flow to Equity
FCFF	:	Free Cash Flow For The Firm
FCFPS	:	Free Cash Flow Per Share
FCFY	:	Free Cash Flow Yield
FI	:	For Instance
FV	:	Future Value
GDSS	:	Group Decision Support Systems
I	:	Investors
IDRA	:	Intercriteria Decision Rule Approach
IFO	:	Income from Operations
IGE	:	Information Generating Element
IJV	:	International Joint Venture
IOIS	:	Intelligent Organizational Information Systems
IRR	:	Internal Rate of Return
IRS	:	Information Reporting Systems
ISE	:	Information Storage Element
ISP	:	Ill Structured Problem
KBMS	:	Knowledge Base Management Systems
KM	:	Knowledge Management
KMS	:	Knowledge Management Systems
KS	:	Knowledge Sharing
K-T	:	Kepner-Tregoe
LDA	:	Linear Discriminant Analysis
LNG	:	Liquidified Natural Gas
LP	:	Linear Program
M&A	:	Mergers and Acusitions
MACBETH	:	Measuring Attractiveness by a Categorical Based Evaluation Technique
MACRS	:	Modified Accelerated Cost Recovery System
MADM	:	Multi Attribute Decision Making
MARSAN	:	Méthode d'Analyse, de Recherche, et de Sélection d'Activités Nouvelles
MAUT	:	Multi-Attribute Utility Theory
MCDA	:	Multiple Criteria Decision Aid
MCDM	:	Multi Criteria Decision Making
MHDIS	:	Multi-group Hierarchical DIScrimination
MIRR	:	Modified Internal Rate of Return
MIS	:	Management Information Systems
MMS	:	Model Management Systems
MODM	:	Multi Objective Decision Making
NFW	:	Net Future Worth
NI	:	Net Income
NOI	:	Net Operating Income
NOPAT	:	Net Operating Profit after Taxes

NPV	:	Net Present Value
NPW	:	Net Present Worth
NPWI	:	Net Present Worth Index
NRR	:	Net Rate of Return
OCF	:	Operating Cash Flow
ODSS	:	Organizational Decision Support Systems
OIS	:	Office Information Systems
ORR	:	Overall Rate of Return
P/E	:	Price/Earning
PACMAN	:	Passive and Active Compensability Multicriteria Analysis
PBIT	:	Profit Before Interest and Taxes
PBV	:	Price/Book Value
PCCA	:	Pairwise Criterion Comparison Approach
PESYS	:	Pascal Expert System Shell
PGE	:	Product Generating Element
PODA	:	Pareto-Optimal Design Alternatives
POP	:	Payout Period
POPI	:	Payout Period with Interest
PSE	:	Product Storage Element
PV	:	Present Value
QDA	:	Quadratic Discriminant Analysis
R&D	:	Research and Development
REV	:	Revenue
ROA	:	Return on Assets
ROAI	:	Return on Average Investment
ROC	:	Return on Capital
ROCE	:	Return on Capital Employed
ROE	:	Return on Equity
ROGI	:	Return on Gross Investment
ROI	:	Return on Investment
ROIC	:	Return on Investment Capital
RONA	:	Return on Net Assets
ROR	:	Rate of Return
ROTAS	:	Rotating and Sliding System
SAW	:	Simple Additive Weighting Method
SMART	:	Simple Multi Attribute Rating Technique
SVA	:	Shareholder Value Added
TBR	:	Total Business Return
TOMASO	:	Technique for Ordinal Multiattribute Sorting and Ordering
TOPSIS	:	Technique for Order Preference by Similarity to Ideal Solution
TSR	:	Total Shareholder Return
US	:	United States
USCG	:	U.S. Coast Guard
UTA	:	Utilitès Additives
UTADIS	:	Utilits Additives Discriminantes
WBS	:	Work Breakdown Structure
WSP	:	Well-Structured Problem

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A NEW GENERIC METHOD FOR LARGE INVESTMENT ANALYSIS IN INDUSTRY AND AN APPLICATION IN SHIPYARD - PORT INVESTMENT

SUMMARY

This research might be one of the *"cross-industry studies"*, which is devoted to solve basically the decision making problems at investment analysis in shipbuilding industry, logistics industry (port investment), shipping industry, energy sector and other mega investment based industries.

A taxonomic (classification) study was tried to be conducted for the literature review of decision making, management systems, investment analysis, mathematical and statistical methods and software and coding. A literature review was performed in industry applications and properties to give detail information about the industry that the case study would be conducted. In management systems classification study, seventy papers and books were in detail studied. The oldest study was published in 1969 and the newest was published in 2006. This research was probably the first and necessary step in the process of developing an Executive Support System, which was in strategic level system of organizations for making the decision at investment analysis in mega investment based industries. In decision making classification study, seventy papers and books were in detail studied. The oldest study was published in 1973 and the newest was published in 2006. In current study, a method based on Analytical Network Process Method was selected for application in the decision making of the investment analysis. In investment analysis classification study, forty papers and books were in detail studied. The oldest study was published in 1988 and the newest was published in 2007. The performance measures were in detail explained and presented. In mathematical and statistical methods classification study, seventy papers and books were in detail studied. The oldest study was published in 1970 and the newest was published in 2008. In software and coding classification study, fourty papers and books were in detail studied. The oldest study was published in 1986 and the newest was published in 2007. In industry applications and properties subtitle, sufficient number of studies were in detail studied to explain the major players and their status in shipbuilding industry and other industries. The oldest study was published in 2005 and the newest was published in 2008.

A new generic method for large investment analysis in industry, based on multi-objective optimization and fuzzy multi attribute decision making is explained. The proposed method has three main phases respectively named as pre-decision phase that has 15 main steps, in which definition and description of investment decision phase model is executed; decision phase that has 31 main steps, in which collection and analyze of investment decision is executed and post-decision phase that has 5 main steps, in which analyze and conclusion.

A case study to demonstrate that the proposed method can be applied to real world investment decisions in shipbuilding industry and logistics industry (port investment), which is characterized as mega-project and mega-investment industry, was conducted in the feasibility evaluation of Gelibolu Ship Industry Shipyard Ltd., that is the name of a legal entity of a shipyard in Turkey and a virtual feasibility evaluation of a virtual entity of port and ship repair yard named as Virtual Gelibolu PORREP.

This thesis and research also concludes by highlighting future directions for research in several industries and in different research areas based on this area.

BÜYÜK YATIRIM ANALİZLERİNDE YENİ GENEL BİR YÖNTEM VE TERSANE - LİMAN YATIRIMINDA BİR UYGULAMA

ÖZET

Bu araştırma genel olarak büyük yatırımların gerektiği sektörlerde yatırım analizleri problemlerine çözüm olmayı amaçlayan çalışmalardan biri olarak karşımıza çıkmaktadır.

Karar verme, yönetim sistemleri, yatırım analizleri, matematiksel ve istatistiksel yöntemler ve yazılım-kodlama literatür taraması çalışmasının gerçekleştirilebilmesi için bir sınıflandırma bilimi çalışması yapılmaya çalışılmıştır. Endüstri uygulamaları ve özellikleri kısmında ise, bir vaka çalışması yapılacak olan gemi inşaatı sektörü ve liman yönetimi hakkında detaylı bilgi literatür taraması ile sunulmuştur. Yönetim sistemleri sınıflandırma bilimi çalışmasında 70 makale ve kitap taranmış kaynaklar arasından sunulanlardır. Kaynaklardan en eskisi 1969 yılı en yenisi 2006 yılı baskılıdır. Bu çalışma bir üst yönetim destek sisteminin temellerinin atılmasına olanak verecektir. Karar verme sınıflandırma bilimi çalışmasında 70 makale ve kitap taranmış kaynaklar arasından sunulanlardır. En eski kaynak 1973 yılı en yeni kaynak 2006 yılı baskılıdır. Bu çalışmada Analitik Ağ Yönteminin kullanılmasına karar verilmiştir. Yatırım analizleri sınıflandırma bilimi çalışmasında 40 makale ve kitap detaylı şekilde taranmış kaynaklar arasından sunulanlardır. En eski kaynak 1988 yılında en yeni kaynak 2007 yılında yayımlanmıştır. Bu kaynaklara dayalı olarak çeşitli performans göstergeleri açıklanmış ve sunulmuştur. Matematiksel ve istatistiksel yöntemler sınıflandırma bilimi çalışmasında 70 makale ve kitap irdelenmiş kaynaklar arasından sunulanlardır. Bu kaynaklardan en eskisi 1970 en yenisi 2008 yılında yayımlanmıştır. Yazılım ve kodlama sınıflandırma bilimi çalışmasında 40 makale ve kitap detaylı olarak incelenmiş kaynaklar arasından sunulanlardır. Bu kaynaklardan en eskisi 1986 yılında en yenisi 2007 yılında yayımlanmıştır. Endüstri uygulamaları ve özellikleri başlığı altında gemi inşaatı sektöründe ve liman yönetiminde bulunan ana oyuncular hakkında detaylı bilgiler sunulmuştur. Bu çalışmaların en eskisi 2005 yılında en yenisi 2008 yılında yayımlanmıştır.

Bu çalışma ile çok amaçlı karar verme optimizasyonuna ve bulanık mantık temelli çok seçimli karar verme yöntemlerine dayalı yeni genel bir yöntem, yatırım analizlerinde kullanılabilmesi için sunulmuştur. Sunulan yöntem üç ana fazdan oluşmaktadır. Bunlardan birincisi ön karar verme aşaması olup 15 adımdan oluşmakta ve yatırım karar modelinin tanımlama ve araştırma kısımlarını kapsamaktadır. İkinci aşama ise 31 ana adımdan oluşmakta ve yatırım bilgilerinin toplanması ve modelin çalışmasını içinde barındırmaktadır. Son aşama ise 5 ana adımdan oluşmakta ve değerlendirmeler ile sonuçları içinde barındırmaktadır.

Bu çalışmada önerilen yöntemin gerçek yaşamdaki yatırım analizlerinde rahatlıkla uygulanabileceğinin kanıtlanması için gemi inşaatı sektöründe ve lojistik sektörünün

alt bir kolu sayılabilecek liman işletmelerinde bir vaka çalışması gerçekleştirilmiştir. Bu iki yatırımda çok büyük projeler ve çok büyük yatırımlar olarak sınıflandırılmaktadır. Gelibolu Gemi Endustrisi Sanayi ve Ticaret A.S. yasal bir Türk işletmesidir ve Türkiyede tersane yatırımını amaçlamaktadır, sanal liman – bakım onarım tersanesi Virtual Gelibolu PORREP ise sanal bir Türk işletmesidir ve sanal liman – bakım onarım tersanesi yatırımını amaçlamaktadır. Bu iki işletmeye ait yatırım analizleri vaka çalışması gerçekleştirilmiştir.

Sonuç bölümünde, bu çalışmaya dayalı olabilecek gelecek çalışmalar hakkında bilgi verilmiştir.

1. INTRODUCTION

In the real life, decision makers such as tycoons, investors, chief executives, experts in financial holdings, consultants, government agencies etc. working in the areas of economics, engineering or social sciences are usually faced with the problem of selecting an alternative from a given set of finite number of alternatives which could be optimal for a given set of objectives or goals that in most cases are conflicting non-commensurable with each other. Investment analysis regardless of the industry is one of the key examples for the defined problem above. In the process of an investment decision, the awareness and the importance of not only the financial aspects but the awareness and the importance of other aspects such as legal, political and environmental etc. were increased by decision makers; thereafter some wrong investments had been done. For instance, the Davis Besse Nuclear Power Plant that is operated by First Energy Nuclear Operating Co. in Ohio State in the United States of America is not accepted as an appropriate decision, in which the operating permitting was issued in 1977, thereafter two major incidents occured, vessel head degradation event on 27/02/2002 and loss of offsite power due to tornado event on 24/06/1998, when environmental aspects are taken in consideration (Greenpeace USA, 2006). Based on hard facts from most of the environmental assessment reports, both coal power plants and nuclear power plants have not been decided according to proper investment analysis methods, which should have been considered not only financial aspects but also health, environment and safety aspects.

The wrong decisions or the correct decisions at investments do influence not only the governments and the cooperations, but also the personal career of managers such as CEOs. The foremost expectation from a CEO is to foresee the future movements of the competitors and the new players in the target market and act or react according to this new status by help of new investment decisions or other management decisions such as M&As or IJVs, which should be made correctly according to legal, political, financial, environmental etc. aspects.

This cooperate expectation makes the earnings of CEOs much higher than any other manager; for example, based on salary, bonus, other pay, gains from exercising options, value of incentive stock that vested and increases in the value of pension plan, Kevin Rollins of Dell earned $39.314.839 in 2005, Sidney Taurel of Eli Lilly earned $16.643.068 in 2005, Richard Parsons of Time Warner earned $12.668.761 in 2005 and H. Lee Scott of Wal-Mart Stores earned $10.610.858 in 2005. In spite of these expectations, hot news proved that the reality was different. Charles Prince, Chief Executive of Citigroup was caused the financial firm would have need an additional $8 billion to $11 billion in sub prime mortgage related write downs, would be leaving the Citigroup. Although in most cases, "*walk-away pay*" is transferred to CEOs bank account, the reputation of CEO is devastated. For example, Douglas Ivester of Coca-Cola, who had been accused the stagnant growth, the declining earnings, the bad publicity and the seriously irritation of shareholders, took $120 million when he stepped down in 2000 in his mid-50s.

In conclusion, this research study, which is both conceptual and mathematical, is one of the first and necessary step for developing an Executive Support System at investment analysis in major investment based industries. The aim of this research is modelling an executive support tool for risk seeking and/or risk averse decision maker to define investment parameters, objectives and constraints; to generate Pareto Optimal (This term is preferred according to literature review in current study, so that it can be slightly different from several science fields.) investment alternatives in different sectors; to define investment attributes and to select of best Pareto Optimal investment alternative. The "*one man show*" decisions on investment analysis in real applications in shipbuilding industry, logistics industry (port investment) as well as in other industries shall be more systematic by help of redounding the academic point by succeeding the current research.

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1.1 Statement of the Problem

Investment analysis by its nature in shipbuilding industry, port management or other industries like shipbuilding industry are characterized as multi objective optimisation situations and multi attribute decision making situations, which have the common problems as follows:

- Mega-projects and mega-investments,

In the real world, at investment analysis in the specified industries, the decisions are made rarely because of being mega projects and mega investments. For instance, in aerospace industry, which is characterized as same as shipbuilding, port management, shipping and energy industries, Eurofighter Typhoon Investment and Project was started in 1979, cost £19 billion; Airbus A380 Investment and Project was started in 1990, cost US $17.1 billion; F-35 Lightning II (Joint Strike Fighter) Investment and Project was started in 1990, cost US $40 billion are the best suitable examples (Url-1). In construction industry, which is characterized as same as shipbuilding industry or energy industry, Kansai International Airport, Japan Investment and Project was started in 1987, cost US $20 billion; Burj Dubai, Dubai, United Arab Emirates Investment and Project was started in 2004, estimated to be cost US $4.1 billion with downtown US $20 billion Three Gorges Dam, China Investment and Project was started in 1992, estimated to be cost US $22.5 billion are best suitable examples (Url-2). These investments are costly, risky and unforeseeable, moreover their decisions are taken rarely; hence they are mega-projects and mega-investments.

Therefore, a good method must consider the importance of risk handling, ease of understanding and usage and finally goodness to fit appropriateness.

- Involvement of multiple objectives,

The most of investment problems involve challenging objectives (payback period minimization, EBITDA: Earnings Before Interest, Taxes, Depreciation, Amortization maximization, IRR: Internal Rate of Return maximization) and are focused on parameters and constraints, that can be either objective or subjective. Consequently, they are cases of multiple objective optimisation problems.

Therefore, a good method must consider the objectives and in a given set of solutions, which “a movement from one solution to another that can make at least one individual better off without making any other individual worse off, alias non-dominance, which is called as Pareto Optimal Set” (Olcer et. al., 2006).

- Imprecise data,

In the real world, decision makers deal with unquantifiable, incomplete, no obtainable, partial information, which increase subjectivity.

Therefore, a good method must consider handling the obstacle of imprecise data.

- The mixture of fuzzy and crisp data,

In real life, a decision maker may face with difficulty in quantifying and processing such linguistic statements, hence decision data are usually fuzzy, crisp, stochastic or mixture of them.

Therefore, a good method must consider dealing with the ambiguity, vagueness, uncertainty, imprecision.

- Involvement of multiple decision makers,

The most of the investment problems, a team of investors, CEOs, experts, consultants, specialists and managers are involved and focused on an analysis and evaluation of decision making process. Consequently, they are cases of multiple attribute based group decision making problems.

Therefore, a good method must consider dealing with group of decision makers.

- Expert weighting,

The importance of each decision maker against an attribute is usually not equal. Sometimes, there are more powerful experts in decision group such as some experts are more experienced than others, so that the investors are more influenced by them.

Therefore, a good method must consider the degree of importance of each decision maker.

In the current study of the multi attribute decision making, multi objective decision making, Pareto efficiency, Executive Support Systems, financial statements, risk analysis, fuzzy logic are useful tools, systems and methods.

1.2 Motivation of Research Study

The modern era of decision making at investment analysis in shipbuilding industry and other major investment based industries is over three decades old now. {If one assumes it began academically when "Planning for Shipyard Investment - A Decision Support System" was published by Jonathan Frank in 1974 (Frank, J., 1974)}. Since then companies have been signing major consultancy deals across the globe for investment analysis to make their decisions as precisely correct as possible. For instance, TTS Consulting, which is the shipbuilding consultancy market leader, has been assisted more than 80 clients including shipbuilders, ship owners, ship brokers, investors, banks, insurance companies etc., world wide up through the past twenty years. Harland & Wolff Heavy Industry requested support for its "Shipyard Development Study" in 2001, Rodman Polyships in 1999 got assistance for its "Feasibility Study", Fundia requested support for its "Business Opportunity Study" in 1996, Belgian Shipbuilders Corp. contracted its "Strategy Study" in 1994 and in 1995, Kværner Warnow purchased service for its "Shipyard Development Plan" in 1993 etc. from TTS Consulting. Companies such like TTS Consulting have been acquired specifically highly educated staff for only this purpose. The methods and conditions on decision making at investment analysis have been changed very fast since Jonathan Frank published his study in 1974. Academics, by and large, have been relatively slow to catch up this phenomenon. Perhaps it is because of a topic that is difficult to research or because of improperness in gathering data, which could be supplied by firms in poor and unreliable way or perhaps because of simply is *"off the radar screen*" for whatever reason by academics. Because of this, awareness of importance on decision making at investment analysis has for the most part been driven by the practitioners in different industries, for instance finance and banking. Although academic research has been increasing on decision making topics over the last years, it seems largely disconnected with investment analysis. There has not been any serious attempt from academics to analyze and synthesize the research on this subject. Whilst academics have been slow to follow up the practitioners, by this research study named as "A New Generic Method for Large Investment Analysis in Industry and An Application in Shipyard - Port Investment", it is now generally recognized as an important area in academic literature once again.

1.3 Research Study Objectives

This research might be one of the *"cross-industry studies"*, which is devoted to solve basically the decision making problems at investment analysis in shipbuilding industry and other major investment industries. This study is undertaken to fill that gap in the field of decision making procedures and models of investment analysis knowledge. More specifically, the main research objectives are as follows:

I. To proffer a compendious and comprehensible framework for exploring, cataloguing, synthesizing and integrating existing literature,

II. To identify and categorize the various research foci,

III. To determine the emphasized theoretical mindsets used to structure the analysis of the topic in existing literature,

IV. To ascertain the methodologies utilized to conduct the analysis,

V. To identify, explain in detail and group or re-group the investment analysis decision or performance factors in several sectors,

VI. To prepare a pros and cons analysis for the existing investment analysis,

VII. To propose a new procedure or technique or "*red tape*" for decision making at investment analysis,

VIII. To analyze the system for building up an Executive Support System based on the new proposed methodology,

IX. To conduct case study one or more of the "*heavy weight*" industries, which could be shipbuilding, shipping, logistics and energy to illustrate how well the proposed method fits to real applications,

X. To demarcate any themes, which could be any trends in the literature, more specifically to make recommendations as well as point out opportunities and suggestions for future research.

1.4 Scope of the Research Study and Overview of Research Study Structure

The scope of this research study is schematically represented in "Figure 1.4.1 Representation of scope of the research study" as below to have a clear of mind and ease of understanding. The supersets represents the main topics and subsets represents the subtopics, which are studied in detail. The fact that there are enourmous subtopics, which can not be represented in the Figure 1.4.1, only a few of names given and others mentioned as dots and ended with n. The scope of the research study as shown, is an intersection set of the main topics that are

A. "*decision making*", which includes "Multi Attribute Decision Making (MADM)" subincluded by "Analytical Hierarchy Process (AHP)", "Analytical Network Process (ANP)" etc., "Simple Multi Attribute Rating Technique (SMART)", "Multi Criteria Decision Making (MCDM)", "Multi Objective Decision Making (MODM)", "Kepner-Tregoe (K-T) decision analysis", "cost-benefit analysis", "the PROMETHEE method" and so on;

B. "*management systems*", which is subdivided as "Executive Information Systems (EIS)", "Decision Support Systems (DSS)", "Executive Support Systems (ESS)", "Group Decision Support Systems (GDSS)", "Organizational Decision Support Systems (ODSS)" and so forth;

C. "*investment analysis*", which has subtopics as "financial statements", "market efficiency and analysis", "risk analysis", "measuring earnings", "financial parameters", "payback period", "cost work breakdown structures", "life cycle cost analysis" and "pros and cons analysis for existing investment analysis approaches" and so on;

D. "*industry applications and properties*", which includes "shipbuilding industry", "banking industry", "real estate industry", "shipping industry", "energy industry", "stock markets" and so forth;

E. "*mathematical and statistical methods*" such as "fuzzy logic", "Pareto Sets", "probability", "regression methods", "Newtonian mathematics", "non-Newtonian mathematics" and so on;

F. "*software and coding*", which includes "C++ coding", "visual basic coding", "on the shelf software packages" and so on.

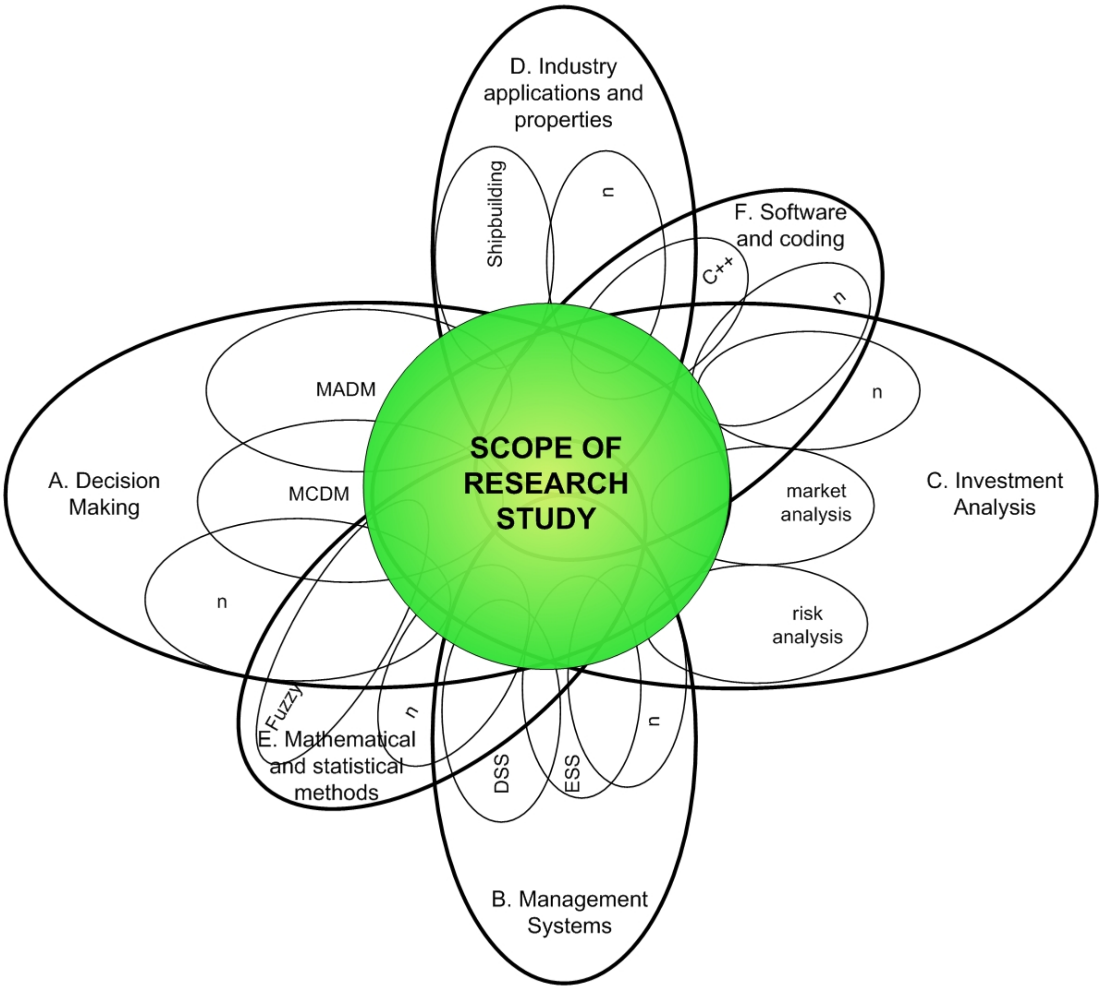


Figure 1.4.1 : Representation of scope of the research study.

The scope of research study as presented in Figure 1.4.1 might get the current study on the edge and might make it more complicated than most of the others, hence the need for a systematic structure for research study is a must. A roadmap was built up based on Farrukh, Cl. J.P. et. al. study named as “Characterisation of Technology Roadmaps: Purpose and Format” (Farrukh et. al., 2001). There are eigth workpackages. In the first one in-depth interviews and brainstorming sessions with the industry experts has been performed, afterwards the gap in the industry at the current topic has been defined. This gap has been defined with a clause as like the base of skyscraper. The following six workpackages has been done for the literature review and at the end of each workpackage the gap according the Figure 1.4.1 and the topic of the study has been defined by help of a sentence.

The final workpackage summarize all sentences and the modelling has been performed, which tested by case study or studies. The roadmap is schematically represented in “Figure 1.4.2 Overview of research study structure” as below.

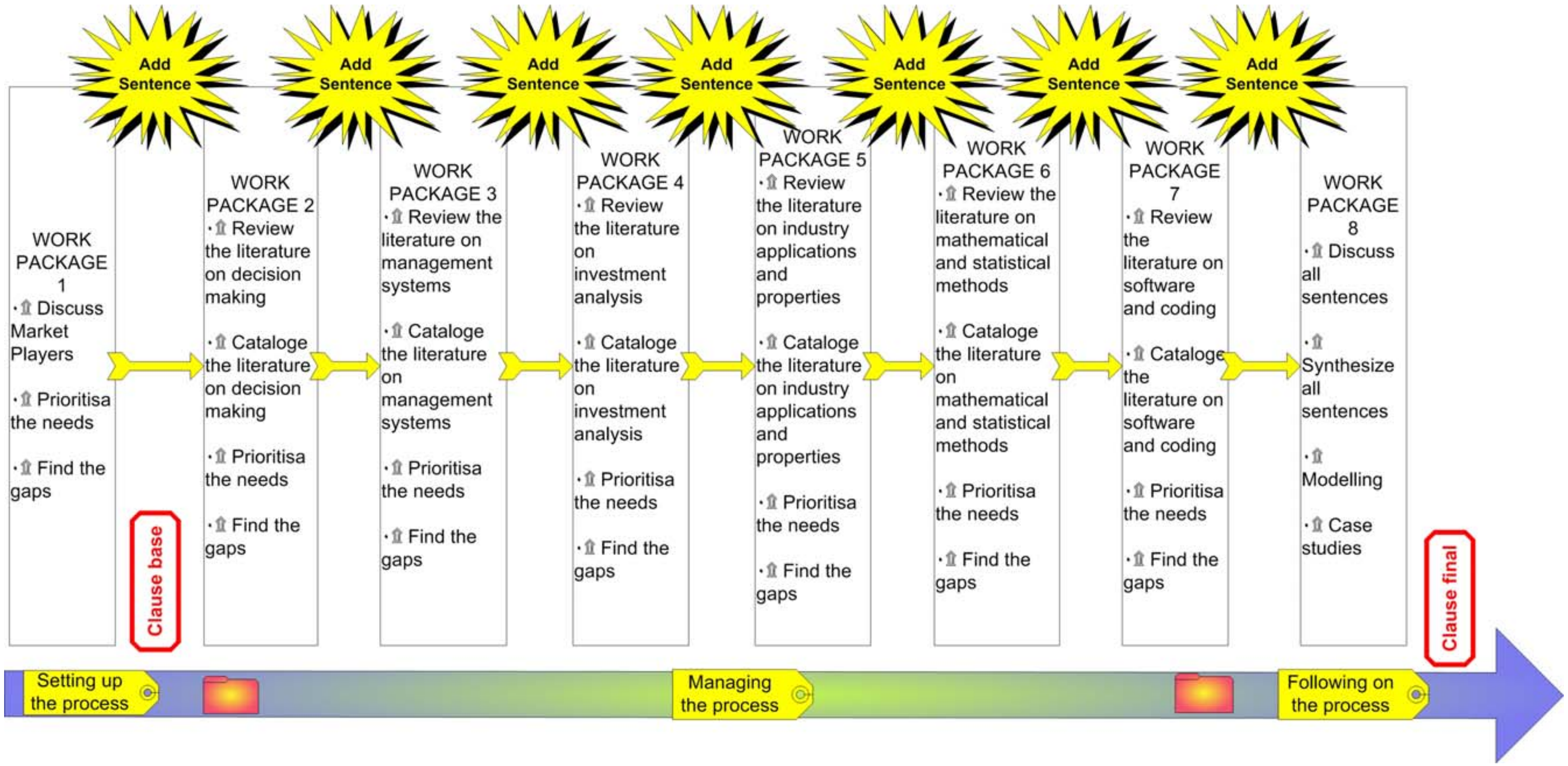


Figure 1.4.2 : Overview of research study structure.

1.5 Thesis Organisation

The thesis consists of five chapters and seven appendices.

The first chapter is an introduction to explain the background of the investment analysis problems and to explain the objectives and the motivation of the research. The problem statements, the goal and the objectives of the research, the scope of the research study and overview of research study structure are given in this chapter.

A review of relevant literature and the classification study of the research topic is summarised in the second chapter. Chapter 2 discusses and reviews the literature on decision making, management systems, investment analysis, industry applications and properties, mathematical and statistical methods, software and coding and constitutes backbone knowledge of this research. Several concepts such as Multi Attribute Decision Making, Analytical Hierarchy Process, Analytical Network Process, Eliminasion et Choix Traduisant la Realité, Simple Multi Attribute Rating Technique, Multi Objective Decision Making, Executive Information Systems, Executive Support Systems, Organizational Decision Support Systems, Financial Statements, Life Cycle Cost Analysis, Fuzzy Logic, Pareto Sets are described and given in this chapter.

In Chapter 3, the conceptual model of the proposed method and its methodology is given. In the proposed method, there are three phases, which are named as Pre-Decision Phase, Decision Phase and Post-Decision Phase. There are totally fifty one steps in these three phases.

In Chapter 4, a case study in shipbuilding industry and logistics industry (port investment) is presented to verify and to validate the proposed methodology and demonstrate its application.

Finally, Chapter 5 concludes this study and suggests future directions for further research.

The taxonomic (classification) literature review is presented in Appendix A through Appendix E. Detailed data, detailed results and their figures of the case study in shipbuilding industry and logistics industry is given in Appendix F and Appendix G.

2. LITERATURE REVIEW

The literature review in this research field was carried out for establishing a background for the proposed research. The selection process of reference studies was involved four phases as electronic database selection or online book shopping web site selection, journal selection, time frame selection and paper selection or book selection. An extensive literature review was conducted to frame as wide a mesh as possible over the current topic. Journals, not only European but also English language American and Asian were reviewed, beyond the proceedings from major investment, shipbuilding, shipping, logistics and energy conferences were also examined. Thirty four conspicuous electronic databases, ten well known online book shopping web sites such as Onlinebooks and Amazon were reviewed. The reviewed databases were shown in "Table 2.1 Details of reviewed database in first phase literature review" as below. The explanations column of Table 2.1 was directly taken from the reviewed database and Istanbul Technical University Online Library explanations.

Table 2.1 : Details of reviewed database in first phase literature review, adapted from Url-3.

Reviewed Database	Explanations
ABI Inform Global	"This database contains information geared towards business, management technologies, accountant, international economy, environmental sciences, law, information sciences, mining, etc. It includes Wall Street Journal, Financial Times and 14,000 fulltext thesis. In this database more than 3800 journals exist and 2800 journals are accessible in fulltext."
ACM Digital Library	"354 journals and proceedings about computer sciences are available in fulltext in this database."
ALPSP-Science & Technology	"138 journals about engineering are accesible in fulltext in this database."
Applied Science&Technology	"This database contains bibliographic information and abstracts of papers about economics from selected periodicals, as well as other publications from economic literature such as books, book reviews, dissertations, etc"
ASCE: American Society of Civil Engineers	"30 journals about civil engineering and related subjects are accesible in fulltext in this database."
ASME : American Society of Mechanical Engineers	"22 journals about mechanical engineering and related subjects are accesible in fulltext in this database."
Blackwell – Synergy	"778 journals covering a broad subject range such as medicine, nursery, veterinary, engineering, entomology and social sciences are accesible in fulltext in this database."

Table 2.1 (continued) **:** Details of reviewed database in first phase literature review, adapted from Url-3.

Reviewed Database	Explanations
Cambridge Journals online	"This database contains all journals of Cambridge University Press which are available in fulltext. 255 fulltext can be accessed. Subject areas of these journals are science and technology, medicine, religion, social sciences and humanities."
CRC ENVIROnetBASE	"283 books are accesible in fulltext in this database."
CRC ITKnowledgeBASE	"186 books are accesible in fulltext in this database."
CRC MATERIALSnetBASE	"201 books are accesible in fulltext in this database."
Digital Dissertations	"This database contains bibliographic information and abstracts of more than 2 million Ph. D. and master thesis published since 1861. More than 450,000 dissertations after 1997 are available in fulltext."
Directory of Open Access Journals (DOAJ)	"DOAJ is a directory service where more than 823 fulltext journals accessible without subscription are listed by subject categories. A broad range of journals is covered such as various engineering disciplines, social sciences, medicine, economy, etc."
Ebrary Electronic Books	"Ebrary contains more than 35,000 elektronic books grouped in five collections: "Business & Economics", "Computers, Technology & Engineering", "Humanities", "Life & Physical Sciences" and "Social & Behavioral Sciences"."
Econlit	"Econlit includes articles in selected periodicals and summaries or bibliographies in the other publications which generate the economic literature. It provides you to scan resources about people and social science."
Emerald Insight	"Various databases that contain fulltext articles, reviews and abstracts about management, library & information services, specialized ranges of engineering, etc. are avaliable via this service. 157 fulltext journals can be reached."
Engineering Village 2	"This database contains the Compendex database which indexes approximately 5,000 selected journals about various engineering disciplines"
ENGnetBASE	"This database contains 734 handbooks of CRC Press about various engineering subjects in fulltext."
Expanded Academic ASAP International	"This is a multi-disciplinary database which contains 2855 journals in fulltext."
Global Books in Print	"This database contains bibliographic information about books from American, British and Canadian publishers, as well as information such as book abstracts, author bibliographies, etc. You can use this database for tracking new publications about your research areas."
Iconda	"This database contains bibliographic information and abstracts of papers about construction from selected periodicals."
IEEE / IEE Electronic Library	"This database provides fulltext access to 131 journal of IEEE, 20 journal of IEE and 620 conference from 1988 about electric-electronic engineering, computer science, applied physics and biotechnology.It also provides access to 100,000 journals and 1600 up-to-date IEEE standards from 1950-1987."
Referex E-Book	"747 e-books which are about chemistry, electric, electronic and computer are available in fulltext in this database."
Safari E-Book	"400 e-books which are about computer, technique, enterprise ve management science are available in fulltext in this database."
Science Direct (Elsevier)	"1837 journals about engineering, technology, medicine, chemistry, computer sciences, social sciences and economy are available in fulltext in this database."

Table 2.1 (continued) **:**Details of reviewed database in first phase literature review, adapted from Url-3.

Reviewed Database	Explanations
Science Online	"Science is inter dicipline weekly science journal, presented by American Association for the Advancement of Science (AAAS) since 1883. Science Online provides to access basic, social, geographical, engineering, medical and life science issues since 1997."
Springer Lecture Notes in Computer Science	"One of the most important resourses that includes new techniques of researches and teaching about computers. Virtual mind and bioinformatics are also subsections. Above 1500 books since 1997 can be accessed in fulltext in this database."
Springer Link	"Springer and Kluwer journals are now accessible from the same interface. 1281 journals about medicine, chemistry, geology, computer sciences, mathematics, astronomy, law and economics are available in fulltext in this database."
SwetsWise	"This database contains table of contents of more than 18,076 journals and give fulltext access to 7778 journals in the same interface."
Taylor & Francis Journals	"1560 journals published by Taylor & Francis are open for fulltext access. A broad range of journals is available, such as various engineering disciplines, social sciences, medicine, economy, etc in this database."
Transportation Research Records	"This database contains fulltext papers about transportation and related subjects"
University of California Press Scholarship Editions	"201 books are accesible in fulltext in this database."
Web of Science	"This database contains Science Citation Index (since 1970), Social Science Citation Index (since 1970) and Arts & Humanities Index (since 1975) databases."
Wiley InterScience	"468 journals about business, finance and administration, law, chemistry, medicine, computer sciences, geology, mathematics and statistics, physics, teaching, engineering and physicology are available in fulltext."

The previous literature was searched spanning from 1968 through 2008, a forty year period. During searching in the electronic database or online book shopping web sites the unlimited truncation option was used. This made the investigation of all possible suffix variations of a root word possible. The key words such as decision making, MADM, MCDM, MODM, attribute generation, data and weight, dominance literature, satisfaction methods, sequential elimination methods, attitude oriented methods, TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), ELECTRE, scoring methods, median ranking method, AHP, ANP, choice & validity methods, fuzzy logic, fuzzy sets, fuzzy relations, membership functions, fuzzy to crisp conversion, fuzzy article number, classical logic, fuzzy rule based systems, fuzzy nonlinear simulation, fuzzy decision making, fuzzy classification, fuzzy pattern recognition, fuzzy control systems, fuzzy software, Decision Support

Systems, Executive Support Systems, investment analysis, Pareto Frontier, Pareto Optimal etc. were written to search tool box.

The literature review is classified into six main groups as management systems, decision making, investment analysis, industry applications and properties which is structured different than other main groups, mathematical and statistical methods, software and coding. The diversity of research is grouped and tabulated in Appendix A, Appendix B, Appendix C, Appendix D, Appendix E based on Dibbern et. al. study named as "Information Systems Outsourcing: A Survey and Analysis of the Literature" (Dibbern et. al., 2004). The classification table includes the following columns: The first (1^{st}) column is the name of the study as the first three words of the name of study; the second (2^{nd}) column is the authors' surname; the third column (3^{rd}) is the journal name; the fourth (4^{th}) column is the journal origin according to continents as North America (NA), South America (SA), Europe (EU), Africa (AF), Asia (AS), Australia (AU) and Antarctica (AN) shown in "Figure 2.1 Journal origin"; the fifth (5^{th}) column is the main group as mentioned above; the sixth (6^{th}) column is the sub group as such there can be two main topics included in the study; the seventh (7^{th}) column is the research level as "macro" which is subdivided into "society" (S), "industry" (I) and "firm" (F) and micro which is subdivided into "group" (G) and "individual" (I); the eight (8^{th}) column is the research approach which can be given as "empirical" and "non-empirical" (Dibbern et. al., 2004). The studies which can be named as empirical research, involve any data from a survey which can be performed as questionnaires, telephone interviews, published statistics or a case study. The empirical research is divided into two groups, "descriptive" (D) and "interpretive" (I) (Dibbern et. al., 2004). Descriptive research presents the beliefs of the researchers or the experts, interpretive research presents the deeper structure to the phenomenon through different approaches. The non-empirical research is not based on specific data. It is more like intangible. The non-empirical research is divided into two groups, "conceptual" (C) and "mathematical" (M) (Dibbern et. al., 2004). The conceptual studies are sort of unstructured thoughts and concepts. The mathematical studies are models and analyses that are based on a set of restrictive assumptions about the nature of the world.

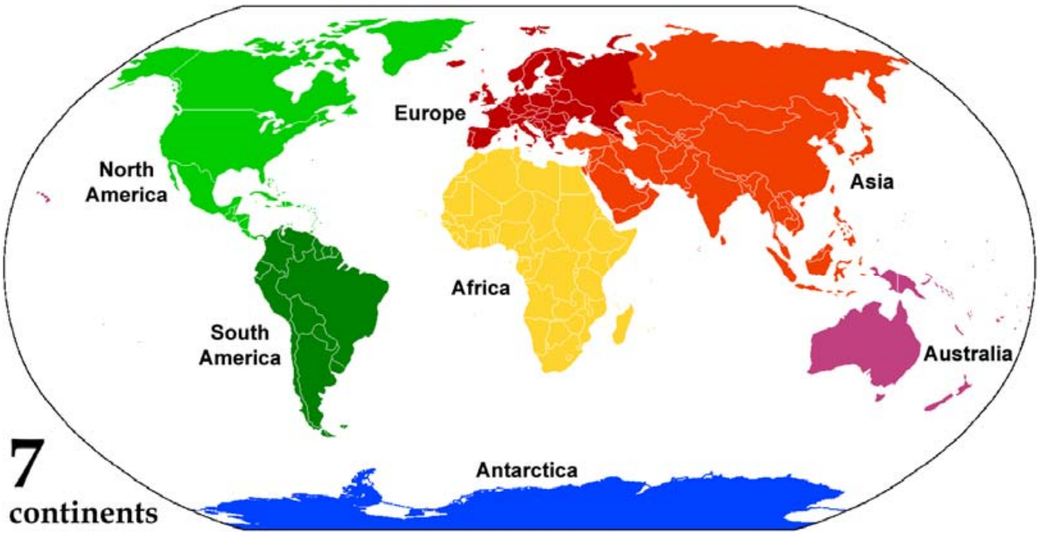


Figure 2.1 : Journal origin, (Source: Url-4).

The ninth (9^{th}) column is the impact level as "short term operational impacts" (ST) (efficiency, cost savings etc.), "mid-term tactical impacts" (MT) (performance measures etc.) and "long-term strategic impacts" (LT) (knowledge-creation) (Dibbern et. al., 2004). The tenth (10^{th}), eleventh (11^{th}) and twelfth (12^{th}) columns present the names of reference theories and sub theories in the main group. These three columns consist of the key methods or properties of the study, which can be used for regrouping in further analysis. The published year of the study is also noted for grouping purposes. The following sub-chapters are organized according to the main groups and each study is summarized at most one paragraph including sufficient information for filling the table.

2.1 Management Systems

The study which has been undergone within this subtitle or main group aims to make a classification study that will guide the thesis within this main group. The table, which is purposed to group the literature review in Appendix A, has been filled in by the information supplied in these summarized studies.

The first study, which was summarized in this topic, was by Weingart (1969). His study presented a conceptual approach to construction of MIS (Management Information Systems) models, which could be described like the nervous system of a firm. The functional elements required to build up a MIS, which was given as shown in Figure 2.1.1.

Decision Making Element
(DME)

Product Generating Element
(PGE)

Information Generating Element
(IGE)

Product Storage Element
(PSE)

Information Storage Element
(ISE)

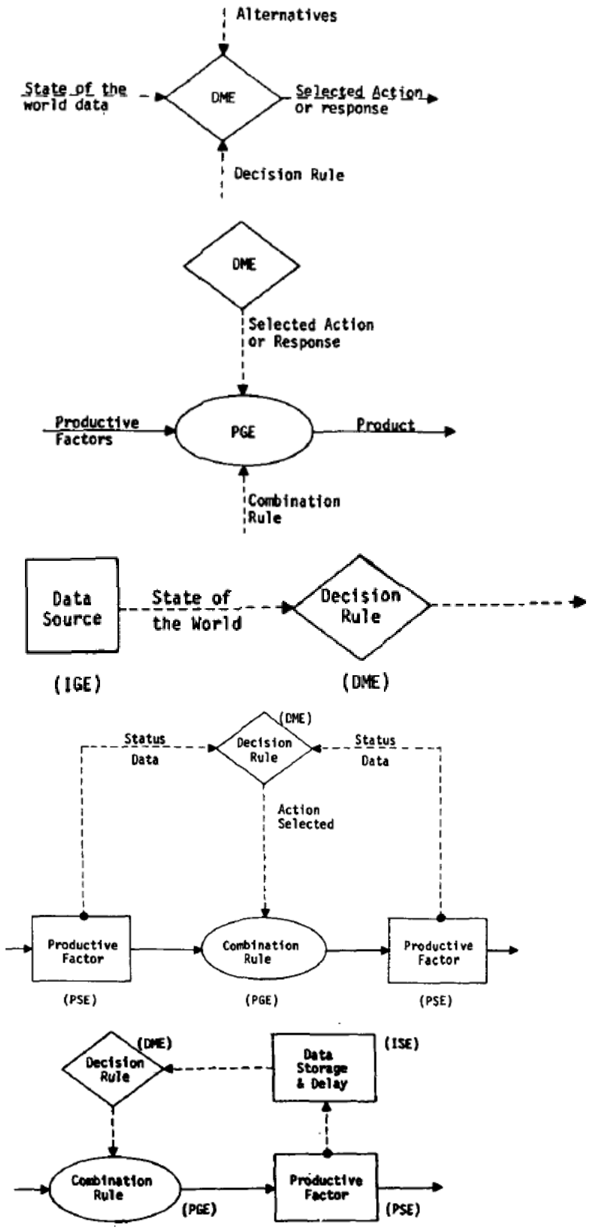


Figure 2.1.1 : Functional elements of MIS, (Source: Weingart, 1969).

Weingart (1969), finalized the study by two important flow diagrams named as “Three Levels of Management in MIS Functional Flow” and “A Model of MIS Functional Elements” (Weingart, 1969).

One of the noticeable and first studies in this main group was by Carlson (1978). He indicated surely the potential benefits of computer support for decision making into two categories as “displaced cost”, which could result from reduced costs for data gathering, computation, data presentation in support of decision making and “added value”, which could result from investigating more alternatives, doing more sophisticated analysis of alternatives, using better methods of comparing alternatives, making quicker decisions and so on (Carlson, 1978). The study figured out that the types of decisions and degree of decision structure differed from each other. For instance, while in management control the most structured one was budget analysis and the most unstructured one was budget preparation; in strategic planning the most structured one was tanker fleet mix and the most instructed one was product planning. The study was finalized by a DSS schematic for investment decisions as shown in Figure 2.1.2.

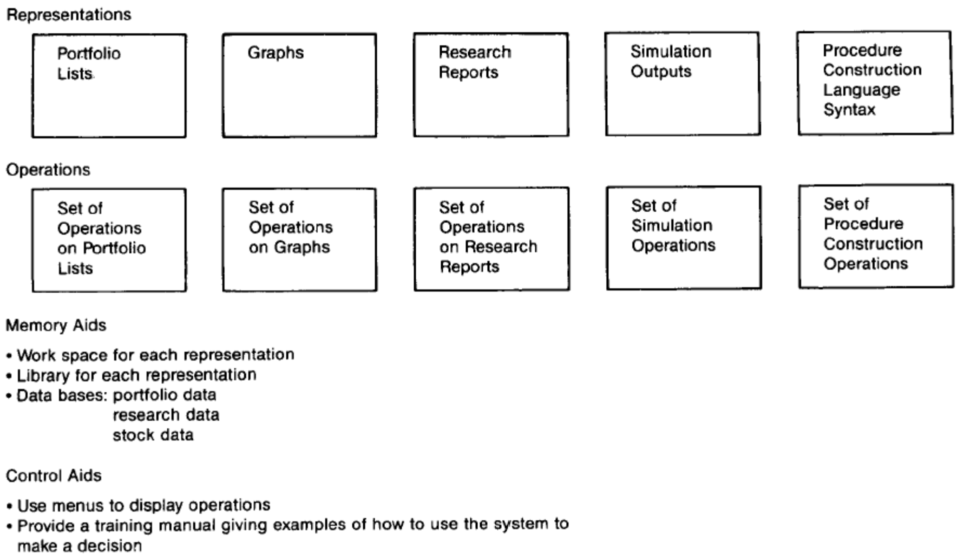


Figure 2.1.2 : DSS schematic resulting from using the DSS design framework to analyze an investment decision, (Source: Carlson, 1978).

Another significant study by its time was by Bahl and Hunt (1984). In their paper, they underlined the importance of “decision-maker’s (DM’s) or decider’s personality”, who confronting the decision making tasks (Bahl & Hunt, 1984). Bahl and Hunt (1984), defined the decision making task as a “focal task” and built up a flow diagram, which described the operations of decision-making and gave a name as “A General Model of Decision Making” as shown in Figure 2.1.3. “Econological model”, “bounded rationality model”, “political/competitive model”, “organizational process model”, “implicit favourite model” were shortly defined (Bahl & Hunt, 1984).

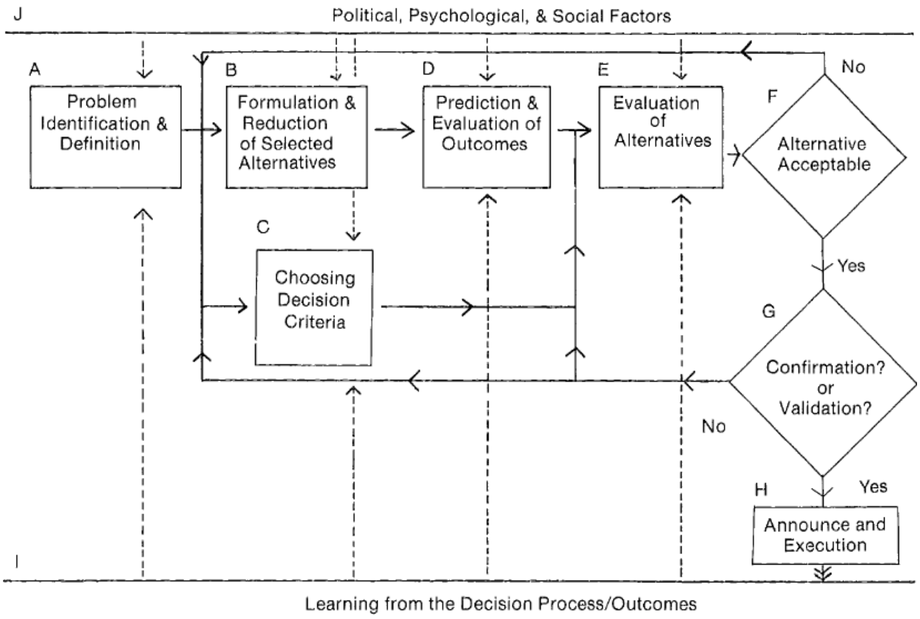


Figure 2.1.3 : A general model of decision-making, (Source: Bahl & Hunt, 1984).

Trauth (1984), studied not only the objective dimensions but also subjective dimensions of the effectiveness of print, electronic messaging and videotape. Management Information Systems (MIS) had been supported by a wide range of information delivery options, thereafter advanced in communication technologies such as electronic messaging systems, video display in the form of videotape, videodisk, cable TV and teleconferencing systems. Both informal and formal information had been implemented by help of electronic messaging for Office Automation Systems. On-line electronic mail systems, menu-based retrieval systems, and videotext services were supported by technological configurations. In this study, “quality of information (applicable, useful)”; “relevancy components (accurate, complete, timely)”; “quality of format (arrangement, readableness)” and “quality of meaning (logical, sensible)” were analyzed by an administered questionnaire (Trauth, 1984). This study provided some useful insights into the channel-selection process in the design of MIS.

DeSanctis and Gallupe (1984), presented an overview of the Group Decision Support System (GDSS) concept including design issues and implementation issues. GDSS was defined as “an interactive computer based system, which facilitated solution of unstructured problems by a set of decision makers working together as a group” (DeSanctis & Gallupe, 1984). DeSanctis and Gallupe (1984), drew a pictorial representative of a typical GDSS as shown in Figure 2.1.4.

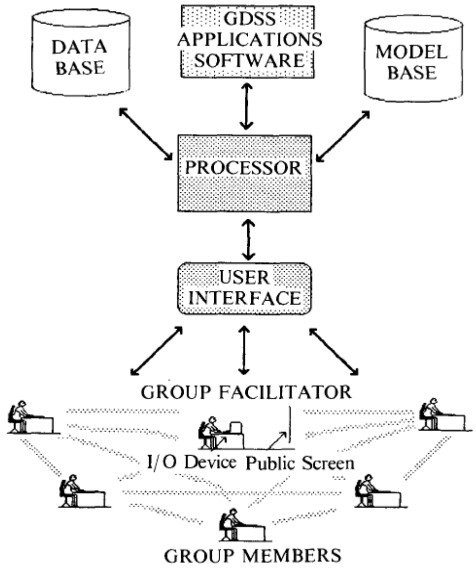


Figure 2.1.4 : A model of a GDSS, (Source: DeSanctis & Gallupe, 1984).

This paper presented a conceptual foundation for R&D of DSS for group-level decision making. Fundamental features of GDSS technology were described. An overview of four scenarios or types of group DSS environments were proposed as shown in Figure 2.1.5.

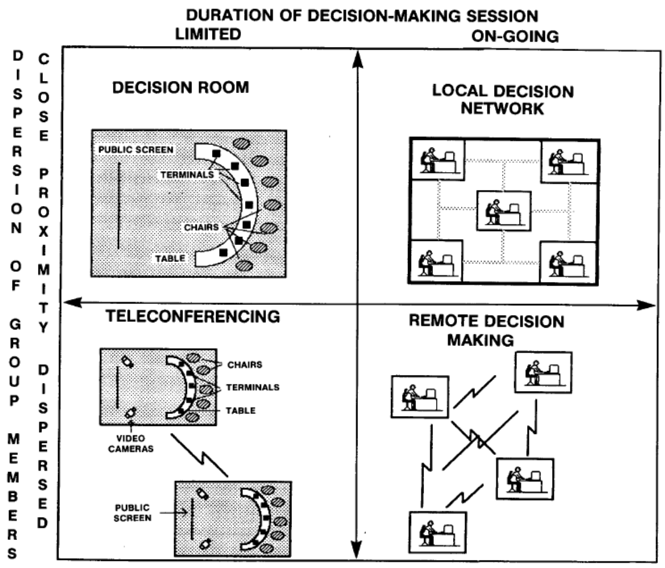


Figure 2.1.5 : Framework: group decision support, (Source: DeSanctis & Gallupe, 1984).

Finally, some specific design issues and implementation issues such as "an objective of GDSS should have been encouraging the active participation of all group members" were identified (DeSanctis & Gallupe, 1984).

Bui and Jarke (1987), focused on GDSSs, which could supply problem-oriented services in communication skills among decision makers to assists in decision making process about complex and also ill-structured problems. On one hand, GDSS could make the communication in ease and fast with subordinates, superiors and pears inside and outside the organizations; on the other hand there might have been the biggest danger that the richness of human dialogue ability and the strength of the conversation with human-being was lost. Bui and Jarke (1987), presented the six architectures for "man-machine" and "man-machine-man" communication in a GDSS as shown in Figure 2.1.6 (Bui & Jarke, 1987). In the architecture of GDSS artificial intelligence techniques, MCDM, game theory and other sophisticated methods could be embodied.

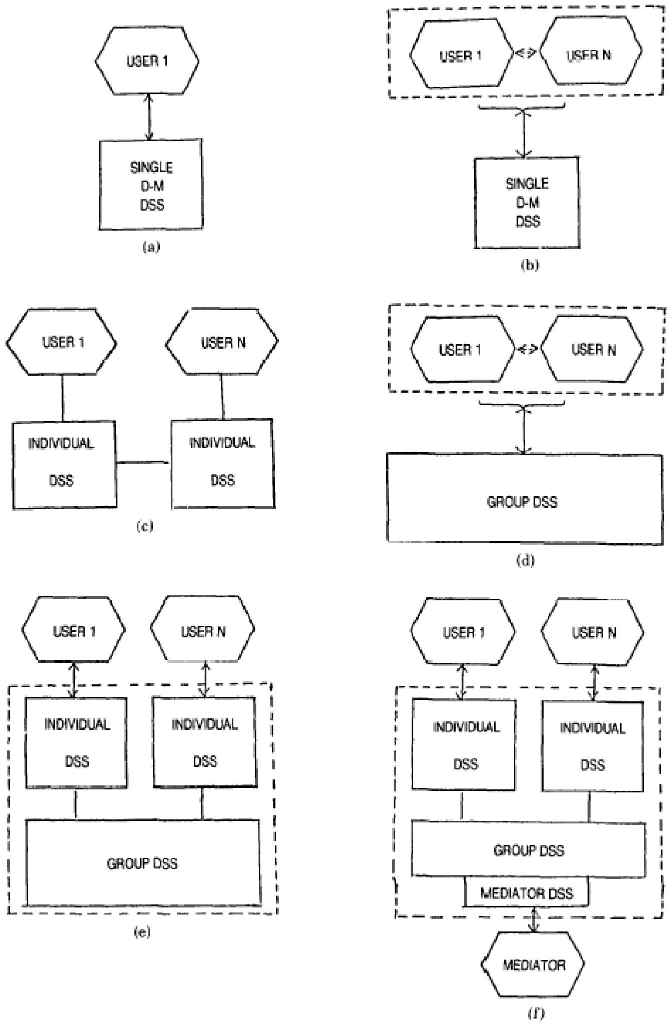


Figure 2.1.6 : A typology of group decision support system (a) Type 1, (b) Type 2, (c) Type 3, (d) Type 4, (e) Type 5, (f) Type 6, (Source: Bui & Jarke, 1986).

Bui and Jarke (1987), in detail study clearly defined and identified the subject of "data transfer systems" such as point to point, public data sharing etc., "interactive conversation" such as online talk, teleconferencing etc., "electronic mail" such as bulletin board, point to point communication, "group decision making techniques" such as sums of the ranks, additive ranking etc. (Bui & Jarke, 1987). Finally, they summarized the pros and cons of GDSS as reducing "miscommunication among geographically dispersed decision makers", "supporting formal and informal communication", "simplifying data transfer protocols", "offering flexibility in setting levels of information sharing ranging from limited to free exchange" and "accommodating protocol changed during the group decision-making process" (Bui & Jarke, 1987).

Hoplin (1987), worked on the Artificial Intelligence (AI) which purposed to prevent old business and management methods of management judgment, intuition, insight, or business experience. AI/Expert Systems would be the forgotten dimension in decision making procedure to solve unstructured or ill problems of business or management on Decision Support Systems (DSS). Hoplin (1987), considered that Management Information System's (MIS) major success was realized from two major important components of the management or business system which were "reporting management" and "management of data using database techniques" (Hoplin, 1987). The MIS model on Hoplin's (1987) study, which was purposed for minimizing risk was shown in Figure 2.1.7. Hoplin defined in his paper the 80 – 20 rules very well as follows:

a) "80% or more of the decisions made by lower or operating management were structured and recurring; thereby lending themselves to algorithmic types of procedural zed decision making.
b) The reverse was true of top management. Here less than 20% of the decision making was structured, recurring and routine. 80% of the decision making was of the high-risk variety that was usually non-recurring and of high dollar value and long-range implications. Procedural decision making did not work result, top management was not adequately the MIS or the DSS.
c) Middle management's decision-making role in between with about 50% falling in the category requiring some decision support routinized procedures" (Hoplin, 1987).

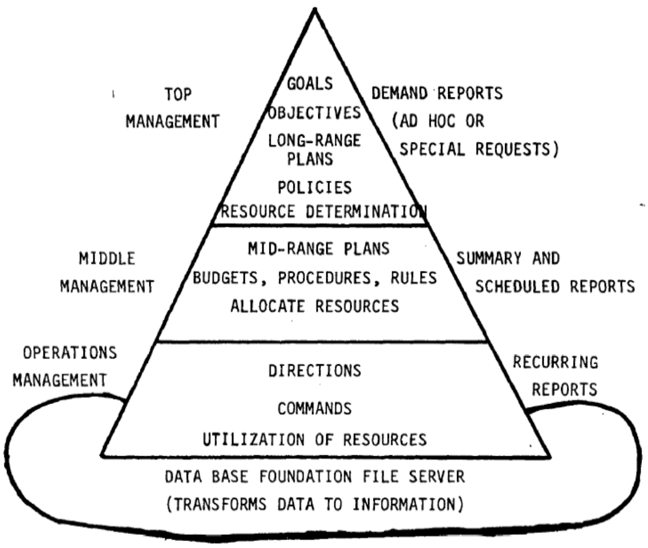


Figure 2.1.7 : MIS model, (Source: Hoplin, 1987).

One of the leading studies by its time was by Holsapple and Whinston (1988). They clearly mentioned that the real advantage of the Decision Support Systems was being a supporting tool for multiple participants. The Decision Support Systems empowered the distributed DM systems in business and management that should have been based on the three important elements of "communication", "individual problem solving" and "coordination" (Holsapple & Whinston, 1988). In this research study, on Decision Support Systems "organization science", "computer science" and "decision science" should have been bring together for forming a unified view of human-computer decision making (Holsapple & Whinston, 1988). It was very much worth mentioning that in their paper "instigation", "goal-driven", "design", "events", "concurrency", "servers", "entities", "formalization", "learning", "interfaces", "coordination" were posed as the key research areas in the systems (Holsapple & Whinston, 1988). Moreover, the importance of Office Automation Systems was underlined in the study.

Kraemer and King (1988), reviewed GDSSs that was designed to meet the needs of "computer-based communications", "computer-based information service provision", and "computer-based decision support" (Kraemer & King, 1988). The most important benefit of GDSSs was the reduction of lengthy meetings. In most cases, decision makers discussed that these meetings were time consuming activities when comparing to other critical activities. Henceforth having an efficient GDSS would reduce the unnecessary work load. Information loss, information distortion and suboptimal decision making were given as the main problems of group decision meetings. Under these conditions it was underlined that GDSS could provide the following information: (1) “Basic information: What were the alternatives? What were the likely future conditions? What criteria were to be used in the decision?” (2) “Elaborating information: What were the probabilities that the future conditions would occur? What was the relative importance of the criteria for deciding? What payoffs accrued to what outcame? What were the constraints on payoffs or costs?” (Kraemer & King, 1988). They summarized the GDSS as a sociotechnical package under four elements as shown in Table 2.1.1. They also prepared a table for giving the features of major GDSS providers. They concluded their study by describing the further research topics in GDSSs, examining a number of successes in use of GDSSs, as well as failures undertaking an investigation for effects on decision process and finally the benefit of GDSS technology in routine organizational settings.

Table 2.1.1 : Major GDSS elements, (Source: Kraemer & King, 1988).

Element	Hardware
Electronic boardroom	Conference room; audio visuals; graphic displays; computer
Teleconference facility	Conference room; audiovisuals; audio, computer or video telecommunication controller
Group network	Offices; file server and computer; work stations; telephone; computer network
Information centre	Conference room; large-screen video projector; computer; display terminals
Decision conference	Conference room; large-screen video projector; display terminals; voting terminals
Collaboration laboratory	Conference room; electronic chalkboard microcomputer workstations, electern
Element	Software
Electronic boardroom	Interactive graphics
Teleconference facility	Communications
Group network	Interactive/asynchronous computer conferencing; terminal linking; real-time meeting scheduling; shared bit-map display
Information centre	Database management software; statistical packages; retrieval, Graphics and text-processing software
Decision conference	Decision analysis software; modelling software; voting tally and display software
Collaboration laboratory	Multi-user interface; WYSIWIS; outlining (COGNOTER); evaluating (Argnoter)
Element	Organizationware
Electronic boardroom	Audiovisuals; corporate reports; standard meeting protocols
Teleconference facility	Audiovisuals; teleconference protocols
Group network	Conference chair conducts meetings
Information centre	Corporate and other databases; standard meeting protocols; standard meetings (e.g., annual report, market forecast)
Decision conference	Democratic decision-making protocols (e.g., one person one vote; all major interests represented; majority opinion rules)
Collaboration laboratory	Standard meeting protocols
Element	People
Electronic boardroom	Participants; audiovisual technician
Teleconference facility	Participants (in two or more locations); teleconference facilitator
Group network	Participants (in two or more local places), group leader

Table 2.1.1 (continued) **:** Major GDSS elements, (Source: Kraemer & King, 1988).

Element	People
Information centre	Participants; computer specialists; modelling specialists
Decision conference	Participants; decision analysts; group process facilitators
Collaboration laboratory	Participants
Element	Examples
Electronic boardroom	NA custom tailored for each site although some “modular” audiovisual rooms exist
Teleconference facility	Picturephone Meeting Service
Group network	MIT Lab for Computer Science RTCAL and MBlink EIES, NOTEPAD, PARTICIPATE CONFER II
Information centre	HOBO System: SYSTEM W, EIS, EXPRESS, XSIM
Decision conference	Group Decision Aid; Decision Conferences of DDI; Decision Tectronics, SUNY, Albany; Planning Lab, University of Arizona; GDSS Lab, University of Minnesota
Collaboration laboratory	Colab Project, Xerox PARC; Project NICK, MCC

Kyratzoglou (1988), developed a computer aided Petri Net Design System for decision-making in organizational architectures. When a single decision-maker did not have the capacity, exprience or proficiency to make the decision, a Decision-Making Organization (DMO) took the lead in decision making process. A team of trained decision-makers were organized. Their skills and authority were important and the DMO should have been formed according to this point of view. Each decision-making process might be divided into sub-processes. Each sub-processes should have been coordinated by a team member. A distributed decision-making organization (DDMO) was formed in the study. Each team member reached a decentralized decision in his or her own area of expertise. “The design system had four modes of operation: graphics editor, text editor, structural analysis, hardcopy made” (Kyratzoglou, 1988).

Whitley (1990), described a new conceptual approach to use expert systems in the decision making process for managers in business and management, who would make decisions on new business project alternatives based on different performance measures such as rates of return, estimated market interest rates. Moreover his study also described an expert system development tool. The developed system was named as PESYS (Pascal Expert System Shell) that was aimed to be implemented on inexpensive, standard hardware (an IBM Personal Computer with keyboard and text screen as a minimum). The earlier versions of PESYS had been widely used at the London School of Economics and Political Science in Income Tax returns; moreover it had also been used to develop numerous much smaller projects. PESYS, which provided support to make decisions, had the capability of an understanding of human communication, based on the theory of Speech Acts. PESYS was presented and its applicability to expert systems was shown in his study.

Gerson et. al. (1992), conducted two U.S. mail surveys. Their aim was to determine the usage and the effects of DSS as a strategic decision making tool. They adapted a group decision process and presented as in Figure 2.1.8.

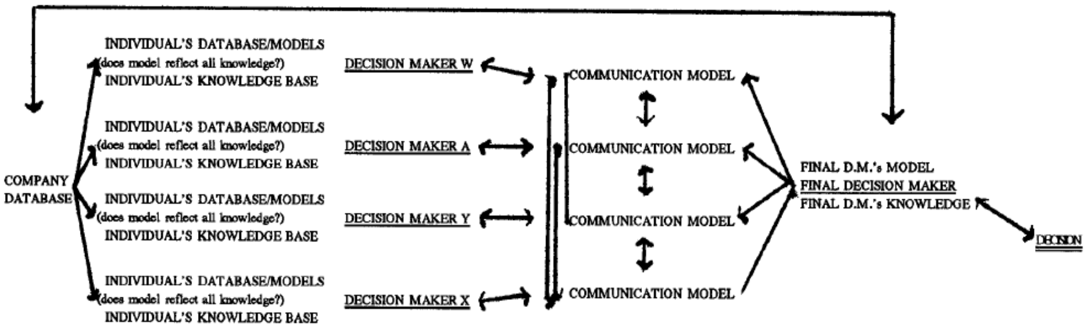


Figure 2.1.8 : Group decision process, (Source: Gerson et. al., 1992).

The results suggested that DSS generated information were used in most of the major management decisions by decision makers. DSS were used for an individual's decision making in business management. On the other hand, the most strategic decisions were made by an individual. In most cases, a group did not affect on strategic decisions in business. Information generated by DSS was used before discussions. The most crucial part of this study was worth mentioning the necessity of a decision system not based on a simple NPV (net present value) on strategic decision making.

Wilson et. al. (1993), worked into developing and implementing Computer-Based Systems (CBS), which were purposed for managerial or business decision-making within several organizations. They underlined that "more behavioural science research on user psychology could save the CBS managerial decision-support concept" (Wilson et. al., 1993). In their study, they questioned the ideals of rational decision-making in business and management furthermore the paradigm of CBS. The importance of "political foundations" and "moral foundations" of system design was subjected to critical appraisal to secure CBS (Wilson et. al., 1993). The development of organizational computing was divided into three distinct eras as "the first era was 1950s and 1960s (data processing)", "the second era was 1960s and 1970s (stock control and on-line order-entry applications)", "the third era was in the early 1970s (automation)" (Wilson et. al., 1993).

Vreede and Brujin (1999), studied the boundaries of effective GSS application by help of an action research approach. Nine case studies was performed which concluded that GSS was effective. The effectiveness of GSS was increased in the orientation phase of policy making of inter-organizational system. The assumptions which were also tested during case studies were “meeting processes should have been fair", “meeting processes should have been opened", “meeting processes should have been rational", “groups should have been guided by a process facilitator”, “groups should have exchanged as much information as possible”, “people were cooperative by nature with respect to each other and the meeting process” (Vreede & Brujin, 1999). They also defined the differences of a decision making process in a network and analytical-rational decision making. On their point of view, analytical rational problem solving focused on problems, moreover focused on information and searched for the right solution, however problem solving in a network focused on interest, moreover focused on relations and searched for support for a solution. Their study proved that “it was paramount to structure the use of GSS to meet the group's needs, but also that conscious preparations were no guarantee for meeting success” (Vreede & Brujin, 1999).

Mentzas (1994), provided the basics of a taxonomic study on three distinct elements of different systems, which were Information Support Systems elements, Decision Support Systems elements and Communication Support Systems elements. Mentzas (1994), examined ten different types of Computer Based Information System (CBIS), which were classified as Management Information Systems (MIS), Executive Information Systems (EIS), Executive Support Systems (ESS), Decision Support Systems (DSS), Group Decision Support Systems (GDSS), Electronic Meeting Systems (EMS), Organizational Decision Support Systems (ODSS), Expert Systems (ES), Office Information Systems (OIS) and Intelligent Organizational Information Systems (IOIS); at the same time the elements of CBIS types, which were database Management Systems (DBMS), Model Management Systems (MMS), Knowledge Based Management Systems (KBMS), Cooperation Management Systems (CMS) and Dialogue Systems (DS) were also studied. One of the important outcomes of the study was the qualitative analysis of each type of system as presented in Table 2.1.2.

Table 2.1.2 : Types of support in CBIS, (Source: Mentzas, 1994).

IS	Information support	Decision support	Communication support
MIS	High	Low	Low
EIS	High	Low	Low
ESS	High	Low	Medium
DSS	Medium	High	Low
GDSS	Medium	High	High
EMS	Medium	Low	High
ODSS	Medium	High	High
ES	Medium	High	Low
OIS	High	Low	High
IOIS	High	High	High

In the study, the elements of CBIS was also analyzed by help of a table as presented in Table 2.1.3., which used two terms as "basic" and "optional" (Mentzas, 1994). The "basic" term refered that the considered element was the fundamental for the system and the "optional" term refered that the considered element was not a necessity for the system (Mentzas, 1994).

Table 2.1.3 : Elements of CBIS, (Source: Mentzas, 1994).

Information System	DBMS	MMS	KBMS	CMS	DS
MIS	Basic				Basic
EIS	Basic	Optional			Basic
ESS	Basic	Optional		Basic	Basic
DSS	Basic	Basic	Optional		Basic
GDSS	Basic	Basic	Optional	Basic	Basic
EMS	Basic	Optional	Optional	Basic	Basic
ODSS	Basic	Basic	Optional	Basic	Basic
ES	Basic	Optional	Basic		Basic
OIS	Basic		Optional	Basic	Basic
IOIS	Basic	Basic	Basic	Basic	Basic

Mentzas (1994), finally provided the degree of support in an organization as shown in Table 2.1.4.

Table 2.1.4 : Degree of support to the individual, group and organization-level, (Source: Mentzas, 1994).

IS	Support of individuals	Support of groups	Support of organizations
MIS	High		
EIS	High		
ESS	High		
DSS	High		
GDSS	Medium	High	
EMS	Medium	High	
ODSS	Low	Medium	High
ES	High		
OIS	Low		High
IOIS	High	High	High

Jacobs and Holten (1995), presented and proved how business models and goal models could be integrated. Their approach was demonstrated by a Decision Support Environment. Design Decision was represented as a “Choice Context” (Jacobs & Holten, 1995). The “Structural IS-Goal” and the “Functional Perspective” product relationship was described as in Figure 2.1.9 (Jacobs & Holten, 1995). Jacobs and Holten (1995), finalized their study by the necessity of fulfilling the three requirements in DSS in management and business modelling as “computer support”, “qualitative decision support”, “visualization” (Jacobs & Holten, 1995).

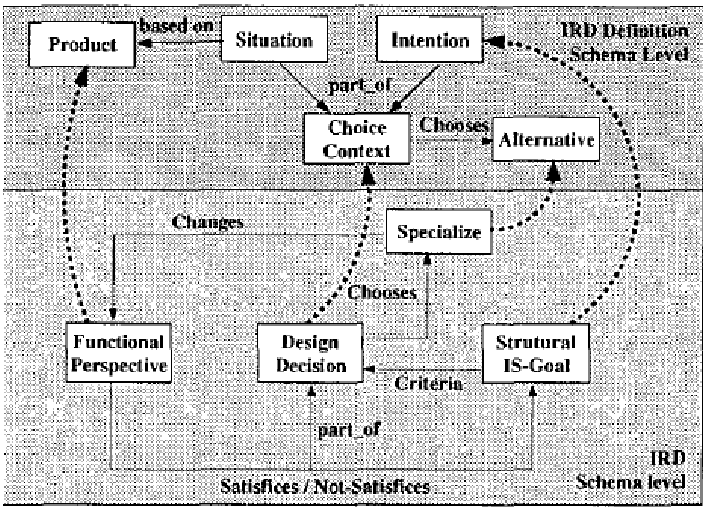


Figure 2.1.9 : Using goals as criteria of design decisions, (Source: Jacobs & Holten, 1995).

Vlahos and Ferratt (1996), prepared a detailed analysis about information systems based on computers, which could be named as CBIS of managers in Greece and the U.S.A. They defined the differences and the similarities between U.S. managers and Greek managers specifically on Information Reporting Systems (IRS), which could be defined as “traditional”, “fixed schedule” and “standard” (Vlahos & Ferratt, 1996). Moreover they defined the differences and the similarities of Office Information Systems (OIS), which could be purposed for word processing and electronic mail. In addition, they defined the differences and the similarities of DSS, which could be defined as flexible and also they defined the differences and the similarities of ESS, which could be defined as systems for higher level managers. The selected methodology for the study was questionnaire survey. 200 middle to large size corporations in Greece and 200 middle to large size corporations in U.S. were reviewed. The findings were summarized under the title of similarities and the differences. The first similarity was “the supporting power of CBIS for the resource allocator that approved and allocated all organizational resources as highest and the negotiator that represented the organization at major negotiations as the lowest" (Vlahos & Ferratt, 1996). The second similarity was "the identification problem, evaluation alternatives and ranking alternatives power of CBIS" (Vlahos & Ferratt, 1996). The third similarity was "the CBIS supporting power for the short-term decisions as the highest and the supporting power for the long-term decisions as lowest" (Vlahos & Ferratt, 1996). The fourth similarity was "the IRS which was more valuable than DSS" (Vlahos & Ferratt, 1996). The fifth similarity was "the managers considered to implement new CBIS systems" (Vlahos & Ferratt, 1996). The first difference was "the Greek managers had rated the mental model of CBIS higher than the U.S. managers" (Vlahos & Ferratt, 1996). The second difference was "the U.S. managers rated the value of CBIS higher than the Greek managers" (Vlahos & Ferratt, 1996). The third difference was "the Greek managers rated the value of online, interactive systems and OIS lower than U.S managers" (Vlahos & Ferratt, 1996). The fourth difference was "the Greek managers preferred PCs than U.S. managers preferred the workstations" (Vlahos & Ferratt, 1996). The fifth difference was "the U.S. managers corresponded via e-mail more" (Vlahos & Ferratt, 1996). These similarities and differences proved the economical and cultural power of the countries. The preferences of computer based systems were highly correlated with the culture and the economic power of cultures.

Sauter (1999), specified that the factors which were too complex for managers' insights should have been involved in DSS with intuitive heuristics. The types of decision-making styles were "left-brain style" (Sauter, 1999). This style emphasised analytical and quantitative techniques. In addition, "left-brain style" employed rational methods and logical methods (Sauter, 1999). On the other hand, "the right-brain style" used intuitive techniques (Sauter, 1999). The "right-brain style" gave more importance on feelings of managers than facts (Sauter, 1999). The "accommodating style" was dominant styles (Sauter, 1999). This style learned from experience decisions of managers. The "integrated style" combined the "left-brain style" and "right-brain style" (Sauter, 1999). Moreover this style took the advantage of their obvious symbiosis. The influence of intuition on decision making of managers was guided in this study. The study was finalized by three critical aspects of DSS. The first aspect was "DSS should have helped decision-makers understood what they knew" (Sauter, 1999). The second aspect was "helping decision-makers to understand the underlying assumptions by providing enough appropriate information for decision-makers to understand the issue without overloading them with unnecessary or unwanted details" (Sauter, 1999). The third aspect was "DSS must have helped users test assumptions, especially those that differ from decision-makers' preconceived ideas" (Sauter, 1999).

Loch and Conger (1996), studied in detail the Theory of Reasoned Action (TRA), which was frequently used to describe ethical decision-making behaviour in literature. They underlined the problem of today very well as "computer users faced an increasing number of ethical dilemmas in their use of computers and novel situations appeared with each new technology" (Loch & Conger, 1996). The most visible and important ethical concern of users in computer based decision systems of a business entity was privacy. Loch and Conger (1996), proposed a model of ethical decision making for computer use as shown in Figure 2.1.10.

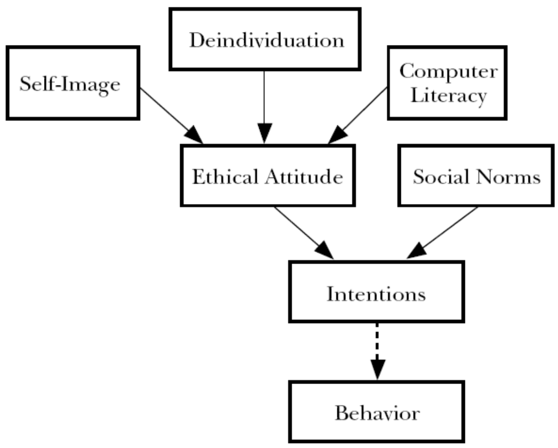


Figure 2.1.10 : Proposed model of ethical DM for computer use, (Source: Loch & Conger, 1996).

Deindividuation was defined as "a feeling of being estranged or separated from others that could lead to behaviour violating established norms of appropriateness" (Loch & Conger, 1996).

Yoo (1997), studied the effects of decision-making processes, use and outcomes of Electronic Communication Technologies (ECT), which was a tool in Group Support Systems (GSS), on Top Management Team (TMT), who had to deal with highly complex, highly uncertain and socially complex tasks. Eight hypotheses such as "H5: TMTs that used ECT intensely would have less formal decision-making processes than TMTs that used ECT less intensely" were developed and tested (Yoo, 1997). The data was collected from all members of the TMT, including the CEOs of 59 U.S. firms and 25 Irish firms with similar characteristics that had in gross sales, from $200 thousand to $330 million. The Nominal Groups Techniques (NGT) or systematic brainstorming, formal face-to-face meetings, informal face-to-face meeting, individual telephone conversations, telephone conference calls, voice mail, electronic mail, formal written communications, informal written communications and electronic conferencing methods had been applied during the study. The intensity of Electronic Communication Technologies use (IECTU) was calculated by help of two variables Traditional Communication Technology (TCT) and Electronic Communication Technology (ECT):

$$IECTU = \frac{Average\ weekly\ usage\ of\ ECT\ by\ TMT}{Average\ weekly\ usage\ of\ TCT\ by\ TMT} \quad \textbf{(2.1.1)}$$

The results of Yoo's (1997) study indicated that "ECT use by a TMT was positively correlated with the participation of outsiders in the TMT's decision-making processes" moreover "ECT use could flatten the organization's hierrachy" (Yoo, 1997). Above all it was underlined that "ECT use was positively correlated with the effectiveness of a TMT's decision making outcomes" (Yoo, 1997). Yoo's (1997) study indicated that when organizations faced with unstable, highly risky environments, the uncertainties could be absorbed by formalizing their decision-making process.

Vlahos et. al. (2000), surveyed German managers by sampling method. They tried to investigate Computer-Based Information Systems (CBIS) and the German managers' perceived value and satisfaction on these systems. The analysis indicated that: "(1) The sample of German managers was selected as predominantly male and old. They had several college computer courses" (Vlahos et. al., 2000). "(2) The sample was used computer-based information systems approximately 10 hours per week" (Vlahos et. al., 2000). "(3) The sample had also top level managers who were the lightest users of information technology" (Vlahos et. al., 2000). The top level managers gave greater value of Computer-Based Information Systems (CBIS) than other managers. "(4) The relative importance of these commonly know systems were: Information Reporting Systems (IRS) 92% (ranking), 4.4 (weighted mean rank); Computer Supported Collaborative Work/Office Information Systems

(CSCW/OIS) 85% (ranking), 3.8 (weighted mean rank); Executive Information System (EIS) 85% (ranking), 3.6 (weighted mean rank); Decision Support System (DSS) 85% (ranking), 3.6 (weighted mean rank); Transaction Processing System (TPS) 85% (ranking), 3.6 (weighted mean rank); Artificial Intelligence/Expert Systems (AI/ES) 44% (ranking), 1.2 (weighted mean rank)" (Vlahos et. al., 2000). This study supported that the perceived value of the computer based decision systems were highly correlated with age, gender, culture, management level.

Power (2002), summarized a multidimensional approach of DSS. They expanded DSS framework, which could have helped to categorize it. They categorized DSS systems as (1) "communications-driven DSS" (communication, collaboration and decision support technologies), (2) "data-driven DSS" (file drawer and management reporting systems, data warehousing and analysis systems, EIS and spatial decision support systems), (3) "document-driven DSS" (storage and processing technologies to provide complete document retrieval and analysis), (4) "knowledge-driven DSS" (suggestion or recommendation actions to managers) and (5) "model-driven DSS" (accounting and financial models, representational models and optimization models) (Power, 2002).

Laudon and Laudon (1999), in detail studied the transformation of business and management by different information systems in several levels of organization. The differences and the similarities of interests, specialties and levels in an organization was in detail explained and followed by a figure, which illustrated the kind of information systems by organizational level as shown in Figure 2.1.11.

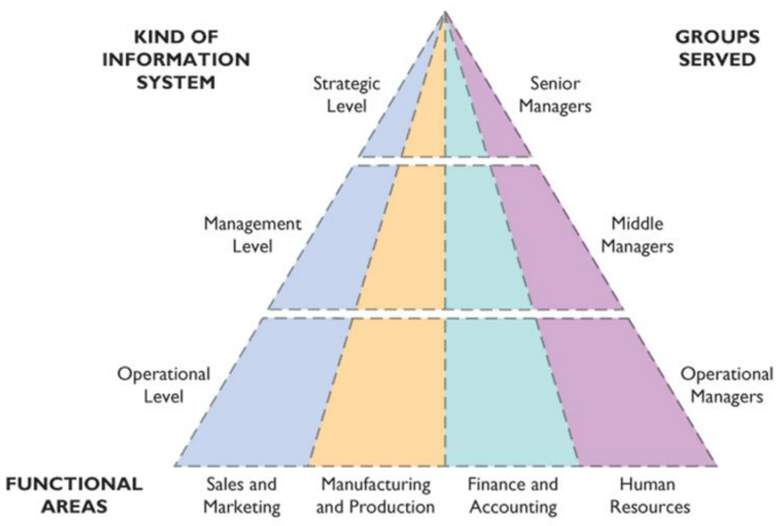


Figure 2.1.11 : Types of information systems, (Source: Laudon & Laudon, 1999).

Moreover they also defined the types of Information Management Systems, which were related with the serving different and several organizational levels and they also explained Information Management Systems' value to the organization. The systems and the details about the systems were presented in Figure 2.1.12. In strategic level of an organization, the Executive Support Systems should have been implemented to serve "5-year sales trend forecasting", "5-year operating plan", "5-year budget forecasting", "profit planning and manpower planning"; in management level of an organization, the Management Information Systems and Decision Support Systems should have been implemented to serve "sales management", "sales region analysis", "inventory control", "production scheduling", "annual budgeting", "profitability analysis", "relocation cost control" and "contract cost analysis"; in operational level of an Organization Transaction Processing Systems should have been implemented to serve "order tracking", "order processing", "machine control", "plant scheduling", "material movement control", "payroll", "accounts payable", "accounts receivable", "employee record keeping" (Laudon & Laudon, 1999). These systems were served to sales and marketing departments, manufacturing and production departments, finance and accounting departments, human resources departments in functional areas.

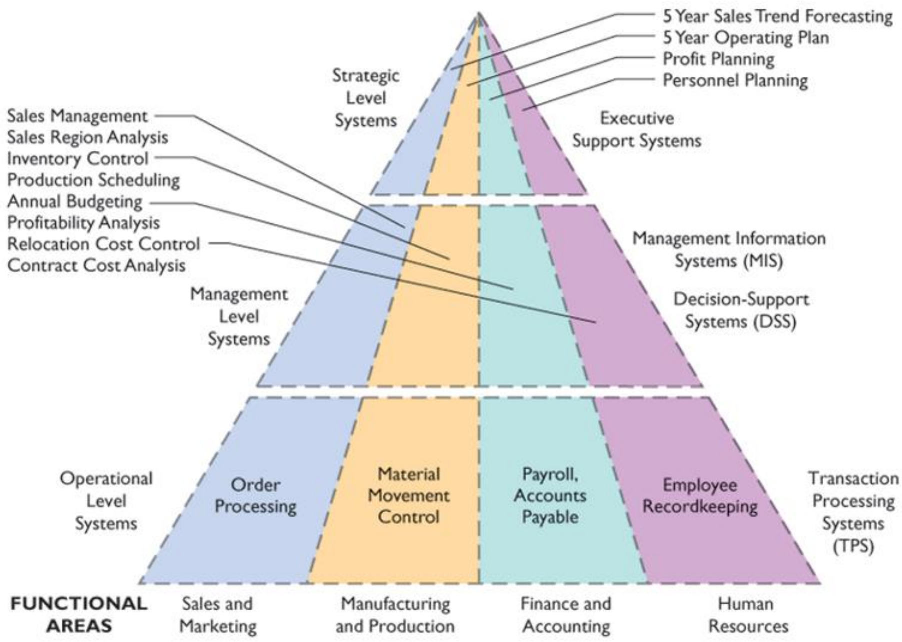


Figure 2.1.12 : Types of information systems – details, (Source: Laudon & Laudon, 1999).

The different organizational levels, types of decisions and the information systems relation were also in detailed studied, analyzed and explained. This relation was presented by help of a graph as shown in Figure 2.1.13.

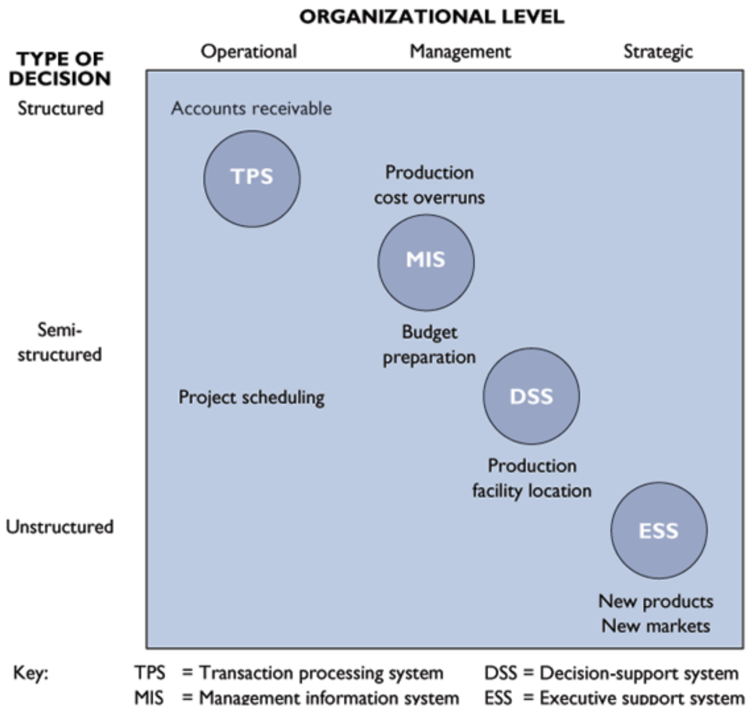


Figure 2.1.13 : Information systems and levels of decision making, (Source: Laudon & Laudon, 1999).

In this study, the transaction of the organizations to information system adopted organizations were also in detail explained.

Mora et. al. (2000), studied in detail the Decision Making Support Systems (DMSS). Moreover, they attempted to integrate the findings of the previous studies and the previous research by help of the Factor Based Approach (FBA) schemes. The summary was presented in their paper as shown in Figure 2.1.14. In this study, it was clearly underlined that the Decision Making Support Systems implementation and its implementation process was not so easy as it was seen. In most cases, even under normal management conditions, the implementation process frequently had been finalized by installation failures. In their study, they also studied the DMSS in stage-based approaches. In the paper, the last 30 years literature review of the Decision-Making Process (DMP) was reported. The DMP was in focus of business and management started from the post-industrial society during the early 1970s. This study integrated the single factors of stand-alone DMSSs, moreover the factors of the categories of the conceptual hierarchy was improved.

Factors from Mora, Cervantes and Forgionne	Type of DMSS			Watson et al's Scheme	Eierman et al's Scheme	Turban and Aronson's Scheme
	DSS	EIS	ES			
1. User characteristics				●	●	●
User aptitude.	✓	✓	✓		●	◗
Norm motivation.	✓	✓			●	◗
Cognitive style.		✓			●	●
Realistic expectations.			✓		●	◗
2. Task characteristics.					●	
Task difficulty and newness	✓					
Task uncertainty degree.		✓				
Task organizational alignment (priority)		✓	✓		◗	◗
Adequate task domain and complexity.			✓		●	
3. Development team characteristics.				●		◗
Project champion	✓	✓	✓			◗
Leader business skills		✓				
Leader technical skills		✓				
Developers technicals skills.			✓			●
4. Implementation process.				●	●	●
User training.	✓			●	●	◗
User involvement.	✓				●	●
Development Methodology (Evolved)	✓	✓	✓	◗	●	●
Development frame time.	✓					◗
Cost-benefit analysis		✓	✓	●		◗
Data accessibility		✓		●		
Change and resistance management		✓	✓			●
Support for evolution and diffusion		✓		●		◗
Support of IS department		✓	✓	●	●	●
Commitment of maintenance.			✓			◗
5. Technological characteristics.				●	●	●
Software.	✓	✓	✓	●	●	◗
Hardware.	✓	✓	✓	●	●	◗
6. Organizational characteristics.				●		●
Top management support.	✓	✓	✓	◗	●	●
Top sponsor.		✓	✓	●	●	◗
Organizational climate.			✓		◗	●
7. Environment characteristics.					●	●
Hostile and uncertainty environment.		✓		◗	●	◗
Relations with IT suppliers and RC			✓			●
8. System (DMSS) characteristics.				●	●	
Accuracy and format of results.	✓	✓			●	
Management level supported.	✓				●	
Decisional phase supported	✓				●	
Relevance of results	✓				●	
Degree of system sophistication		✓			●	
Timeless information		✓		◗	●	
Easiness of usage		✓		◗	◗	
Impact in user´s work			✓			◗
Legal and ethical issues			✓			●

Figure 2.1.14 : Scheme of factors for DMSS implementation, (Source: Mora et. al., 2000).

Meikle and Yearwood (2001), described in details the framework of MODDE (Model of Decision Support System Design and Evaluation). This research and the work was for the Refugee Review Tribunal (RRT) of Australia. Refugee law was in in progress and it should not have seen as rigid rules. Instead it should have had many “open textured terms” (Meikle & Yearwood, 2001). These “open textured terms” could not have defined ahead of their use (Meikle & Yearwood, 2001). A DSS should be adopted to RRT to cope with high volumes of work and information. This DSS should have reduced the time frames in maintaining decisions. In their study, the experts in the experts' domain defined the dimensional concepts. These were "consistency", "discretion" and "resolution" (Meikle & Yearwood, 2001). The development and implementation of DSS was divided into three phases in this study. These phases were the "investigation and problem clarrification phase", the "problem analysis and system design phase", the "implementation and evaluation phase" (Meikle & Yearwood, 2001). The two areas which were "usability aspects" and "technical aspects" of DSS were addressed (Meikle & Yearwood, 2001). Lastly a Generic Argument Structure (GAS) was adapted as shown in Figure 2.1.15.

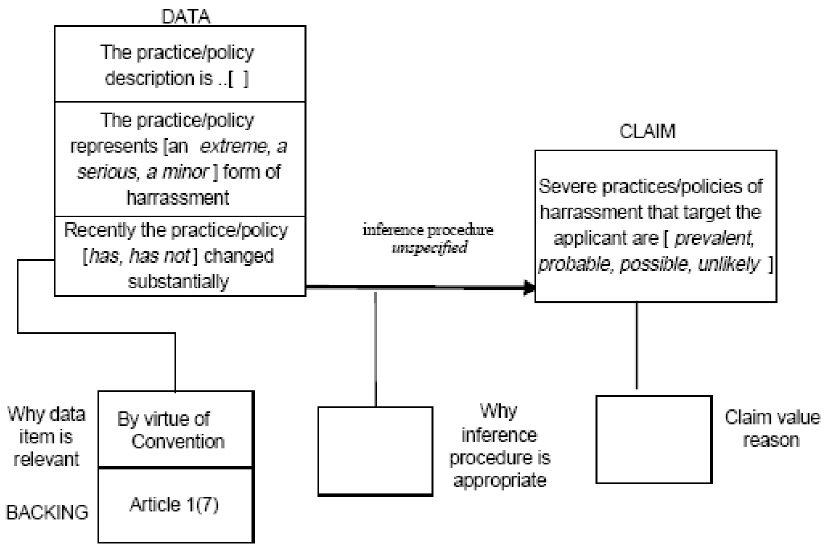


Figure 2.1.15 : Generic argument structure (GAS), (Source: Meikle & Yearwood, 2001).

Forgionne (2002), investigated various information systems, which supported the decision making process in management, business and other systems. In this study, Individual Support Systems, Decision Support Systems (DSS), Executive Information Systems (EIS) such as Geographical Information System (GIS), Artificially Intelligent Systems (AIS), Knowledge-Based Systems (KBS), Machine Learning Systems (MLS) and Creativity Enhancing Systems (CES) were in detail analysed and the illustration of these systems were drawn one by one. Afterwards the Integrated Decision Making Support Systems, Intelligent Decision Support System (IDSS) which integrated the functions of DSS and KBS, Executive Support System (ESS) which integrated the functions of DSS and EIS, Whole-Brained Decision Support System (WDSS) and Group Decision Support System (GDSS) which integrated the functions of DSS and CES, Management Support System (MSS) which integrated the functions of DSS, EIS and KBS were in detail analysed. Finally, beside the combination of two systems an alternative strategy was offered. This alternative strategy was creation of one and only one Decision Making Support System. This Decision Making Support System synthesized the main features and core functions of the systems given above. This was called Decision Technology System (DTS) as shown in Figure 2.1.16.

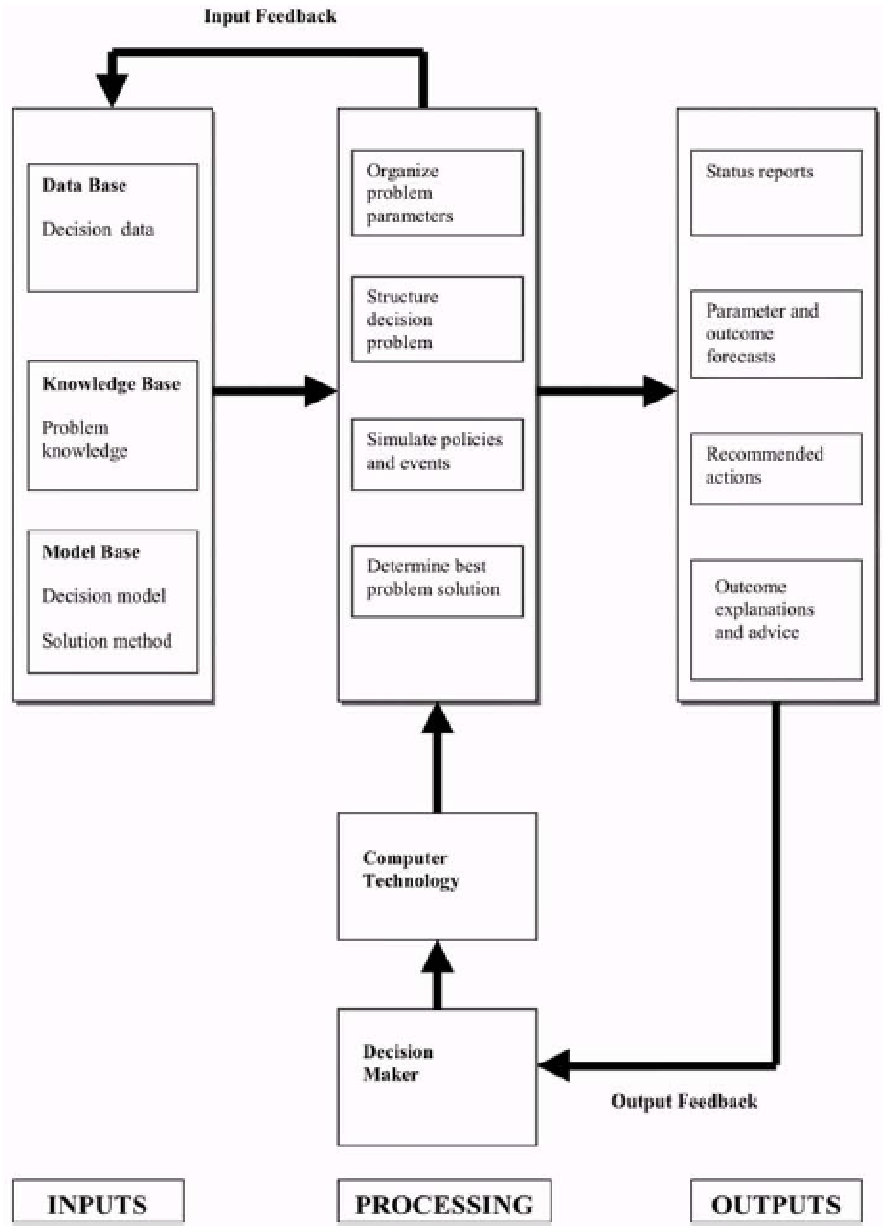


Figure 2.1.16 : Decision technology system (DTS), (Source: Forgionne, 2002).

Nemati et. al. (2002), proposed a warehouse architecture for knowledge management. This warehouse supported by and to DSS and knowledge management efforts. In this study, the main differences between “tacit knowledge” and “explicit knowledge” was defined, in addition their relationship was described (Nemati et. al., 2002). In this study, explicit knowledge was defined as “knowledge that could have been expressed formally and could therefore have been easily communicated or diffused throughout an organization” (Nemati et. al., 2002). “Tacit knowledge” was defined as “knowledge that was uncodified and difficult to diffuse in other words it was hard to verbalize because it was learned and expressed through action-based skills and could not have easily been reduced to rules and recipes” (Nemati et. al., 2002). The relationship was presented by help of the knowledge spiral as in Figure 2.1.17.

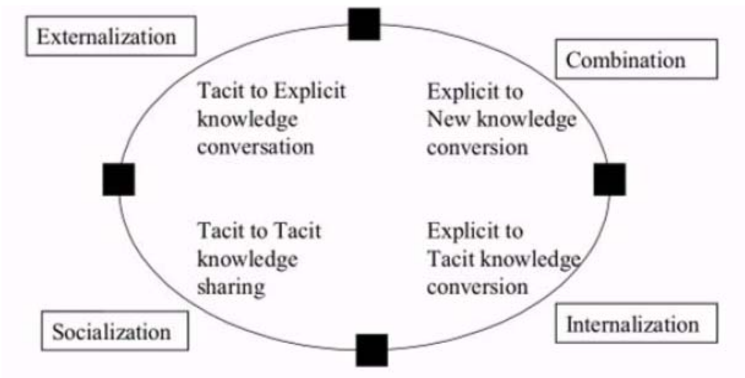


Figure 2.1.17 : The knowledge spiral, (Source: Nemati et. al., 2002).

They defined that the socialization was the sharing experiences such as shared mental models and technical skills, moreover they defined that the externalization was the sharing of metaphors, analogies, models or stories. They also defined that the combination was the process of combining or reconfiguring different parts of explicit knowledge. The internalization was defined as the process of learning and changing people’s mental models. Finally, knowledge warehouse architecture was proposed.

Pomerol and Adam (2002), studied at the first stage, the human decisions and the results of these decisions under psychological bias. The main characteristics of this process was analyzed. They separated the decision process into two sections. These were “diagnosis” and “look-ahead” as shown in Figure 2.1.18 (Pomerol & Adam, 2002). They explained that DMSSs were similar to “look-ahead” machines. Moreover, they added that the difficult and important challenges in the development and the implementation of DSS, which was the paradoxical problem of the designers, was “developing systems capable of helping people in situations that neither the user nor the program could have been foreseen” (Pomerol & Adam, 2002).

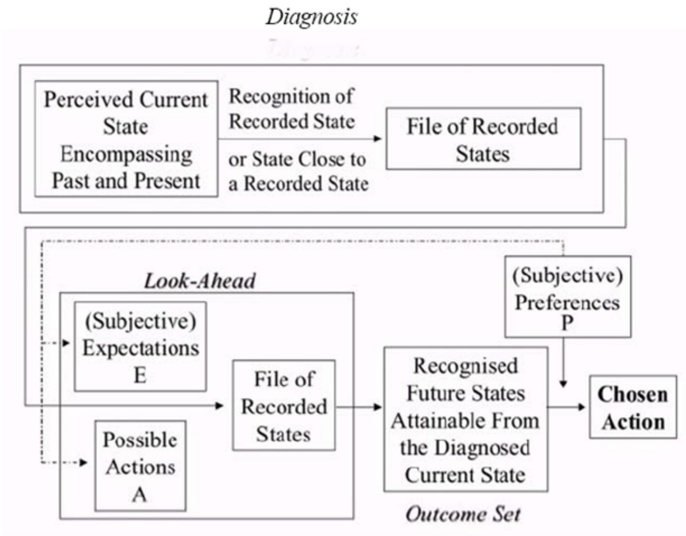


Figure 2.1.18 : The decision process, (Source: Pomerol & Adam, 2002).

They claimed that "the basis of the human ability to perform look-ahead reasoning was the what-if analysis", which enforced "DMSSs to adapted heuristic search and what-if analysis at different cognitive levels" (Pomerol & Adam, 2002).

Hope (2002), described the development of a computer based system. This system assisted to teams in middle management and upper management in improving business processes such as "knowledge acquisition", "requirements analysis" and "system development" (Hope, 2002). They preferred to adopt ESS, which assisted structuring complex problem solving tasks. ESS were neither DSS because they did not rank decision alternatives, nor Expert Systems because they did not reach conclusions. On the other hand, they utilized Expert System knowledge representations, tools and techniques. Expert Support Systems were mainly differ from Expert Systems. For instance, they required the human to do more of the work. They developed the prototype and the prototype was tested by Executive Vice Presidents and Senior Vice Presidents.

Yew (2002), provided detail information about the Knowledge Management (KM) concepts, moreover they introduced the Knowledge Management Systems (KMS). The theory for KM research were presented. The models for "Knowledge Cycle" were also provided (Yew, 2002). Knowledge Sharing (KS) was an important and critical topic for a knowledge organization. KS helped to increase the organizational capabilities such as competitiveness, efficiency, competency, creativity. A diagram of the components of a KMS was presented in the paper as shown in Figure 2.1.19.

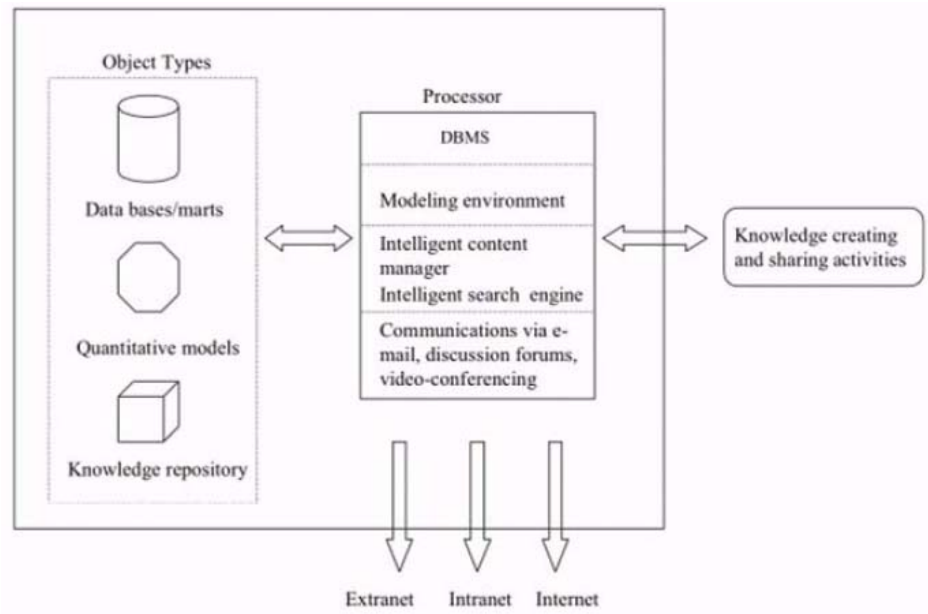


Figure 2.1.19 : A knowledge management system (KMS), (Source: Yew et. al., 2002).

Findler (2002), created a DSS for the strategic and the tactical planning processes. This DSS was created for the U.S. Coast Guard (USCG) in a multi-year project, SENTINEL. Three significant innovations accomplished in the project. The first innovation was "Dynamic Scoping referred to a need-driven change in the size of the domain from which moving resources were called upon to accomplish moving tasks" (Findler, 2002). The second innovation concerned resource scheduling under time constraints. The utility function was defined as

$$PRIORITY = IMPORTANCE \times URGENCY \qquad \textbf{(2.1.2)}$$

where "importance was a measure of the relative static importance of an attribute in the decision making process and urgency characterizes its gradually changing (usually increasing) relative importance over time" (Findler, 2002). The third innovation was about interagent communication and optimum message routing. They introduced "the constrained lattice-like communication structure that permited direct interaction between functionally related agents at any level" (Findler, 2002).

Pott et. al. (2005), studied an extremely different industry named as anaesthesiology, which was a complex socio-technical system. They introduced a new approach for developing DSS. This new DSS was combined with a cognitive process model. They underlined that the prediction of all effects of actions or events in patient problem was very difficult. The main reason was the highly interconnected and the interacting subsystems in the “operating theatre” (Pott et. al., 2005). In their study, a questionnaire was prepared and distributed among anaesthetists via e-mail. Although the response rate was not given in the paper, the total number of replies was given as 245 completed questionnaires from 29 different countries.

Sauter and Free (2005), addressed the development and the implementation of a DSS in a health care case. They explored and studied the characteristics of DSS. These were “to track fuzzy and qualitative information”, “to transform these data into knowledge”, “to provide competitive intelligence and to support strategic planning” (Sauter & Free, 2005). Their goal was to prove how the DSS could support managers in executive level or other high-level decision making. They underlined and mentioned the importance of Knowledge Management (KM), however they clearly underlined the high and the unacceptable development and implementation cost of a system based on KM.

Zannier and Maurer (2005), examined and studied the software design decision making process and presented the process of “rational and irrational software design decision making” or “naturalistic and non-naturalistic software design decision making” (Zannier & Maurer, 2005). The rational decision making was defined as “making the decision of selecting the optimal alternative by help of a utility function” (Zannier & Maurer, 2005). The assigned value of each possible alternative was based on its outcome and probabilities. The naturalistic decision was defined as “having a goal of selecting a satisfactory alternative” (Zannier & Maurer, 2005). The naturalistic decision was described as dynamic. The naturalistic decision was made on reactive actions to changing conditions, moreover it embodied real-time reactions-actions and embraced ill-defined tasks. Simon (1973), defined an ill-structured problem (ISP) as “a problem that was not well structured; contrary a well-structured problem (WSP) was a problem that had a criteria that reveal relationships between the characteristics of a problem domain and the characteristics of a method by which to solve the problem” (Simon, 1973). Zannier and Maurer (2005), presented an empirical and qualitative research study, which was powerfully supported by inductive interviewing, deductive interviewing and also deductive observations.

The final research, that was summarized in current study, was by Yardi et. al. (2005), who developed software named as VERN, which aimed online collaboration of analyzing the best appropriate meeting times across the members of a management group. VERN system combined a democratic process. These processes were the e-mail chain conversations and the process of remapping of the voting. A case study was designed “to evaluate the success of VERN as a standalone meeting scheduling system and to consider future implications for applications other than meeting scheduling systems based on principles of unconstrained democracy in group decision making” (Yardi et. al., 2005). The software was built on three main terms “groupware”, “GDSS” and “unconstrained democratic voting process” (Yardi et. al., 2005).

In management systems classification study, seventy papers and books are in detail studied. The oldest study is published in 1969 and the newest is published in 2006, which makes the literature review appropriate to show the improvements in this subject, furthermore half of the studies are later than 2000 which is good to fit the latest systems presentation ability. There are two sub groups which are highly classified as software and coding and decision making. Most of the studies are in society level and concentrated on individuals. The effective period of the reviewed studies are mostly in mid term. The journal or publisher origin of this management systems classification study is presented in Figure 2.1.20.

Continents	Number of Studies
North America	68
South America	0
Europe	1
Asia	1
Africa	0
Australia	0
Antarctica	0
Total	70

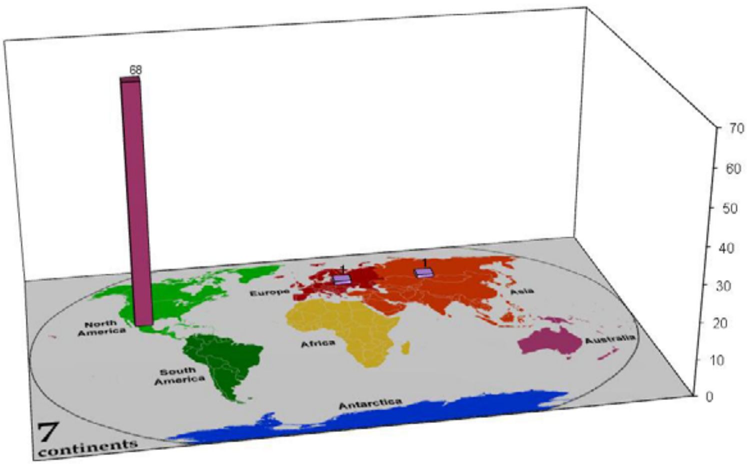


Figure 2.1.20 : Journal or publisher origin.

The literature review of management systems is presented by a table in Appendix A. During and after literature review on management systems it is clearly decided out that researchers and practitioners have considered closely on different management systems such as Decision Support System, Executive Support System, Group Decision Support System and so forth in several industries in several research depth, however none of the academic researches and practitioners’ studies are in shipbuilding, shipping, port management, energy industry or other mega investment industries, which all have unique characteristics. Contrarily, these previous studies prove the need for a new support system for these industries to make the investment decisions as appropriate as possible.

In conclusion, *in management systems point of view, this research is probably one of the first necessary step in the process of developing an Executive Support System, which is in strategic level system of organizations for making the decision at investment analysis in shipbuilding, shipping, port management, energy and other mega investment based industries*. In this research preferably off the shelves software's shall be integrated manually or automatically to build up an executive support system in major investment based industries.

2.2 Decision Making

The study which has been undergone within this subtitle or main group aims to make a classification study, that will guide the thesis within this main group. The table which is purposed to group the literature review in Appendix B has been filled in by information supplied in these summarized studies. The decision making methods and algorithms have been in detailed analysed by help of published studies and the approach of methods have been explained. These methods shall be a basis for the purposed method in which "*black box*" procedures should be avoided that simply means being understandable by the decision-makers.

The first study, which was summarized in this topic, was by Olcer et. al. (2006). Their study focused to develop a new MCDM methodology. This methodology would help the subdivision arrangement of Ro–Ro vessels. The purposed method integrated the multi-objective optimisation and the fuzzy multi-attributive group decision-making technique. The study aimed of generating, finding and ranking the finite number of Pareto-optimal design alternatives. A genetic algorithm was build up based on multi-objective optimisation technique. The solution space was searched and the best set of Pareto-optimal design alternatives were chosen, afterwards the best alternative was selected for optimisation purpose. The subjectiveness and imprecision was modelled by help of linear trapezoidal fuzzy numbers. These fuzzy numbers was modelled by means of linguistic terms. An attribute based aggregation technique for homogeneous and heterogeneous groups of experts was employed. The proposed new MCDM methodology was shown in Figure 2.2.1.

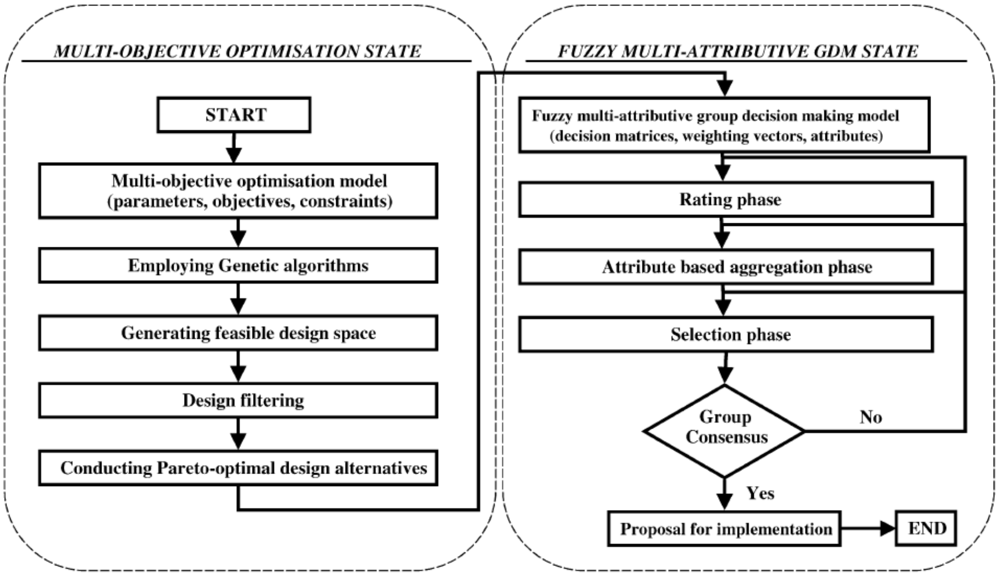


Figure 2.2.1 : Flow chart of the proposed methodology, (Source: Olcer et. al., 2006).

The proposed method had two major stages. These were "the multi-objective optimisation model state" which determined the Pareto-optimal design alternatives (PODAs) and "the fuzzy multi attributive group decision making state" which evaluated the PODAs according to both predetermined objective and subjective attributes (Olcer et. al., 2006). The hierarchical structure showing the overall objective, the attributes and alternatives was shown in the paper as presented in Figure 2.2.2.

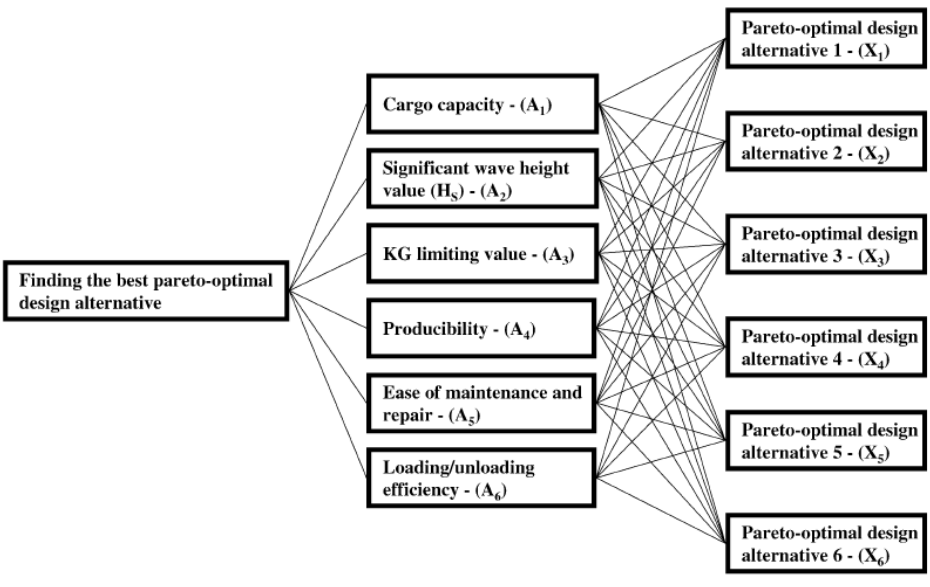


Figure 2.2.2 : Decision hierarchy of multiple attribute evaluation for PODAs, (Source: Olcer et. al., 2006).

The proposed approach was very suitable and also effective in dealing with experts' fuzzy opinions. A case study was also conducted and presented in the study.

The second study, which focused on ELECTRE (Elimination Et Choix Traduisant la Realité) method that was one of the outranking methods of multi attribute decision making methods, was by Figueira et. al. (2005). The ELECTRE methods originated back to 1965. This method was first developed by one of the European consultancy company named SEMA. On those days, a secret research team from SEMA worked on solving a concrete, multiple criteria, real-world problem. This weird problem caused to build a general multiple criteria method, which was named as MARSAN (Méthode d'Analyse de Recherche et de Sélection d'Activités Nouvelles). Afterwards, SEMA research team noticed serious problems and drawbacks in the application and implementation of this technique and formed a new technique named as ELECTRE method for choosing or selecting the best alternative from a given set of alternatives in 1965. This method was nowadays named or referred as ELECTRE I. ELECTRE Iv (ELECTRE One Vee) took into account the veto threshold. This method expressed the power to a given criterion to be against the assertion "a outranked b" (Figueira et. al., 2005). The difference of the evaluation between g(b) and g(a) was greater than this threshold. ELECTRE IS (ELECTRE One Esse) modeled the imperfect data. In late sixties, a method was developed and called ELECTRE II (ELECTRE two). This method dealed with the problem of ranking alternatives. This was done from the best option to the worst option. ELECTRE III (ELECTRE three) was found a few years later. It introduced the use of "pseudo-criteria" and also "fuzzy binary outranking relations" (Figueira et. al., 2005). ELECTRE IV (electre four) arose during the Paris subway network project. It gave the capability of ranking alternatives. This method was not using the relative criteria importance coefficients. ELECTRE A has not been relased for public yet. It was devised, applied and implemented for a large banking company. This large banking company faced with the problem of accepting credit requests or refusing credit requests by firms in ten different sectors. ELECTRE TRI (ELECTRE tree) was the latest developed method inspired by earlier methods.

ELECTRE methods were relevant to be chosen for using for the solution of problems under below situations:

1. "In the model, at least three criteria should have been included. The appropriate one was more than five criteria should have been included (up to twelve or thirteen)" (Figueira et. al., 2005).

At least one of the following situations must have been verified:

2. "Actions were evaluated (for at least one criterion) on an ordinal scale or on a weakly interval scale" (Figueira et. al., 2005).
3. "A strong heterogeneity related with the nature of evaluations existed among criteria (e.g. duration, noise, distance, security, cultural sites, monuments)" (Figueira et. al., 2005).
4. "Decision makers must not have been accepted the compensation of the loss on a given criterion by a gain on another one" (Figueira et. al., 2005).
5. "For at least one criterion the following holded true: small differences of evaluations were not significant in terms of preferences, while the accumulation of several small differences might have became significant. This required the introduction of discrimination thresholds (indifference and preference), which leaded to a preference structure with a comprehensive intransitive indifference binary relation" (Figueira et. al., 2005).

The steps of this method was defined in simplified manner by Yoon and Hwang (1995). The first step was "normalization step" (Yoon & Hwang, 1995). The attributes of benefits and the attributes of costs were transformed by vector normalization. The second step was "weighted normalization" (Yoon & Hwang, 1995). The weights were multiplied with each column of rating matrix. The third step was "division the sets of concordence and the sets of discordance" (Yoon & Hwang, 1995). Each pair of alternatives A_p and A_q (p, q= 1, 2, 3,…………,m and p≠q) was divided into two distinct subsets. The concordance set was composed of all attributes which had been defined. A_p was preferred to alternative A_q, could be written as $C(p,q) = \{ j \mid v_{pj} \geq v_{qj} \}$. v_{pj} was the weighted normalized rating of alternative. A_p was better than or equal to A_q. The complement of C(p,q) was called the discordance set. It contained all attributes for which A_p was worse than A_q. This could be written as $D(p,q) = \{ j \mid v_{pj} < v_{qj} \}$. The fourth step was "finding concordance and discordance indexes" (Yoon & Hwang, 1995). The concordance index C_{pq} represented the degree of confidence in the pairwise judgments of ($A_p \rightarrow A_q$). The concordance index of C(p,q) was defined as

$$C_{pq} = \sum_{j^*} w_j^* \qquad \textbf{(2.2.1)}$$

where j* were attributes contained in the concordance set C(p,q). The discordance index measured the power of D(p,q). The discordance index of D(p,q) represented the degree of disagreement in ($A_p \rightarrow A_q$). It could be defined as

$$D_{pq} = \left(\sum_{j^o} \left| v_{pj^o} - v_{qj^o} \right|\right) / \left(\sum_{j} \left| v_{pj} - v_{qj} \right|\right) \qquad \textbf{(2.2.2)}$$

where j^o were attributes. These were contained in the discordance set D(p,q). The fifth step was "outranking relationships" (Yoon & Hwang, 1995). The dominance relationship of alternative A_p over alternative A_q became stronger with a higher concordance index C_{pq}. A lower discordance index was D_{pq}. The method defined that A_p outranked A_q when $C_{pq} \geq \bar{C}$ and $D_{pq} < \bar{D}$, where $\bar{C}$ and $\bar{D}$ were the averages of C_{pq} and D_{pq} respectively.

This method has been widely used in agriculture and forest management, energy, environment and water management, finance, military, transportation and project selection.

The third study, which focused on PROMETHEE Methods, one of the outranking methods of multi attribute decision making methods, was by Brans and Mareschal (2005). The PROMETHEE I which was partial ranking method and afterwards the PROMETHEE II which was complete ranking method were developed by Brans in 1982. A few years later Brans and Mareschal developed PROMETHEE III which was ranking based on intervals method and PROMETHEE IV which was continuous case method. In 1992, Brans and Mareschal improved their method and called PROMETHEE V which was MCDA including segmentation constraints method; in 1994, an extension was suggested in PROMETHEE VI which was representation of the human brain method. The natural dominance relation associated to a multicriteria problem of type

$$\max\{g_1(a), g_2(a), ..., g_j(a), ..., g_k(a) \mid a \in A\} \qquad \textbf{(2.2.3)}$$

was defined as follows

For each (a,b) $\in$ A

$$\begin{cases} \forall j : g_j(a) \geq g_j(b) \\ \exists k : g_k(a) \succ g_k(b) \end{cases} \Leftrightarrow aPb,$$

$$\forall j : g_j(a) = g_j(b) \Leftrightarrow aIb, \qquad \textbf{(2.2.4)}$$

$$\begin{cases} \exists s : g_s(a) \succ g_s(b) \\ \exists r : g_r(a) \succ g_r(b) \end{cases} \Leftrightarrow aRb,$$

where P standed for preference, I standed for indifference and R standed for incomparability. This defined that an alternative was better than another alternative where it was at least as good as the other on all criterias. “If an alternative was better on a criterion s and the other one better on criterion r it was impossible to decide which the best one without additional information was” (Brans & Mareschal, 1992). Henceforth both alternatives were incomparable. Alternatives that were not dominated by any other were called “efficient solutions” (Brans & Mareschal, 1992). PROMETHEE could be run, particularly with the information that consisted of the criterias. The sum of all relative importance of the different criteria shall have been equal to 1. The information within each criterion in which the preference structure was defined as “pairwise comparisons” which meaned that (Brans & Mareschal, 1992).:

$P_j(a,b) = F_j\left[d_j(a,b)\right] \quad \forall a,b \in A$ where

$d_j(a,b) = g_j(a) - g_j(b)$ and for which **(2.2.5)**

$0 \leq P_j(a,b) \leq 1$

this function was given by generalised criterion. Six types of particular preference functions had been identified and proposed by Brans and Mareschal (2005) as shown in Figure 2.2.3.

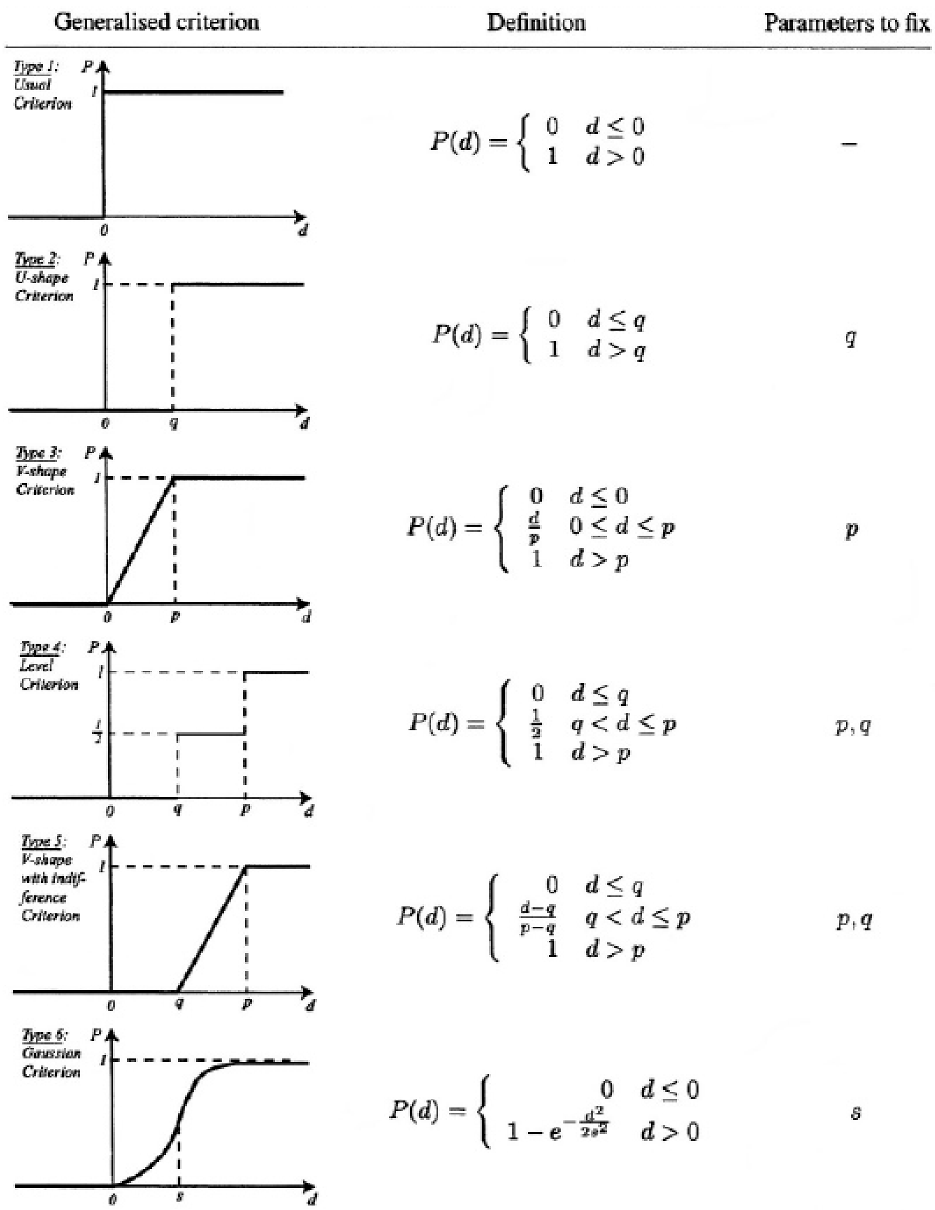


Figure 2.2.3 : Types of generalized criteria (P(d): Preference function), (Source: Brans and Mareschal, 2005).

Aggregated preference indices and aggregated outranking flows were defined as following:

Let a,b ∈ A and let:

$$\begin{cases} \pi(a,b) = \sum_{j=1}^{k} P_J(a,b) w_j \\ \pi(b,a) = \sum_{j=1}^{k} P_J(b,a) w_j \end{cases} \qquad \textbf{(2.2.6)}$$

$\pi(a,b)$ expressed with which degree a was preferred to b over all the criteria and $\pi(b,a)$ how was preferred b to a. The following properties held for all (a,b) ∈ A

$$\begin{cases} \pi(a,a) = 0, \\ 0 \le \pi(a,b) \le 1, \\ 0 \le \pi(b,a) \le 1 \\ 0 \le \pi(a,b) + \pi(b,a) \le 1 \end{cases} \qquad \textbf{(2.2.7)}$$

It was clear that:

$$\begin{cases} \pi(a,b) \sim 0 \text{ implied a weak global preference of a over b,} \\ \pi(a,b) \sim 1 \text{ implied a weak global preference of a over b,} \end{cases} \qquad \textbf{(2.2.8)}$$

Afterwards a complete valued outranking graph was obtained. This included two arcs between each pair of nodes as shown in Figure 2.2.4.

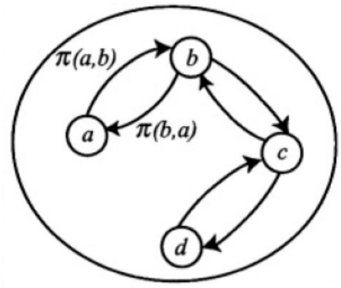


Figure 2.2.4 : Valued outranking graph, (Source: Brans & Mareschal, 2005).

The outranking flows for the PROMETHEE method was defined as following:

"Each alternative a face to (n-1) other alternatives in A. The outranking flows were the positive outranking flow and the negative outranking flow" which was shown in Figure 2.2.5 (Brans & Mareschal, 2005).

$$\begin{aligned} \phi^{+}(a) &= \frac{1}{n-1}\sum_{x \in A} \pi(a,x), \\ \phi^{-}(a) &= \frac{1}{n-1}\sum_{x \in A} \pi(a,x), \end{aligned} \qquad \textbf{(2.2.9)}$$

The $\phi^{+}(a)$ outranking flows The $\phi^{-}(a)$ outranking flows

Figure 2.2.5 : The PROMETHEE outranking flows, (Source: Brans & Mareschal, 2005).

The positive outranking flow expressed how an alternative had been outranked. The higher $\phi^{+}(a)$ was, the better the alternative was. The negative outranking flow expressed how an alternative had been outranked. The lower $\phi^{-}(a)$ was, the better the alternative was. PROMETHEE I and PROMETHEE II were appropriate to select one alternative. GAIA was a graphical tool for this method. PROMETHEE V was appropriate to select a subset of identified alternatives. These were powerful decision making tools, however the most critical method based on PROMETHEE method was PROMETHEE GDSS. This procedure followed the steps in three phases as:

PHASE I: “Generation of Alternatives and Criteria” (Brans & Mareschal, 2005)

STEPS:

1: “First contact Facilitator - DM’s” (Brans & Mareschal, 2005): The facilitator met and interviewed with the DM’s together or individually. The facilitator enriched and expended his or her knowledge of the problem.

2: “Description of problem in the GDSS room” (Brans & Mareschal, 2005): The facilitator described the computer and information infrastructure, the PROMETHEE methodology and introduced and explained the problem.

3: “Generation of alternatives” (Brans & Mareschal, 2005): Each DM implemented the possible alternatives. Their extended description was also included by help of computers.

4: “Stable set of alternatives” (Brans & Mareschal, 2005): All the proposed alternatives were collected and displayed. The facilitator could use one by one on the video-screen or in some cases not by help of computers.

5: “Comments on the alternatives” (Brans & Mareschal, 2005): Each DM implemented his or her comments on all the alternatives by help of computers.

6: “Stable set of evaluation criteria” (Brans & Mareschal, 2005): The same procedure as for step 4 of the alternatives was applied. This was done to define a stable set of evaluation criteria.

PHASE II: “Individual Evaluation by each DM” (Brans & Mareschal, 2005): Each DM had a decision power. This was given by a non-negative weight ($w_r, r = 1, 2, ..., R$) so that.

$$\sum_{r=1}^{R} w_r = 1 \quad \textbf{(2.2.10)}$$

7: "Individual evaluation tables" (Brans & Mareschal, 2005): The evaluation table ($n \times k$) had to be completed. This was performed by each DM.

8: "Additional PROMETHEE information" (Brans & Mareschal, 2005): Each DM developed his or her own PROMETHEE-GAIA analysis.

9: "Individual PROMETHEE-GAIA analysis" (Brans & Mareschal, 2005): The PROMETHEE I and PROMETHEE II rankings were obtained. In addition, the profiles of the alternatives were obtained. The GAIA plane and the net flow vector $\phi_{r(\bullet)}$ were also obtained. Henceforth each DM easily got his or her own clear view of the problem.

PHASE III: "Global Evaluation by the Group" (Brans & Mareschal, 2005)

10: "Display of the individual investigations": "The rankings and the GAIA plane of each DM were collected and displayed by the facilitator so that the group of all DM's was informed of the potential conflicts." (Brans & Mareschal, 2005)

11: "Global evaluation" (Brans & Mareschal, 2005): "The net flow vectors $\{\phi_{r(\bullet)}, r = 1, 2, ..., R\}$ of all the DM's were collected by the facilitator and put in a ($n \times R$) matrix." (Brans & Mareschal, 2005)

The direction of the associated PROMETHEE decision axis was very important and the decision was given by this axis. If the conflicts on the decision were too sensitive then the procedure was turned back to the weighting of the DM's. Afterwards the procedure was turned back to the individual evaluations. Afterwards the procedure was turned back to the set of criteria. Afterwards the procedure was turned back to the set of alternatives. Afterwards the procedure was turned back to the starting phase to include an additional stakeholder.

This method was widely used in banking industry, the procedure of industrial location decision making, manpower planning, water resources, investment analysis, medicine, chemistry, health care, tourism, ethics in OR, dynamic management.

Some other outranking methods such as ARGUS, ORESTE, EVAMIX, REGIME, TACTIC, QUALIFLEX, MELCHIOR, which was somehow linked the idea of ELECTRE and MAPPAC, PRAGMA, IDRA, PACMAN, which were developed according to Pairwise Criterion Comparison Approach (PCCA) were studied by Martel and Matarazzo (2005).

Martel and Matarazzo (2005), presented the detail information about QUALIFLEX. QUALIFLEX was a metric procedure. In QUALIFLEX procedure, the alternatives were ranked and evaluated according to each criterion. In QUALIFLEX procedure, on ordinal scale from family F was used. “For each permutation, one computed a concordance/discordance index for each couple of alternatives that reflected the concordance and the discordance of their ranks and their evaluation preorder from the impact matrix” (Martel & Matarazzo, 2005). In the set of alternatives A, the concordance/discordance index for each couple of alternatives were defined as $(a,b), a,b \in A$ at the level of preorder according to the criterion $g_i \in F$. The ranking for k^{ith} permutation was:

$$I_{jk}(a,b) = \begin{cases} 1 & \text{if concordance} \\ 0 & \text{if ex aequo} \\ \text{-1} & \text{if discordance} \end{cases} \quad \textbf{(2.2.11)}$$

The concordance/discordance index: $I_{jk} = \sum_{a,b \in A} I_{jk}(a,b)$ **(2.2.12)**

The comprehensive concordance/discordance index: $I_k = \sum_j \pi_j I_{jk}(a,b)$ **(2.2.13)**

where π_j was the weight of criterion g_j, j=1,2,……..,n.

The best compromise was the permutation that: $\max_{P(\pi_j)} I_k$ **(2.2.14)**

where P(π_j) was the set of feasible weights. The limitation of this method was the number of permutations. The number of permutations increased extremely with the number of alternatives.

Martel and Matarazzo (2005), explained in detail REGIME method. The REGIME method was an ordinal generalization of pairwise comparison methods. The method started with the concordance C_{il}

$$C_{il} = \sum_{j \in \dot{C}_{il}} \pi_j \quad \textbf{(2.2.15)}$$

where $\dot{C}_{il}$ was the concordance set.

The focal point of the method was on the sign of $C_{il} - C_{li}$ for each pair of alternatives. The regime matrix was formed by pairwise comparison of alternatives. Each criterion g_j, j=1,2,3……..,n and for each pair of alternatives (a_i,a_l) an indicator $c_{il,j}$ was defined as

$$c_{il,j} = \begin{cases} +1 \, if \; r_{ij} < r_{lj} \\ 0 \; if \; r_{ij} = r_{lj} \\ -1 \, if \; r_{ij} > r_{lj} \end{cases} \qquad \textbf{(2.2.16)}$$

where r_{ij} (r_{lj}) was the rank of the alternative a_i (a_l) according to criterion g_j. On all criteria each alternative was compared with each other. A vector was formed:

c_{il} = ($c_{il,1}$,…….. $c_{il,j}$,……….., $c_{il,n}$) was called a regime. All these regimes which determined the rank order of alternatives formed the regime matrix. The concordance index:

$C_{il} = \sum_j \pi_j c_{il,j}$ the concordance matrix C = |C_{il}| was shown as below matrix

$$\begin{array}{cc} & \begin{array}{ccccc} a_1 & \dots & a_l & \dots & a_m \end{array} \\ \begin{array}{c} a_1 \\ \vdots \\ a_m \end{array} & \begin{pmatrix} 0 & \cdots & \cdots & \cdots & \\ \vdots & \ddots & C_{il} & \vdots & \vdots \\ & \cdots & \cdots & \cdots & 0 \end{pmatrix} \end{array}$$

The REGIME method could be applied to ordinal criteria and cardinal criteria. The information contained in the quantitative evaluation, was not lost in this application. Martel and Matarazzo (2005), studied in detail ORESTE method. The ORESTE had an objective to find a global preference structure. The ORESTE was developed to deal with the problems. The alternatives were ranked according to each criterion. The ranking was performed by their importance. The method had three phases as “projection of the position-matrix”, “ranking the projections”, “aggregation of the global ranks” (Martel & Matarazzo, 2005). The ORESTE built a preference structure O = {I, P, R} on A as: a_iPa_l if a_i was comprehensively preferred to a_l (O_{il}=1, O_{li}=0), a_iIa_l if a_i was indifferent to a_l (O_{il}=0, O_{li}=1), a_iRa_l if a_i and a_l was comprehensively incomparable (O_{il}=O_{li}=0). The projection could be done in several ways. However Martel and Matarazzo (2005) selected the following way: The distance d(0,a_j) was defined with the use of {rj(a),r_j} such that d(0,a_j)< d(0,b_j), if aP_jb, where a_j=g_j(a) was the evaluation of alternative a with respect to criterion g_j. If g_jIg_k and r_j(a)=r_k(b) then d(0,a_j)=d(0,b_k). The distance was adequate: d(0,a_j)=αr_j(a)+(1-α)r_j. α stood for a substitution rate (0<α<1). The ranking was performed by assigning a mean rank $R(a_j)$ to a pair (a,g_j). $R(a_j) \leq R(b_k)$, if $d(0,a_j) \leq d(0,b_k)$, were called "comprehensive ranks" in the closed interval (1, mn) (Martel & Matarazzo, 2005).

In the last phase, in "aggregation phase", the "comprehensive ranks" of each alternative over the set of criteria was computed with the summation operation (Martel & Matarazzo, 2005). The final aggregation for an alternative a was:

$$R(a) = \sum_{j} R(a_j) \tag{2.2.17}$$

C(a,b) index was also computed in the ORESTE method as following:

$$C(a,b) = \sum_{j:aP_jb} [R(b_j) - R(a_j)] \tag{2.2.18}$$

The preference structure O = {I, P, R} was obtained as R(a)≤ R(b) than aIb or aPb or aRb. β stood for an "indifference level" and γ for an "incomparability level" (Martel & Matarazzo, 2005). The flow diagram of the ORESTE method was presented by Martel and Matarazzo (2005) as shown in Figure 2.2.6.

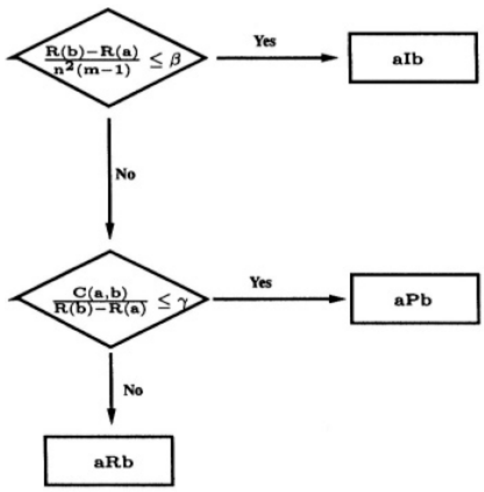


Figure 2.2.6 : ORESTE flow chart, (Source: Martel & Matarazzo, 2005).

Martel and Matarazzo (2005), presented detail information about ARGUS method. The ARGUS method used qualitative values for representing the preference. An ordinal scale was used. One of the following qualitative relations was selected: "indifference", "small", "moderate", "strong" or "very strong preference" (Martel & Matarazzo, 2005). The evaluation on the criteria was performed on an ordinal scale. The evaluations of each alternative with respect to each criterion could be quantitative. For instance interval scale or ratio scale or qualitative scale such as ordinal scale could be used. The DM must have indicated his/her preference for each pair of values. A preference matrix had to be constructed as shown in Figure 2.2.7 to model the preference structure of the DM.

$g_i(b)$	very poor	poor	average	good	very good
$g_i(a)$ very poor	indiff.				
poor		indiff.			
average			indiff.		
good				indiff.	
very good					indiff.

Figure 2.2.7 : Preference matrix for a criterion with ordinal evaluation, (Source: Martel & Matarazzo, 2005).

The preference structure of the DM for each criterion and the importance of each criterion was found. After the preference structure of the DM was known, the comparison of two alternatives a and b with respect to the criterion g_j led to a two-dimensional table as shown in Figure 2.2.8.

	criteria preference	not imp.	little imp.	moderate imp.	very imp.	extremly imp.	w_j
$g_j(a) > g_j(b)$	very strong	f_{11}	f_{12}	f_{13}	f_{14}	f_{15}	a
	strong	f_{21}	f_{22}	f_{23}	f_{24}	f_{25}	b
	moderate	f_{31}	f_{32}	f_{33}	f_{34}	f_{35}	$\vdots$
	small	f_{41}	f_{42}	f_{43}	f_{44}	f_{45}	$\vdots$
$g_j(a) = g_j(b)$	no	f_{51}	f_{52}	f_{53}	f_{54}	f_{55}	$\vdots$
$g_j(a) < g_j(b)$	small	f_{61}	f_{62}	f_{63}	f_{64}	f_{65}	$\vdots$
	moderate	f_{71}	f_{72}	f_{73}	f_{74}	f_{75}	$\vdots$
	strong	f_{81}	f_{82}	f_{83}	f_{84}	f_{85}	b
	very strong	f_{91}	f_{92}	f_{93}	f_{94}	f_{95}	a

Figure 2.2.8 : Preference importance table for g_j,a,b, (Source: Martel & Matarazzo, 2005).

f_{st} stood for the number of criteria of a certain importance. A certain preference between the alternatives a and b occurred

$$\sum_s \sum_t f_{st} = n \qquad \textbf{(2.2.19)}$$

The combined preferences with weights variable was calculated where $g_j(a)>g_j(b)$, $u_1=f_{15}$, $u_2=f_{14}+f_{25}$, $u_3=f_{13}+f_{24}+f_{45}$, $u_4=f_{12}+f_{23}+f_{34}+f_{45}$, $u_5=f_{11}+f_{22}+f_{33}+f_{44}$, $u_6=f_{21}+f_{32}+f_{43}$, $u_7=f_{31}+f_{42}$, $u_8=f_{41}$; where $g_j(a)<g_j(b)$, $v_1=f_{95}$, $v_2=f_{85}+f_{94}$, $v_3=f_{75}+f_{84}+f_{93}$, $v_4=f_{65}+f_{74}+f_{93}+f_{92}$, $v_5=f_{64}+f_{73}+f_{82}+f_{91}$, $v_6=f_{63}+f_{72}+f_{81}$, $v_7=f_{62}+f_{71}$, $v_8=f_{61}$. The decision

maker altered this ranking until it matched his/her personal conception. The most crucial disadvantage of the ARGUS method was the great and disturbing effort from the DM to model his/her preferences.

Martel and Matarazzo (2005), explained in detail the EVAMIX method. This method was a generalization of concordance analysis. Mixed information was involved. The determination of concordance and discordance indices was made. This was done by a pairwise comparison for all pairs of alternatives. The main difference in this method was the separate indices. These were constructed or built up for the qualitative and quantitative criteria. The set of criteria was divided into two. The first one was a set of qualitative (ordinal) criteria O. The second one was a set of quatitative (cardinal) criteria C. The alternatives were expressed by two dominance measures. The first one was a dominance score for the ordinal criteria. The second one was a dominance score for the cardinal criteria in the following structure:

$$\begin{aligned} a_{ii'} &= f(e_{ij}, e_{i'j}, \pi_j), \text{ for all j} \in \text{O}, \\ a_{ii'} &= g(e_{ij}, e_{i'j}, \pi_j), \text{ for all j} \in \text{C}, \end{aligned} \quad \textbf{(2.2.20)}$$

where e_{hj} was the evaluation of alternative a_h on the criterion g_j and π_j. The importance weight associated to this criterion was defined as follows:

$$a_{ii'} = \left[\sum_{j \in O} \left\{ \pi_j \operatorname{sgn}(e_{ij} - e_{i'j}) \right\}^c \right]^{\frac{1}{c}}, \quad \operatorname{sgn}(e_{ij} - e_{i'j}) = \begin{cases} +1 & \text{if } e_{ij} > e_{i'j} \\ 0 & \text{if } e_{ij} = e_{i'j} \\ -1 & \text{if } e_{ij} < e_{i'j} \end{cases} \quad \textbf{(2.2.21)}$$

c was any positive odd value. This denoted an arbitrary scaling parameter. The quantitative dominance measure was defined in a similar manner. The rankings $e_{ij}(j \in O)$ of the qualitative criteria represented "the higher, the better" (Martel & Matarazzo, 2005). The standardized dominance measures was written as $\delta_{ii'} = h(\alpha_{ii'})$ and $d_{ii'} = h(\alpha_{ii'})$. h was the standardization function. The overall dominance measure $D_{ii'}$ for each pair of alternatives (a_i, $a_{i'}$) was

$$D_{ii'} = \pi_0 \delta_{ii'} + \pi_c d_{ii'}, \text{where } \pi_o = \sum\nolimits_{j \in O} \pi_j \text{ and } \pi_c = \sum\nolimits_{j \in C} \pi_j \quad \textbf{(2.2.22)}$$

Finally, the appraisal score was calculated as

$$s_i = \left[\sum_{i'} \frac{D_{i'i}}{D_{ii'}} \right]^{-1} \quad \textbf{(2.2.23)}$$

The overall dominance measure $D_{ii'}$ was defined as.

$$D_{ii'} = \frac{s_i}{s_i + s_{i'}}, \; D_{ii'} + D_{i'i} = 1 \quad \textbf{(2.2.24)}$$

This method was based on two assumptions as functions f, g, h and k. The definition of the weights were the sets O and C.

Vansnick (1983), presented detail information about TACTIC method. The "true-criteria" or the "quasi-criteria" (criteria with an indifference threshold q>0) were considered. g_j,j=1,…,n and the correspondent preference structures were (P,I) or (P,I,R) (Vansnick, 1983). R was the incomparability relation. The following subset of $\Im$ was defined for modeling the preferences.

$$\forall a,b \in A, a \neq b: \; \Im_T(a,b) = \left\{ j \in \middle| : g_j(a) > g_j(b) + q_j[g_j(b)] \right\} \quad \textbf{(2.2.25)}$$

$q_j[g_j(b)]$ was the marginal indifference threshold. The statement aPb was true if and only if the following concordance condition was satisfied:

$$\sum_{j \in \Im_T(a,b)} \lambda_j > \rho \sum_{j \in \Im_T(a,b)} \lambda_j, i.e. \frac{\sum_{j \in \Im_T(a,b)} \lambda_j}{\sum_{j \in \Im_T(b,a)} \lambda_j} > \rho \; if \; \Im_T(b,a) \neq \theta \quad \textbf{(2.2.26)}$$

ρ was called required concordance level.

In this method, there were two types of intransitivity: 1-) aPb, bPc, aIc (or aRc), 2-) aPb, bPc, cPa. The basic concordance-discordance procedure was for structures (P,I)

$$aPb \; iff \sum_{j \in \Im_T(a,b)} \lambda_j > \sum_{j \in \Im_T(b,a)} \lambda_j, \; aIb \; iff \sum_{j \in \Im_T(a,b)} \lambda_j = \sum_{j \in \Im_T(b,a)} \lambda_j, \quad \textbf{(2.2.27)}$$

for structures (P,I,R)

$$aPb \ iff \sum_{j \in \Im_T(a,b)} \lambda_j > \sum_{j \in \Im_T(b,a)} \lambda_j, and \ g_j(b) - g_j(a) \le \upsilon_j[g_j(a)], \forall_j \in \Im;$$

$$\begin{aligned}
&aIb \ iff \sum_{j \in \Im_T(a,b)} \lambda_j > \sum_{j \in \Im_T(b,a)} \lambda_j, and \\
&g_j(b) - g_j(a) \le \upsilon_j[g_j(a)], \forall_j \in \Im; and \\
&g_j(a) - g_j(b) \le \upsilon_j[g_j(a)], \forall_j \in \Im. \\
&aRb \ iff \ non(aPb), \ non(bPa) \text{ and } non(aIb).
\end{aligned} \tag{2.2.28}$$

In TACTIC method, no particular exploitation procedure was suggested. In TACTIC method, spliting indifference and incomparability situations was difficult.

Leclercq (1984), explained in detail the MELCHIOR method. The criteria g_j with an indifference threshold was q_j. A preference threshold was p_j ($p_j > q_j \geq 0$) such that, $\forall j \in \Im$ and $\forall a, b \in A$:

- "a was strictly preferred to b (aP_jb) with respect to g_j iff $g_j(a)>g_j(b)+p_j[(g_j(b)]$,
- a was weakly preferred to b(aQ_jb) with respect to g_j iff $g_j(b)+p_j[(g_j(b)] \geq g_j(a)>g_j(b)+q[(g_j(b)]$,
- a and b were indifferent (aI_jb) iff there was no strict or weak preference between them" (Leclercq, 1984).

In this method, a criterion g_j ε F was said to be in favor of the outranking relation. In this method, aSb was found if one of the following situations was verified:

- "aP_jb (marginal strict preference of a over b),
- aP_jb or aQ_jb (marginal strict or weak preference of a over b),
- $g_j(a)>g_j(b)$" (Leclercq, 1984)

The concordance analysis with respect to the outranking relation was aSb, a,b ε A. This was made by checking if the family of criteria G in favor of this relation. There existed a criterion g_j from G such that

- g_jMg_i,
- g_jMg_i or not (g_iMg_j)

"By choosing two suitable combinations of the above conditions, the first stricter than the other and verifying the concordance and the absence of discordance, a strong and a weak comprehensive outranking relation could be respectively built up.

Then these relations were in turn exploited as in ELECTRE IV method" (Martel & Matarazzo, 2005).

Martel and Matarazzo (2005), presented brief information about MAPPAC method. This was based on pairwise criterion comparisons. a dominates b (aDb), a,b ε A, with respect criteria from F if a was at least as good as b for the considered criteria. This was strictly preferred to b for at least one criterion:

$$aDb \Leftrightarrow g_i(a) \geq g_i(b), \forall g_i \in F \text{ and } \exists j \in J : g_j(a) > g_j(b) \quad \textbf{(2.2.29)}$$

a weakly dominated b (aD_wb) if a was at least as good as b for all the criteria from F:

$$aD_wb \Leftrightarrow g_i(a) \geq g_i(b), \forall g_i \in F \quad \textbf{(2.2.30)}$$

a strictly dominated b (aD_sb) iff where $g_i(a) \geq g_i(b), \forall i \in F$. At most only one equality was valid. The binary relation D_w was a partial preorder. While D and D_s was a partial order, the correspondent preference structures were partial order and strict partial order respectively.

$$D_s \subset D \subset D_w, aDb, aD_wc \Rightarrow aDc \text{ and } aD_wb, bDc \Rightarrow aDc, \forall a,b,c \in A. \quad \textbf{(2.2.31)}$$

The "basic indices $\pi_{ij}(a,b)$" were interpreted as "credibility indices" (Martel & Matarazzo, 2005). The partial dominance $aD_{ij}b$ indicated the fuzzy degree of preference of a over b in the MAPPAC method. The "global index $\pi(a,b)$" was interpreted as the "credibility index" (Martel & Matarazzo, 2005). The strict dominance was aD_sb in the MAPPAC method.

If all criteria from F were interval scales, $\Delta_j(a,b)=g_j(a)-g_j(b)$, for each $j \in J$ and $a,b \in A, w_j$ was the trade-off weight. λ_j was the importance weight of criterion $g_j, j \in J$. The axiomatic system of MAPPAC partial indices were presented in Figure 2.2.9.

$\pi_{ij}(a,b)$	Binary Relations	Signs of $\Delta_i(a,b)\cdot\Delta_j(a,b)$	Signs of $\Delta_i(a,b)+\Delta_j(a,b)$	Pair of Signs of $\Delta_i(a,b),\ \Delta_j(a,b)$
$]0,1[$	$aP_{ij}b, bP_{ij}a,$ $aI_{ij}b$	<0	$\gtreqless$	$(+,-),(-,+)$
$\frac{1}{2}$	$aI_{ij}b$	$=0$	$=0$	$(0,0)$
1	$aD_{ij}b$	≥ 0	>0	$(+,+),(+,0),$ $(0,+)$
0	$bD_{ij}a$	≥ 0	<0	$(-,-),(-,0),$ $(0,-)$

Figure 2.2.9 : Axiomatic system of MAPPAC basic indices, (Source: Martel & Matarazzo, 2005).

The preference indices would also be calculated.

$$w_j\Delta_j(a,b) = w_j(g_j(a) - g_j(b)),\ j \in J, a, b \in A \qquad \textbf{(2.2.32)}$$

was the normalized weighted difference of evaluations of actions a and b with respect to criterion g_j. The preference indeces were shown in Figure 2.2.10.

$\pi_{ij}(a,b)$	$\pi_{ij}(b,a)$	
1	0	if $g_i(a) > g_i(b)$ and $g_j(a) > g_j(b)$
0	1	if $g_i(a) < g_i(b)$ and $g_j(a) < g_j(b)$
0.5	0.5	if $g_i(a) = g_i(b)$ and $g_j(a) = g_j(b)$
$\frac{w_i(g_i(a)-g_i(b))}{w_i(g_i(a)-g_i(b))+w_j(g_j(b)-g_j(a))}$	$\frac{w_j(g_j(b)-g_j(a))}{w_i(g_i(a)-g_i(b))+w_j(g_j(b)-g_j(a))}$	if $g_i(a) > g_i(b)$ and $g_j(a) \leq g_j(b)$ $g_i(a) = g_i(b)$ and $g_j(a) < g_j(b)$
$\frac{w_j(g_j(a)-g_j(b))}{w_i(g_i(b)-g_i(a))+w_j(g_j(a)-g_j(b))}$	$\frac{w_i(g_i(b)-g_i(a))}{w_i(g_i(b)-g_i(a))+w_j(g_j(a)-g_j(b))}$	if $g_i(a) \leq g_i(b)$ and $g_j(a) > g_j(b)$ $g_i(a) < g_i(b)$ and $g_j(a) = g_j(b)$

Figure 2.2.10 : Preference indices, (Source: Martel & Matarazzo, 2005).

The "global preference index" π(a,b) was the sum of all the $\binom{m}{2}, m > 2$ (Martel & Matarazzo, 2005). The "basic preference indices" π_{ij}(a,b) weighted each time by the normalized importance weights (Martel & Matarazzo, 2005). λ_{ij} considered couple of criteria g_i, g_j:

$$\pi(a,b) = \sum_{ij(i<j)} \pi_{ij}(a,b)\frac{\lambda_{ij}}{\Lambda}, \text{ where } \Lambda = \sum\nolimits_{ij(i<j)} \lambda_{ij}. \qquad \textbf{(2.2.33)}$$

The “global preference index” was the summation of the following indeces $\pi_{PP}(a,b)$, $\pi_{PO}(a,b)$, $\pi_{NN}(a,b)$, $\pi_{OO}(a,b)$, $\pi_{PN}(a,b)$ (Martel & Matarazzo, 2005). The features of the basic preference indices with respect to the dominance and compensation pointed out that MAPPAC was considered as an intermediate MCDA methodology between the ELECTRE and MAUT methods.

Martel and Matarazzo (2005), explained in detail the Preference Ranking Global Frequencies In Multicriteria Analysis Method (PRAGMA). The PRAGMA was a pairwise comparison by means of couples of distinct criteria and on the aggregation of these partial results. The data input and the preferential information was same as the MAPPAC method. The basic preferences indices of MAPPAC method was used to support decision maker. In this method, partial and global ranking frequencies were respectively built for each feasible action. These frequencies were given to DM for a useful recommendation. Particular properties of the ranking frequencies by the PRAGMA were:

- “The partial ranking frequencies and global ranking frequencies of $a_h \in A$ were functions of the value of the normalized weighted differences between the evaluations of a_h and those of the remaining feasible actions for each criteria.
- If a_h strictly dominated n-k actions where a_h partially dominated by the remaining k-1 actions, k=1,2,……..,n the results was $f_{ij}^{(k)}(a_h)=1$, whatever the values λ_i and λ_j.
- If a_h strictly dominated n-k actions where a_h partially dominated by the remaining k-1 actions, k=1,2,……..,n the results was $f^{(k)}(a_h)=1$, whatever the values λ_i, $j \in J$.
- If $f^{(k)}(a_h)=1$, the action a_h held the k^{th} position, k=1,2,……,n in every monocriterion ranking and a_h was preceded and followed by the same subset of actions in these rankings” (Martel & Matarazzo, 2005).

The PRAGMA method could be used to build a final ranking of the feasible actions. This was the intersection of the two decreasing and increasing rankings. In the PRAGMA method used the same discordance indices as in the MAPPAC method. Moreover, in this method, it was also possible to consider other analogous discordance indices.

Greco (1997), published a paper named as "A new PCCA method: IDRA", which presented the Intercriteria Decision Rule Approach (IDRA) as a new MCDA (Multiple Criteria Decision Aid) method that adopted to the PCCA (Pairwise Criterion Comparison Approach) methodology (Greco, 1997). The main features of the IDRA method was described as using the mixed utility function and allowing the bounded consistency. The principal idea of the IDRA could be defined. On the contrary matching was a questioning procedure to collect the intercriteria information. This was named as trade-off. Hence in this method there was only one utility function U^M. This consisted not only trade-off (α_j) and importance (λ_j) weights where j $\in J$. For each $a_h \in A$: $U^M(a_h) = \sum_{j=1}^{m} \lambda_j \alpha_j g_j(a_h)$. The scheme of pairwise criterion comparison approach was used in the intercriteria decision rule. This approach was for implementing the bounded consistency. For any couple of distinct criteria $g_i, g_j \in F$, the DM delivered one of the following information:

- "The trade-off and the judgement about the relative importance of the criteria;
- Only the trade-off;
- Only the judgement about the relative importance of the criteria;
- Neither the trade-off nor the judgement about the relative importance of the criteria" (Greco, 1997).

The distinctive characteristics of IDRA were defined at the first pace. The DM did not supply any intercriteria information. For instance, the relative importance between g_i and g_j was not given. At the second pace, the DM could say that her or his capacity for a trade-off between g_i and g_j was not enough.

Giarlotta (1998), explained a new approach named as PACMAN (Passive and Active Compensability Multicriteria Analysis), which based on the Pairwise Criterion Comparison Approach (PCCA). This method classified "the active criterion" from "the passive criterion" (Giarlotta, 1998). The binary relation between each couple of alternatives was determined by the compensated preference introduced in this method. The generic alternatives were compared by terms of relations. These terms were defined as "strong preference", "weak preference", "indifference" or "incomparability" (Giarlotta, 1998). The PACMAN method had three main steps.

The first step was "compensability analysis which aimed to model relations by means of compensability" (Giarlotta, 1998). The second step was "binary indices which were the evaluation of the active and passive preference" (Giarlotta, 1998). Finally the last step was "the determination of a binary relation on the basis of compensated preference" (Giarlotta, 1998). The "compensability analysis" was performed by the help of "compensatory function" (Giarlotta, 1998). This was a fuzzy function, $CF_{i \triangleright j}$ of i over j. The advantage of the fuzzy modelling was to minimizing the workload of decision maker. This was done by minimizing the amount of information given by the decision maker without losing the content. In PACMAN method, the degree of confidence was expressed by compensatory function. This was performed by establishing the zones and afterwards by using "monotonicity" and "continuity" (Giarlotta, 1998). The extension by linearization was performed. The examples for compensatory function were given in Figure 2.2.11.

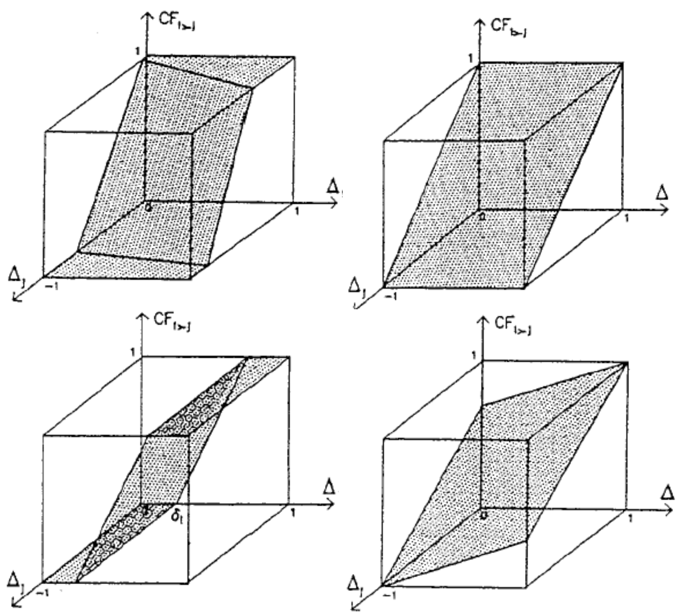


Figure 2.2.11 : Examples of compensatory function, (Source: Giarlotta, 1998).

One of the crucial and important features of PACMAN was the modelling ability of the real scenarios for each pair of criteria in an appropriate way. In the location of a pair of actions were shown in a diagram as shown in Figure 2.2.12.

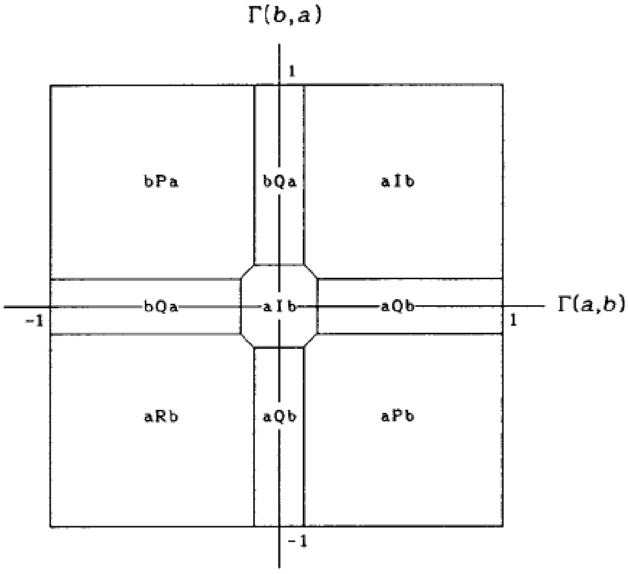


Figure 2.2.12 : Locating the relation of weak preference in an area using suitable thresholds, (Source: Giarlotta, 1998).

Martel and Zaras (1997), explained their new approach which was based on the stochastic dominance comparison of the alternatives. This was used for modeling a multi-criteria problem. This was represented by alternatives, attributes and decision makers. In their approach there were three important steps. These steps were the "comparisons of partial preferences", the "outranking relations based on concordance index and discordance index" and finally the "prescription by help of outranking relations" (Martel & Zaras, 1997). In this model, there were two situations. These were the "clear situation" ($SD = FSD \cup SSD \cup TSD$ stochastic dominance conditions were verified) and the "unclear situation" (none of the stochastic dominance condition was verified) (Martel & Zaras, 1997). The FSD was the first stochastic dominance condition. The SSD was the second stochastic dominance condition. The TSD was the third stochastic dominance condition. The value of concordance index had two parts. The first part was "explicable concordance" and the second part was "non-explicable concordance" (Martel & Zaras, 1997). Martel and Zaras (1997), proposed that the outranking relations could either be presented by help of a graph as shown in Figure 2.2.13 or by help of exploiting them.

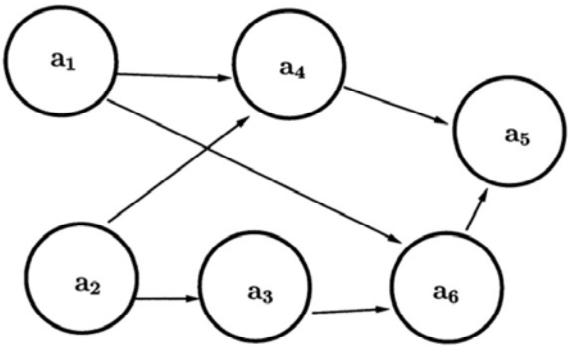


Figure 2.2.13 : Partial preorder, (Source: Martel & Zaras, 1997).

Jacquet-Lagrèze and Siskos (1982), proposed the method called UTA (UTilitès Additives). This method inferred one or more additive value functions from a given ranking on a reference set A_R. The additive value function was assumed to be in the following form

$u(g) = \sum_{i=1}^{n} p_i u_i(g_i)$ subjected to normalized constraints

$$\begin{cases} \sum_{i=1}^{n} p_i = 1 \\ u_i(g_{i^*}) = 0, u_i(g_{i^*}) = 1, \forall_i = 1, 2, ..., n; \end{cases} \quad \textbf{(2.2.34)}$$

in this equation u_i,i=1, 2, ……., n were non-decreasing real valued function. This was named as marginal value or utility function. This was normalized between 0 and 1. p_i was the weight of u_i. The normalized marginal value function, which had the monotonicity property of the true criterion, was shown in Figure 2.2.14.

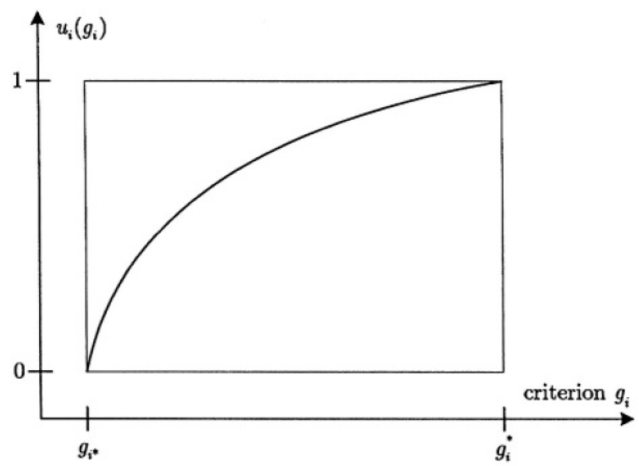


Figure 2.2.14 : The normalized marginal value function, (Source: Jacquet-Lagrèze & Siskos, 1982).

The value of each alternative $a \in A_R$ might have been written in the following form. The term $\sigma(a)$ was the potential eror:

$$u'\left[g(a)\right] = \sum_{i=1}^{n} u_i\left[g_i(a)\right] + \sigma(a) \qquad \forall a \in A_R \tag{2.2.35}$$

The marginal value functions were estimated by means of a Linear Program (LP). The constraints and the objective function depended as below:

$$\begin{cases} [\min] F = \sum_{a \in A_R} \sigma(a) \\ subject \quad to \\ \left.\begin{array}{l} \Delta(a_k, a_{k+1}) \geq \delta \ if \ a_k \succ a_{k+1} \\ \Delta(a_k, a_{k+1}) \geq \delta \ if \ a_k \succ a_{k+1} \end{array}\right\} \forall k \\ u_i(g_i^{j+1}) - u_i(g_i^{j+1}) \geq 0 \, \forall i \ and \ j \\ \sum_{i=1}^{n} u_i(g_i^*) = 1 \\ u_i(g_{i^*}) = 0, u_i(g_i^j) \geq 0, \sigma(a) \geq 0 \qquad \forall a \in A_R, \forall i \text{ and } j. \end{cases} \tag{2.2.36}$$

This Linear Program considered as a post-optimal analysis problem. The post optimal solutions space defined by the polyhedron. This could be explored by branch and bound methods.

Siskos and Yannacopoulos (1985), proposed an improved version of UTA (UTilitès Additives), which was named as UTASTAR. In this method a double positive error function was introduced. The value of each alternative was became to the following form:

$$u'\left[g(a)\right] = \sum_{i=1}^{n} u_i\left[g_i(a)\right] - \sigma^+(a) + \sigma^-(a) \qquad \forall a \in A_R \tag{2.2.37}$$

The UTASTAR algorithm had the following steps:

"Step 1: Expressing the global value of reference actions in terms of marginal values and variables by means of following expressions:

$$\begin{cases} u_i(g_i^1) = 0 \ \forall i = 1, 2, ..., n \\ u_i(g_i^j) = \sum_{t=1}^{j-1} w_{it} \ \forall i = 1, 2, ..., n \text{ and } j = 2, 3, ..., \alpha_i - 1 \end{cases} \tag{2.2.38}$$

Step 2: Introduction two error functions σ^{+} and σ^{-} on A_R

Step 3: Solving Linear Program

$$\begin{cases} [\min]z = \sum_{k=1}^{m}[\sigma^{+}(a_k) + \sigma^{-}(a_k)] \\ \quad \textit{subject to} \\ \left.\begin{array}{l} \Delta(a_k, a_{k+1}) \geq \delta \text{ if } a_k \succ a_{k+1} \\ \Delta(a_k, a_{k+1}) = 0 \text{ if } a_k \sim a_{k+1} \end{array}\right\} \forall k \\ \sum_{i=1}^{n}\sum_{j=1}^{\alpha_i - 1} w_{ij} = 1 \\ w_{ij} \geq 0,\ \sigma^{+}(a_k) \geq 0,\ \sigma^{-}(a_k) \geq 0 \qquad \forall i, j \text{ and } k \end{cases} \tag{2.2.39}$$

Step 4: Performing the stability analysis" (Siskos & Yannacopoulos, 1985).

Siskos and Yannacopoulos (1985), presented a comparison analysis between UTA and UTASTAR algorithms and gave numerical examples.

There were also some other techniques, which were grouped under the name of meta-UTA techniques, which were purposed to improve the value function. Despotis and Yannacopoulos (1990), tried to minimize the dispersion of errors; Beuthe and Scannella (2001), looked for optimal values of s and/or δ. Siskos (1983), developed a stochastic UTA method; Jacquet-Lagrèze and Siskos (1982), presented a new approach named as UTADIS method (UTilits Additives DIScriminantes) similar to UTASTAR method; Zopounidis and Doumpos (2000), presented the MHDIS method (Multi-group Hierarchical DIScrimination) an extending framework of the UTADIS method.

Saaty (1980), developed the Analytic Hierarchy Process (AHP) method. This method could easily formalize the intuitive understanding. It was underlined that the AHP method allowed the decision makers to structure very complex and very diffucult problems in hierarchical form. Objectives and alternatives should have been defined in simple manner. Each alternative in its given level should be identified with respect to other related factors.

In AHP approach, each pairwise comparison between alternatives, which were given as A_1, A_2, … , A_m for each attribute was supplied by the ratios a_{ij}. The comparison matrices as represented below were presented for n+1 positive pairwise alternatives. n showed the number of attributes.

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ . & . & & . \\ . & . & & . \\ . & . & & . \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} = \begin{bmatrix} w_1/w_1 & w_1/w_2 & \dots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \dots & w_2/w_n \\ . & . & & . \\ . & . & & . \\ . & . & & . \\ w_n/w_1 & w_n/w_2 & \dots & w_n/w_n \end{bmatrix} \tag{2.2.40}$$

The pairwise comparison matrices were used for each attribute for computing the performance score of alternative or the weights of the attributes. A_i represented the alternative with respect to attribute X_j, r_{ij}. The performance scores and the weight set were found from the equation below:

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ . \\ . \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} X_1 & X_2 & \dots & X_n \end{array} \\ \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ . & & & \\ . & & & \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix} \end{array} \tag{2.2.41}$$

$$\underline{w} = (w_1, w_2, \dots, w_n)$$

$r_{ij} \varepsilon \Re$ and $w_j \varepsilon \Re$, $\forall i, j$. The utulities of A_i, U_i, $\forall I$ were found from:

$$U_i = \sum_{j=1}^{n} w_j r_{ij} / \sum_{j=1}^{n} w_j \tag{2.2.42}$$

The basic axioms of the AHP method were given as “reciprocal judgments”, “homogeneous elements”, “hierarchic dependent structure” and “rank order expectations” (Saaty, 1980). Finally, in the AHP method, the rank of alternatives with respect to factors were presented.

Saaty (1999), presented in detail the Analytic Network Process, which was basically structured by networks. The Analytic Network Process was a generalization of the Analytic Hierarchy Process. Saaty (1999), outlined the steps of the ANP as:

1. “The control hierarchies including their criteria for comparing the components of the system and their subcriteria for comparing the elements of the system was determined. One hierarchy was for benefits, a second one was for costs, a third one was for opportunities and a fourth was for risks.

2. For each control criterion or subcriterion, the clusters of the system with their elements was determined.
3. The development of the model, for each control criterion the clusters and their elements in a convenient way was organized.
4. The approach being influenced by other clusters and elements or influencing other clusters and elements with respect to a criterion was determined.
5. For each control criterion, a three-column table placing each cluster label in the middle column was constructed. In the left column, on a line all the clusters that influenced the cluster and in the column on the right those clusters which it influenced, were listed.
6. Following each entry in the table above, paired comparisons on the clusters as they influenced each cluster and on those that it influenced, with respect to that criterion was performed. The derived weights were used later to weight the elements of the corresponding column clusters of the supermatrix corresponding to the control criterion. A zero when there was no influence, was assigned.
7. Paired wised comparisons on the elements within the clusters themselves according to their influence on each element in another cluster was performed. They could be connected to their own clusters. The comparisons were made with respect to a criterion or subcriterion of the control hierarchy.
8. For each control criterion, the supermatrix by laying out the clusters in the order were constructed. They were numbered and all the elements in each cluster both vertically on the left and horizontally at the top were found. In the appropriate position the priorities were derived from the paired comparisons as parts (subcolumns) of the corresponding column of the supermatrix.
9. The limiting priorities of each supermatrix according to irreducible (primitive or imprimitive cyclic) were computed or it was reducible with one being a simple or a multiple root and whether the system was cyclic or not.

10. The limiting priorities by weighting each limiting supermatrix and by the weight of its control criterion and adding the resulting supermatrices were synthesized.
11. The synthesis for each of the four control hierarchies were repeated: the first was for benefits, the second was for costs, the third was for opportunities, and the fourth was for risks.
12. The results from the four control hierarchies by multiplying the benefits by the opportunities and dividing by the costs multiplied by the risks was synthesized. Then the highest priority alternative or the desired mix of alternatives were read off" (Saaty, 1980).

One of the important parts of the ANP method was the "supermatrix", which was a two dimensional matrix (Saaty, 1980). The priority vectors were shown in the appropriate column of the "supermatrix" (Saaty, 1980).

Saaty and Vargas (2006), showed how the ANP method could handle the "tangibles" and "intangibles". Moreover in their study, the types of elements in network of the ANP method were presented as shown in Figure 2.2.15.

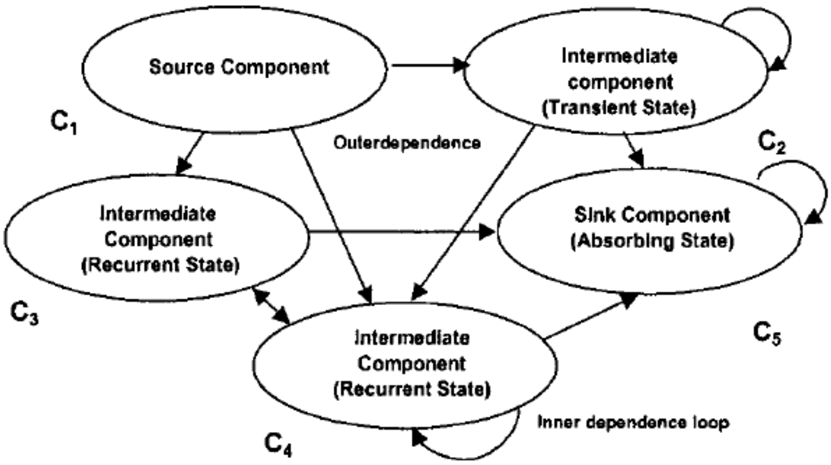


Figure 2.2.15 : Types of components in a network, (Source: Saaty & Vargas, 2006).

Above all, in their paper they defined the "benefits" (Saaty & Vargas, 2006). These were favorable sure concerns of a decision. They defined "costs" (Saaty & Vargas, 2006). These were unfavorable sure concerns of a decision. They defined "opportunities" (Saaty & Vargas, 2006). These were the positive uncertain concerns. They defined "risks" (Saaty & Vargas, 2006). These were the negative uncertain concerns. They also gave examples of execution of the ANP method in financial crises, outsourcing decision, wild life, Maglev Project, energy security, social security, conflict management and group decision making.

Bana e Costa and Vansnick (1995), explained the MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) method. It was one of the multicriteria decision analysis approach. It was underlined that only qualitative judgements were required in this method. The qualitative judgements of difference of attractiveness were represented in six MACBETH categories. These categories were “very weak”, “weak”, “moderate”, “strong”, “very strong” and “extreme” (Bana e Costa and Vansnick, 1995). In the MACBETH method, the preferential information should have been gathered by different types of questioning procedures. In the MACBETH method, the different types of information obtained from an evaluator, either an individual or a group. In the questioning procedure “A first question (Q1) was asked of J: Q1: Was one of the two elements more attractive than the other? J’s response (R1) could be: Yes or No, or I didn’t know. If R1 = Yes, a second question (Q2) was asked: Q2: Which of the two elements was the most attractive? Q3: How did you judge the difference of attractiveness between x and y. The evaluator’s response (R3) would be provided in the form d_s were semantic categories of difference of attractiveness defined so that, if i<j, the difference of attractiveness d_i was weaker than the difference of attractiveness d_j” (Bana e Costa and Vansnick, 1995). The MACBETH approach was used in several industries for several problems such as suppliers performance evaluation, credit scoring, portfolio management, human resources evaluation and management, total quality management, location of military facilities, applications in the telecommunications sector.

Roubens (2001), described the TOMASO method (Technique for Ordinal Multiattribute Sorting and Ordering). The TOMASO method was based on two techniques. The stages of this method were defined as:

1. “The criteria evaluations were modified into scores;
2. The discriminant function was defined by use of a Choquet integral where the Choquet integral was given as:

$$C_v(S(x)) = \sum_{i=1}^{n} S_{(i)}(x)[v(A_{(i)}) - v(A_{(i+1)})] \qquad \textbf{(2.2.43)}$$

where v represented a fuzzy measure on J. J was a monotone set function v: $2^J \rightarrow [0,1]$ fulfilling v(Ø)=0 and v(J)=1. S(x) was the partial scores vector described as $S(x)=(S_1(x),\ldots\ldots\ldots, S_n(x))$. The parentheses were used to represent permutation. $A_{(i)}$ represented the subset {(i),……..,(n)}

3. DM assessed the fuzzy measures by solving a linear constraint satisfaction problem;
4. The borders of the classes were calculated and the alternatives to the classes were assigned;
5. The results (interaction, importance, leave one out, visualisation) were analysed" (Roubens, 2001).

Roubens (2001), underlined that in the TOMASO method, the most difficult task was to modifiying the original ordinal evaluations of the alternatives. Moreover, it was explained that among all the methods, the TOMASO method was the most well know method, which concentrated at the importance indexes and also the interaction indexes.

Another approach was developed for the verbal decision making principles that were the ordinal verbal scales and tradeoffs. This new approach was named as ZAPROS. The main idea of ZAPROS was developed in 1980s by a group of Russian scientists. Larichev was the leader of this group. The ZAPROS was an abbreviation of Russian words: "Closed Procedures near Reference Situations" (Larichev & Moshkovich, 1995). The first publication in English was by Larichev and Moshkovich (1995). They explained the ZAPROS method. Larichev (2001), proposed another improved method named as ZAPROS III that was based on the same principles of ZAPROS. He explained that "all pairs of criteria was used for comparison of real alternatives" (Larichev, 2001). It was underlined that as "the number of comparisons increased drastically, which made the calculations time consuming and almost impossible with the increased number of alternatives or factors" (Larichev, 2001). This method should have been used for relatively small problems. Moshkovich et. al. (2002), developed and presented method which was called STEP-ZAPROS. The STEP-ZAPROS method used additional comparisons. The "joint ordinal scale" was used (Moshkovich et. al., 2002). This made the process iterative in this method. Another method was also developed for verbal decision making principles. This method was named as ORCLASS and presented in mid 1990s by Larichev (1994).

Doumpos and Zopounidis (2002), in detail explained and studied the methods such as discriminant analysis, logit and probit analysis, fuzzy set theory, neural networks, machine learning, rough sets, AHP method, outranking classification methods, ELECTRE TRI method, UTADIS (UTilités Additives DIScriminantes) method, ELECTRE TRI, MHDIS (Multi-group Hierarchical DIScrimination), LDA (linear discriminant analysis), QDA (quadratic discriminant analysis).

Zavadskas, Ustinovichius and Peldschus (2003), studied the solution of one-sided and two-sided problems. In their paper the principles of solution were based on simple and extended min-max principle, Wald's rule, Savage criterion, Hurwicz's rule, Laplace's rule, Bayes's rule, Hodges-Lehmann rule. They also presented the description of a software.

Jones (2004), in detail explained the business economics and defined the methods for decision making process for managers and other decision makers. The main subjects that he studied and concentrated on, were demand analysis, risk versus uncertainty, sales revenue maximization, profit maximization, Williamson's managerial utility model, isoquant analysis, optimal choice of factors, decision making in regulated sectors.

Wang (2002), in detail explained and presented the engineering decision making. He concentrated on subjects such as the uncertainty, risk analysis, what if analysis, distubutions and decision trees. Moreover he presented detailed information about investment analysis such as internal rate of return, payback period and so forth.

Goodwin and Wright (2004), gave detailed information about SMART, decision trees, decision making under uncertainty, risk analysis methods, decision making methods such as AHP. Moreover they prepared and attached excel spreadsheets for the application of the methods in their book.

Baker et. al. (2001), in detail explained the mentality and the properties of decision making methods. They also gave information about the pros and cons analysis, Kepner-Tregoe (K-T) decision analysis, Analytic Hierarchy Process (AHP), Multi-Attribute Utility Theory (MAUT), cost-benefit analysis, custom tailored tools. They underlined that K-T was a quantitative comparison method and added that a team of experts numerically should have scored the criteria and the alternatives, which were based on individual judgements or assessments. Baker et. al. (2001), also added that "K-T method, which only required the basic arithmetic, was only appropriate for moderately complex decisions involving a few criteria" (Baker et. al., 2001). Moreover they underlined that "the main disadvantage was that it might not have been certain or clear how much better a score of 10 was than a score of 8" (Baker et. al., 2001). Above all, they defined that the total score of alternatives might have been close together which made a clear choice to be made very difficult.

Yoon and Hwang (1995), presented and gave detail information about the attribute generation, data and weight, conjunctive method, disjunctive method, lexicographic methods, elimination by aspects, maximin, maximax, simple additive weighting method (SAW), weighted product method, TOPSIS, ELECTRE, median ranking method, AHP.

Golden et. al. (2005), studied and presented detailed information about network analysis, stochastic modeling, integer and mixed integer programming, heuristic search, decision making methods classification, clustering and ranking in their book.

Hwang and Yoon (1981), developed the TOPSIS method. They also published the necessary information for application. In this method, the solution was based on the concept of the shortest distance of chosen alternative from the positive-ideal solution. They also underlined the importance of index called similarity or relative closeness, moreover they also added that in TOPSIS, each attribute took either monotonically increasing or decreasing utility. The TOPSIS method had the following steps:

1. "*Calculate Normalised Ratings*. the element (r_{ij}) of the normalised decision matrix, which was given as

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \; i = 1, 2, \ldots , m \; ; \; j = 1, 2, \ldots , n. \qquad \textbf{(2.2.44)}$$

   where x_{ij} was the value of alternative i with respect to attribute j.

2. *Calculate Weighted Normalised Ratings*. An element of the weighted normalised decision matrix was calculated as

$$v_{ij} = w_j r_{ij} \,, \; i = 1, 2, \ldots , m; \qquad j = 1, 2, \ldots , n \qquad \textbf{(2.2.45)}$$

where w_j was the weight of the jth attribute.

The final step of the weighting procedure was to normalise the relative importances, $\{r_1, r_2, \ldots, r_M\}$, to obtain the weights $\{w_1, w_2, \ldots, w_M\}$. The standard normalisation was

$$w_i = \frac{r_i}{\sum_{i=1}^{M} r_i}, \ i = 1, 2, \ldots, M, \text{ where } 0 \leq w_i \leq 1 \text{ and } \sum_{i=1}^{M} w_i = 1 \qquad \textbf{(2.2.46)}$$

3. *Identify Positive-Ideal and Negative-Ideal Solutions*. Let the positive-ideal solution, A^* and the negative-ideal solution; A^-, be defined in terms of the weighted normalised values:

$$A^* = \{v_1^*, v_2^*, \ldots, v_j^*, \ldots, v_n^*\}, \text{ where}$$

$$v_j^* = \left\{\max_i v_{ij}, j \in J_1; \quad \min_i v_{ij}, j \in J_2\right\} = \{v_1^-, v_2^-, \ldots, v_j^-, \ldots, v_n^-\}, \qquad \textbf{(2.2.47)}$$

where

$$v_j^- = \left\{\min_i v_{ij}, j \in J_1; \quad \max_i v_{ij}, j \in J_2\right\}$$

where J_1 was the set of benefit attributes (the larger, the more preference) and J_2 was the set of cost attributes (the larger, the less preference).

4. *Calculate Separation Measures*. Separation of each alternative from the positive-ideal solution was given by

$$S_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2}, \ i = 1, 2, \ldots, m$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, \ i = 1, 2, \ldots, m \qquad \textbf{(2.2.48)}$$

5. *Calculate Similarities to Positive-Ideal Solution*. Relative closeness (or similarity) of A_i with respect to A* was defined as

$$C_i^* = \frac{S_i^-}{S_i^* + S_i^-}, \ 0 < C_i^* < 1; \ i = 1, 2, \ldots, m \qquad \textbf{(2.2.49)}$$

6. *Rank Preference Order*. An alternative with the maximum C_i^* or rank alternatives according to C_i^* in descending order was chosen" (Hwang & Yoon, 1981).

Moffett and Sarkar (2006), reviewed 26 MCDM methods and presented the main ideas of 19 of them. A taxonomy of MCDM methods was also presented by a figure as shown in Figure 2.2.16. Moreover they presented a decision procedure for the selection of MCDM method as shown in Figure 2.2.17.

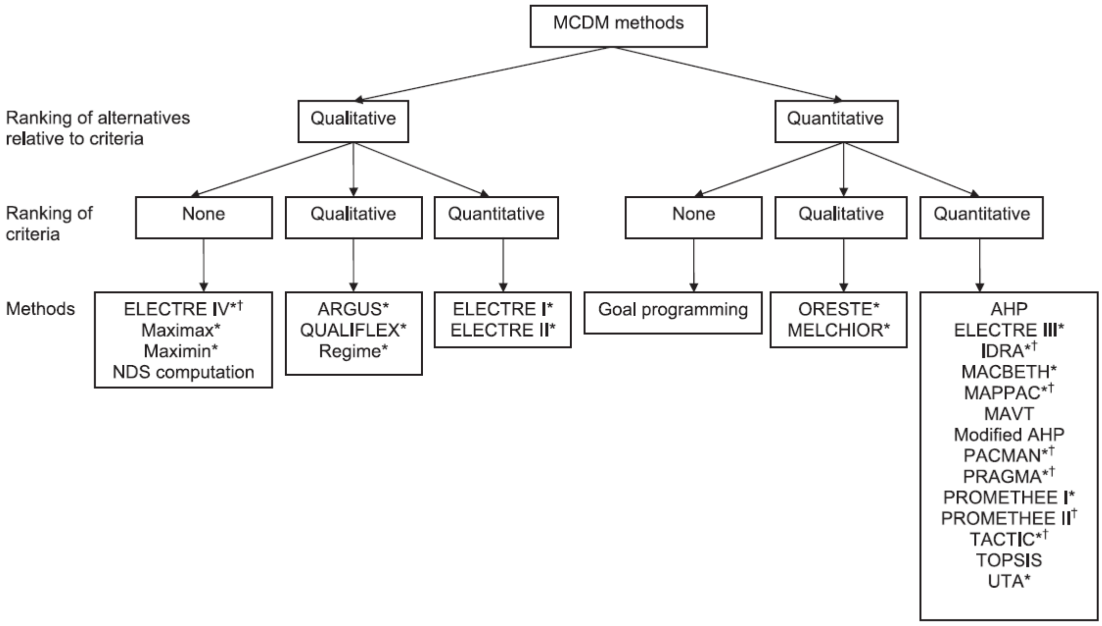


Figure 2.2.16 : A taxonomy of MCDM methods based on requirements placed on criteria and alternatives, (Source : Moffett & Sarkar, 2006).

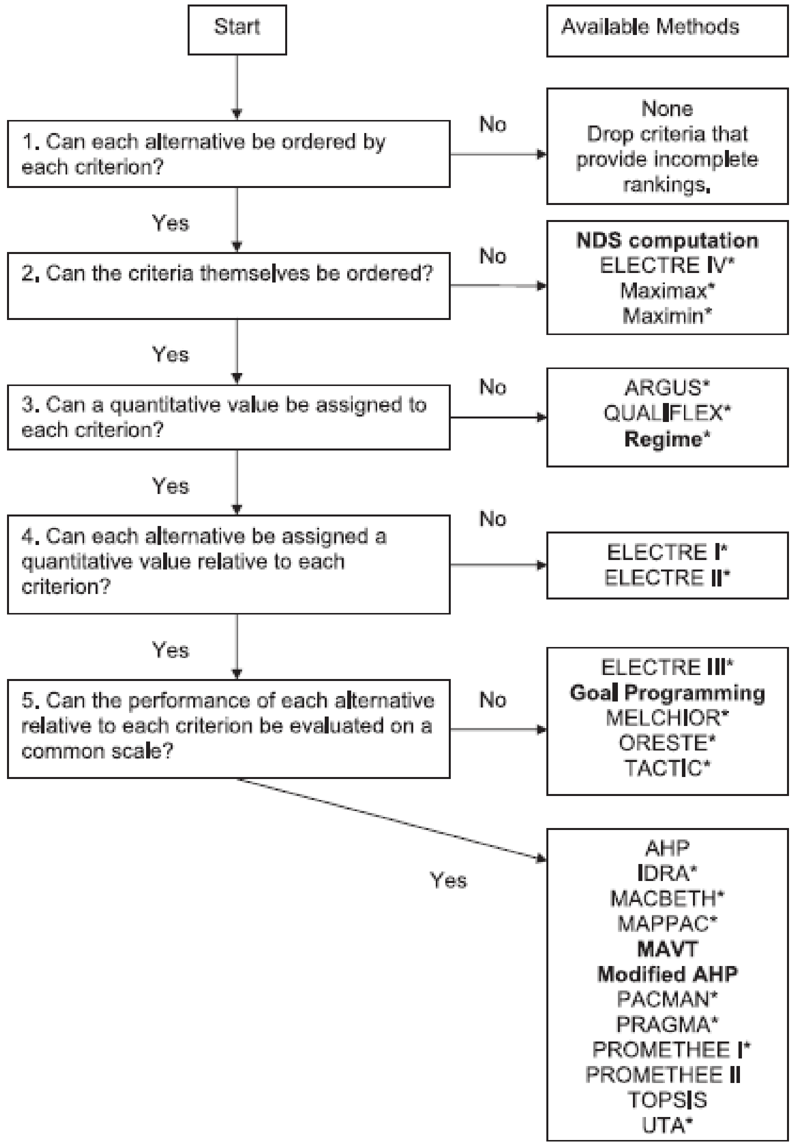


Figure 2.2.17 : A decision procedure for the selection of an existing MCDM method. A '*' indicates that this method has never been used in conservation planning; methods indicated in bold are recommended, (Source: Moffett & Sarkar, 2006).

In decision making classification study, seventy papers and books are in detail studied. The oldest study is published in 1973 and the newest study is published in 2006, which makes the literature review appropriate to show the improvements in this subject, furthermore half of the studies are later than 2000, which is good to fit the latest decision making approaches capability. There is one powerful representative sub group, which is highly classified as mathematical and statistical methods. The effective period of the reviewed studies are mostly in long term. The journal or publisher origin of this decision making systems classification study is presented in Figure 2.2.18.

Continents	Number of Studies
North America	48
South America	0
Europe	21
Asia	1
Africa	0
Australia	0
Antarctica	0
Total	70

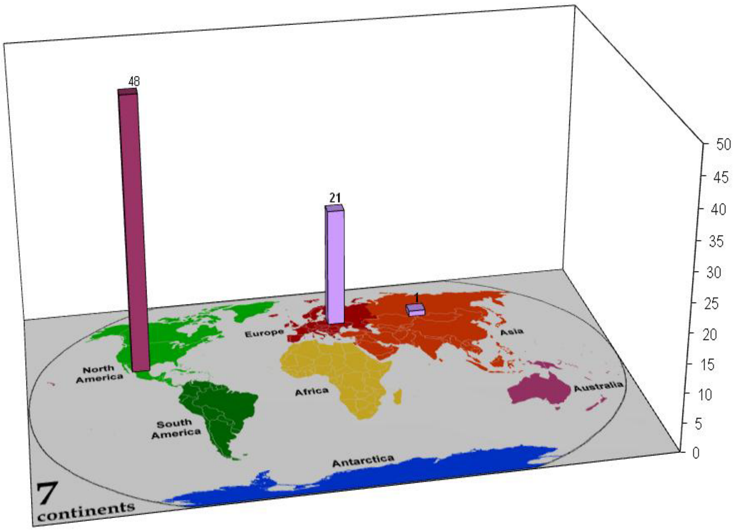


Figure 2.2.18 : Journal or Publisher origin.

The literature review of decision making is presented by a table in Appendix B. During and after literature review on decision making, it is clearly realized that there are several methods that can be executed. In current study, *basically based on Moffett and Sarkar (2006)'s existing MCDM method decision procedure, a method based on ANP method is selected for application in the decision making process in the investment analysis*.

2.3 Investment Analysis

The study, which has been undergone within this subtitle or main group, aims to make a classification study that will guide the thesis within this main group. The table, which is purposed to group the literature review in Appendix C, has been filled in by information supplied in these summarized studies. The investment analysis methods and the key indicators have been in detailed analysed by help of published studies.

The first study, which was summarized in this topic, was by Damodaran (2002). In this study, all basic knowledge about the financial and investment approaches for valuation, understanding of financial statements, option pricing theory and model, market efficiency, riskless rates and risk premiums, estimating risk parameters and costs of financing, measuring earnings, the cash flow analysis, estimating growth, closure in valuation, the measuring of earnings, acquisitions and takeovers, the valuing bonds and so forth were in detail explained including the sub-related topics. He defined clearly the set of valuation myths over time as below.

- “Myth 1: Since valuation models were quantitative, valuation was objective.
- Myth 2: A well-researched and well-done valuation was timeless.
- Myth 3: A good valuation provided a precise estimate of value.
- Myth 4: The more quantitative a model, the better the valuation was.
- Myth 5: To make money on valuation, you had to assume that markets were inefficient.
- Myth 6: The product of valuation (i.e. the value) was what mattered. The process of valuation was not important” (Damodaran, 2002).

The valuation approaches, which were widely used by analysts, were also given as below.

- Discounted Cashflow Valuation:

$$DCF = \sum_{t=1}^{n} \frac{CF_t}{\left(1+r\right)^t} \qquad \textbf{(2.3.1)}$$

where n was the life of the asset, CF_t was the cash flow in period t and r was the discount rate reflecting the riskiness of the estimated cash flows.

- Return on Assets (ROA) & Return on Capital (ROC): The operating efficiency of a firm could be computed by this measure.

$$ROA = \frac{EBIT \times (1\text{-}tax\ rate)}{Total\ Assets} \qquad \textbf{(2.3.2)}$$

$$ROA = \frac{Net\ Income + Interest\ Expenses \times (1\text{-}tax\ rate)}{Total\ Assets} \qquad \textbf{(2.3.3)}$$

$$\mathrm{Pr}e\text{-}tax\ ROA = \frac{EBIT}{Total\ Assets} \qquad \textbf{(2.3.4)}$$

- It was worth mentioning that a more useful and important measure of return related the operating income to the capital invested in the firm or entity, was the return on capital (ROC).

$$\mathrm{Pr}e\text{-}tax\ ROC = \frac{EBIT}{BV\ of\ Dept + BV\ of\ Equity} \qquad \textbf{(2.3.5)}$$

$$After\text{-}tax\ ROC = \frac{EBIT \times (1-t)}{BV\ of\ Dept + BV\ of\ Equity} \quad \textbf{(2.3.6)}$$

- Return on Equity: "the return on equity (ROE) examined profitability from the perspective of the equity investor by relating profits to the equity investor (net profit after taxes and interest expenses) to the book value of the equity investment" (Damodaran, 2002).

$$ROE = \frac{Net\ Income}{Book\ Value\ of\ Common\ Equity} \quad \textbf{(2.3.7)}$$

- Interest Coverage Ratios: "This ratio measured the capacity of the firm to meet interest payments from pre-debt, pre-tax earnings" (Damodaran, 2002).

$$Cash\ burn\ ratio = \left| \frac{Cash\ Balance}{EBITDA} \right| \quad \textbf{(2.3.8)}$$

$$Interest\ Coverage\ Ratio = \frac{EBIT}{Interest\ Expenses} \quad \textbf{(2.3.9)}$$

- Fixed Charges Coverage Ratio:

$$Fixed\ Charges\ Coverage\ Ratio = \frac{EBIT + Fixed\ Charges}{Fixed\ Charges} \quad \textbf{(2.3.10)}$$

- Cash Fixed Charges Coverage Ratio:

$$Cash\ Fixed\ Charges\ Coverage\ Ratio = \frac{EBITDA}{Cash\ Fixed\ Charges} \quad \textbf{(2.3.11)}$$

- Operating Cash flow to Capital Expenditures:

$$Operating\ Cash\ flow\ to\ Capital\ Expenditures = \frac{Cash\ flows\ from\ Operations}{Capital\ Expenditures} \quad \textbf{(2.3.12)}$$

- Return on Capital:

$$Return\ on\ Capital = \frac{EBIT \times (1-t)}{Capital\ Invested} \quad \textbf{(2.3.13)}$$

- Cash Burn Ratio:

$$Cash\ burn\ ratio = \left| \frac{Cash\ Balance}{EBITDA} \right| \quad \textbf{(2.3.14)}$$

- Cash Flow Return On Investment

$$CFROI = \frac{Gross\ Cash\ Flow - Economic\ Depreciation}{Gross\ Investment} \quad \textbf{(2.3.15)}$$

Damodaran (2002), finalized their study by giving most widely used financial multiples and factors by sector.

Abrams (2001), in detail studied and explained cash flow, Gordon Model, calculation of discount rates, sample restricted stock discount study, sample appraisal report, Abrams' Valuation Theory, ESOPs (measuring and apportioning dilution), Capital Asset Pricing Model (CAPM) and heteroscedasticity. He also defined the valuation approaches as mentioned in Damodaran (2002) study, however the present worth (PW) calculations, net present value calculations and annuity worth calculations were in more detail studied. He also underlined the logarithmic relation between the firm investment value and firm size, including the book value of common equity, five-year average net income, market value of invested capital, five-year average EBITDA, sales and number of employees in a firm or entity. Earnings Before Interest but After Taxes (EBIBAT), Earnings Before Interest and Taxes (EBIT) were also defined as the performance measures for the calculations. He finally gave detailed information about the Cumulative Abnormal Returns (CARs).

Penman and Sougiannis (1996), presented detailed information about Discounted Cash Flow Analysis (DCF), ex post valuation errors, ex ante expectations, estimates of ex ante errors, operating income, finite-horizon analysis, unconditional analysis, Dividend Discount Model (DDM).

Collier (2003), explained accounting, accountability and the account, the role of management accounting, recent developments in management accounting, capital and product markets, value-based management, accounting and strategy, structure of business organizations, business events, transactions and the accounting system, the double entry, recording transactions, extracting financial information from the accounting system, principles and limitations of accounting, cost terms and concepts management control systems, management planning, management planning control systems and management accounting, non-financial performance measurement, strategic management accounting, a theoretical framework for management accounting alternative paradigms, the interpretive paradigm and the social construction perspective, culture, control and accounting, the radical paradigm and critical accounting, power and accounting financial accounting. In addition to these subjects, he gave detailed information about reporting profitability, reporting financial position, accruals accounting, depreciation, reporting cash flow, working capital, managing debtors, managing stock, managing creditors interpreting financial statements, ratio analysis, profitability, liquidity, gearing, activity/efficiency, shareholder return, interpreting financial information using ratios social and environmental reporting, intellectual capital, institutional theory marketing strategy, cost behaviour, cost–volume–profit analysis, alternative approaches to pricing, cost-plus pricing, target rate of return pricing, optimum selling price, special pricing decisions, transfer pricing, segmental profitability the operations function, managing operations-manufacturing, managing operations-services, accounting for the cost of spare capacity, capacity utilization and product mix, theory of constraints, operating decisions: relevant costs, equipment replacement, relevant cost of materials, total quality management, cost of quality the cost of labour, relevant cost of labour, business processes and activity-based costs, cost classification, calculating product/service costs, shifts in management accounting thinking, alternative methods of overhead allocation, contingency theory, international comparisons, management accounting in Japan, behavioural implications of management accounting strategy, investment appraisal, accounting rate of return, payback the decentralized organization and divisional performance measurement, return on investment, residual income, controllability cash forecasting research and theory in management accounting. The performance measures or the performance factors were defined in his study as Return on Capital Employed (ROCE), Return on Investment (ROI), earnings per share, operating profit, which was the subtraction of expenses from gross profit, was also called as net profit, Profit Before Interest and Taxes (PBIT) or Earnings Before Interest and Taxes (EBIT), Earnings Before Interest, Taxes, Depreciation and Amortization (EBITDA), Return on Investment (ROI), Return on Capital Employed (ROCE), working capital, acid test (or quick ratio), operating profit/sales, gross profit/sales, gearing ratio, interest cover, asset turnover, dividend per share, dividend payout ratio, dividend yield, earnings per share, Price/Earnings (P/E) ratio, Internal Rate of Return (IRR), Accounting Rate of Return (ARR), Net

Present Value (NPV), payback period, Cash Value Added (CVA) or profitability index (the ratio of the NPV to the initial capital investment).

Brealey et. al. (2001), studied and gave information about sole proprietorships, the financing decision, the capital budgeting decision, partnerships, corporations, hybrid forms of business organization, financial institutions, financial markets, future values and compound interest, present values, multiple cash flows, level cash flows: perpetuities and annuities, inflation and the time value of money, effective annual interest rates, components of a financial planning model, book values and market values, profits versus cash flow, corporate tax, personal tax, the components of working capital, working capital and the cash conversion cycle, the working capital trade-off, forecast sources of cash, forecast uses of cash, the cash balance, options for short-term financing, evaluating the plan, leverage ratios, liquidity ratios, efficiency ratios, discount interest, profitability ratios. They also explained bank loans, commercial paper, secured loans, simple interest, interest with compensating balances managing inventories, managing inventories of cash, uncertain cash flows, cash management in the largest corporations diversification, asset versus portfolio risk, market risk versus unique risk mutually exclusive projects, replacing an old machine, investment timing, long versus short lived equipment, mutually exclusive projects and the IRR rule, soft rationing, hard rationing, pitfalls of the profitability index capital investment, investment in working capital, cash flow from operations sensitivity analysis, scenario analysis, decision trees, the option to expand, abandonment options, flexible production facilities, investment timing options mergers, acquisitions and corporate control. The performance measures or the performance factors were defined in their study as EBIT, long-term debt ratio, debt-equity ratio, total debt ratio, times interest earned ratio, cash coverage ratio, net working capital, current ratio, cash ratio, interval measure, asset turnover ratio, average collection period, inventory turnover ratio, net profit margin, Return on Assets (ROA), Return on Equity (ROE), payout ratio, EBITDA, rate of return, Net Present Value (NPV), Degree of Operating Leverage (DOL) which was the ration of percentage change in profits to percentage change in sales.

Hovakimian and Hovakimian (2005), studied in detail the investment cash flow analysis, the sensitivity both under-investment (low cash flows) and over-investment (high cash flows). They underlined that the accessibility of external capital was positively correlated with cash flows. In their study, the results implied that the cash flow sensitive firms faced with the financial constraints and the financial constraints had an impact on investment timing.

Damodaran (1994), construed the topics on estimating discount rates, estimating cash flows, estimating growth and terminal value, equity DCF models: DDM (Dividend Discount Model) and Free Cash Flow to Equity (FCFE) models, firm DCF models: cost of capital, APV and excess return models, relative valuation, relative valuation - first principles, equity multiples, firm and enterprise value multiples, valuing cash and cross holdings, employee options and restricted stock, the value of intangibles, the value of control, the value of liquidity, the value of synergy, the cost of distress, the value of transparency. The performance measures or the performance factors were defined in their study as EBIT, Free Cash Flow to Equity (FCFE), equity cash flows associated with capital expenditure needs, Earnings Before Interest, free cash flow to equity, EBITDA, Return on Equity (ROE), Return on Capital (ROC), Net Present Value (NPV), PE ratios or EV/EBITDA.

Damodaran (2003), studied in detail equity risk and expected return, the Capital Asset Pricing Model (CAPM), measuring risk, the mechanics of present value, uncertainty into valuation, investment strategy and total trading costs, earnings delays and price reaction, takeover-based investment strategies, stock splits, arbitrage relationships, convertible arbitrage, determinants of success, mutual fund managers and roadmap of investment philosophy. The performance measures or the performance factors were defined in his study as pre-tax interest coverage, EBITDA interest coverage, pre-tax return on permanent capital, operating income/sales, funds from operations/total debt, free operating cash flow/total debt, long term debt/capital, total debt/capitalization, pre-tax ROA, Return on Assets (ROA), the Earnings Before Interest and Taxes (EBIT), the Return on Equity (ROE), current ratio, quick ratio, accounts receivable turnover, inventory turnover, days receivable outstanding, days inventory held, accounts payable turnover, days accounts payable outstanding, required financing period, interest coverage ratio, fixed charges coverage ratio, cash fixed charges coverage ratio, operating cash flow to capital expenditures, cash flow from operations, Price/Earnings Ratio (P/E), the Price/Book Value Ratio (P/BV). In this study, sector rotation was also in detailed given. It was mentioned that some investors were staying out of the market because of their views on the market that the sector was either too costly or not feasible. “The investors might have been able to decide that their market timing into superior returned by switching across sectors of the market as their views of the market changed” (Damodaran, 2003). Damodaran (2003), provided Stovall summary of the conventional wisdom on sector rotation as shown in Figure 2.3.1.

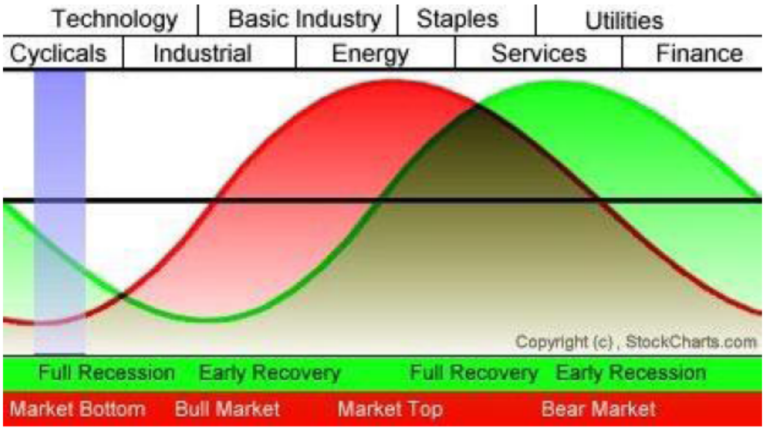


Figure 2.3.1 : Sector rotation-sector emphasis as a function of market cycle, (Source: Damodaran, 2003).

Ardalan (2000), in detail analyzed and explained costs and benefits, importance of time (time value of money), interest rate, equivalence, continuous compounding of interest, effective rate of interest, nominal interest rate, cash flow diagram, inclusion of nonmonetary costs and benefits, importance of cash flow diagram, the process of decision making, financial analysis methods, derivation of the formulae, Present Value (PV), net present worth, present value of uniform annual series, present value of arithmetic gradient series, multiple alternatives and equalizing lives, exclusivity, future worth, Future Value (FV), future value of uniform annual series, multiple alternatives, annual worth, Annual Worth and Equivalent Uniform Annual Worth (EUAW) of an arithmetic gradient, multiple rates of return, rate of return, multiple alternatives and incremental analysis, multiple alternatives, benefit-cost ratio, equalizing lives and incremental analysis, benefit-cost ratio and payback methods, payback. He also presented information about inflation and purchasing power, inflation and interest rate combined, inflation adjusted discount rate, deflation, general inflation indices, effects of income tax, depreciation, book value and capital gain, straight-line depreciation, Double Declining Balance (DDB) depreciation, Modified Accelerated Cost Recovery System (MACRS) depreciation, Sum of Years Digit depreciation, change of depreciation methods, amortization and depletion, financial analysis with tax and depreciation, analyzing financial structure of an investment, general structure of problems, system life, physical life, technological life, economic life, life of interest and planning horizon, phases of the lifetime, lifetime estimation and calculation, concurrent engineering, the cash flow diagram, Work Breakdown Structure and Cost Breakdown Structure (WBS & CBS), lifetime worth calculation, lifetime cost estimation, parametric estimation, comparative estimation, engineering estimation, combination of the estimating methods, opportunity cost, estimation accuracy, replacement philosophy, universal ratios, retirement and replacement, replacement decision making, economic life and continuous replacement, replacement process, computer determination of the economic life, depreciation and tax. The performance measures or the performance factors were defined in his study as Net Present Worth (NPW), the Net Future Worth (NFW), the Equivalent Uniform Annual Worth (EUAW), the Rate of Return (ROR), the Benefit-Cost Ratio (B/C), payback period.

Park and Tippett (1999), studied in detail the cost of money, the elements of transactions involving interest, equivalence calculations, interest formulas, nominal and effective interest rates, loss of purchasing power, describing project cash flows, present worth analysis, annual equivalent method, rate of return analysis, mutually exclusive alternatives, accept/reject decision rules, operating profit, net income, accounting depreciation, corporate income taxes, tax treatment of gains or losses for depreciable assets, after-tax cash flow analysis, effects of inflation on project cash flows, project risk, sensitivity analysis, scenario analysis, risk analysis, procedure for developing an NPW distribution, expected value and variance.

Straub (1997), studied in detail the financial statements, the income statement, the balance sheet, the cash flow statement, the financial analysis, the inventory valuation and depreciation. The performance measures or the performance factors were defined in his study as gross profit, operating expenses, earnings before income tax, income tax, net income, ratio of net income to net sales, inventory turnover, current ratio, acid-test ratio, ratio of debt to stockholders' equity, rate of return on stockholders' equity, rate of return on total assets.

Levine (1988), gave detail information about technical security analysis, analysis of support and supply levels, basic technical methods, basic chart types, trend analysis, relative strength, group and sector analysis and so forth.

Logue (1998), presented detail information about calculation of a present value, calculation of a future value, future value time line analysis, present value time line analysis, Newton's approximation technique, relationship between future value and present value, straight loan, discounted loan, compensating balance, installment loan, discounted instalment loan, amortization schedule, bond analysis, discount rates and pricing, effective return and so forth.

Aven (2003), explained in detail the importance of risk and uncertainty assessments, the need to develop a proper risk analysis framework, risk analysis, reliability analysis, finance and portfolio theory, the Bayesian paradigm, assignments based on classical statistical methods, probability theory.

Helfert (2001), studied in detail understanding business economics, business system, supporting strategy development, appropriate economic tools, relevant decision information, performance assessment and incentives, valuation and investor communications, economic incentives, total systems management, investment decisions, operating decisions, financing decisions, interrelationship of strategy and value creation, the balance sheet, the income statement, the cash flow statement, the statement of changes in shareholders' equity, the funds cycle for manufacturing, the funds cycle for sales, the funds cycle for services, variability of funds flows, seasonal variations, cyclical variations, generalized funds flow relationships, growth/decline variations, interpreting funds flow data, funds management and shareholder value, cash management, working capital management, ratio analysis and performance, investment management, assessment of business performance, management's point of view, operational analysis, resource management, profitability, owners' point of view, investment return, disposition of earnings, market indicators, lenders' point of view, liquidity, financial leverage, debt service, ratios as a system, elements of return on assets, elements of return on equity, integration of financial performance analysis, inventory costing. He also explained depreciation methods, the impact of inflation, pro forma income statement, pro forma balance sheet, pro forma cash flow statement, cash budgets, operating budgets, sales budget, production budget, interrelationship of financial projections, financial modelling, sensitivity analysis, analytical support, operating leverage, target profit analysis, financial leverage, financial growth plans, basic financial growth model, sustainable growth and the sustainable growth equation, integrated financial plan, analytical support, discounting, compounding, and equivalence, components of analysis, net investment, net operating cash inflows, economic life, terminal value, methods of analysis, simple measures, economic investment measures, nature of the investment, refinements of investment analysis, a machine replacement, net investment refined, operating cash inflows refined, unequal economic lives, capital additions and recoveries, analytical framework, a business expansion, mutually exclusive alternatives, maintain versus replace, full-fledged versus economy solution, comparing different scenarios, dealing with risk and changing circumstances, specifying risk, ranges of estimates, business investments as options, probabilistic simulation, risk-adjusted return standards, when to use investment measures. He also presented in detail leasing, accelerated depreciation, inflation and investment analysis, accuracy, investment decisions, operating decisions, financing decisions, cost of operating funds, cost of long-term debt, preferred stock, common equity, weighted cost of capital, cost choices, weighting the proportions, calculating the weighted cost of capital, cost of capital and return standards, cost of capital as a cut-off rate, risk categories, cost of capital in multibusiness companies, multiple rate analysis, cost of incremental funds, risk exposure, flexibility, timing, control, current performance, long-term debt in the capital structure, preferred stock in the capital structure, common stock in the capital structure, range of earnings chart, the optimal capital structure, some special forms of financing, business valuation, valuing the equity, valuing the total company, using shortcuts in valuing an ongoing business, creating value in restructuring and combinations, restructuring and value, combinations and synergy, combinations and share values, integration of value analysis. The performance measures or the performance factors were defined in his study as gross margin, return on total net worth, current ratio, profit margin, return on common equity, acid test, EBIT, EBITDA, Earnings Before Interest After Taxes (EBIAT), earnings per share, quick sale value, the Net Operating Profit After Taxes (NOPAT), cash flow per share, share price appreciation, total shareholder return, operating leverage, return on assets (after taxes), price/earnings ratio, interest coverage, return before interest and taxes, burden coverage, return on current value basis, EVA and economic profit, sales to assets, assets to sales, sales to net assets, net assets to sales, inventory turnover, Return on Assets (ROA or RONA), return on assets before interest and taxes, return on equity, return on average equity, Return on Common Equity (ROE), Total Shareholder Return (TSR), Net Present Value (NPV), Benefit Cost Ratio (BCR), Internal Rate of Return (IRR), the Capital Asset Pricing Model (CAPM), Earnings Per Share, Return on Investment (ROI), Return on Net Assets (RONA), Return on Capital Employed (ROCE), Cash Flow Return on Gross Investment (ROGI), Total Shareholder Return (TSR), Cash Flow Return on Investment (CFROI), Total Business Return (TBR). Finally Helfert (2001), presented also the systems' view of key ratios and their elements as shown in Figure 2.3.2.

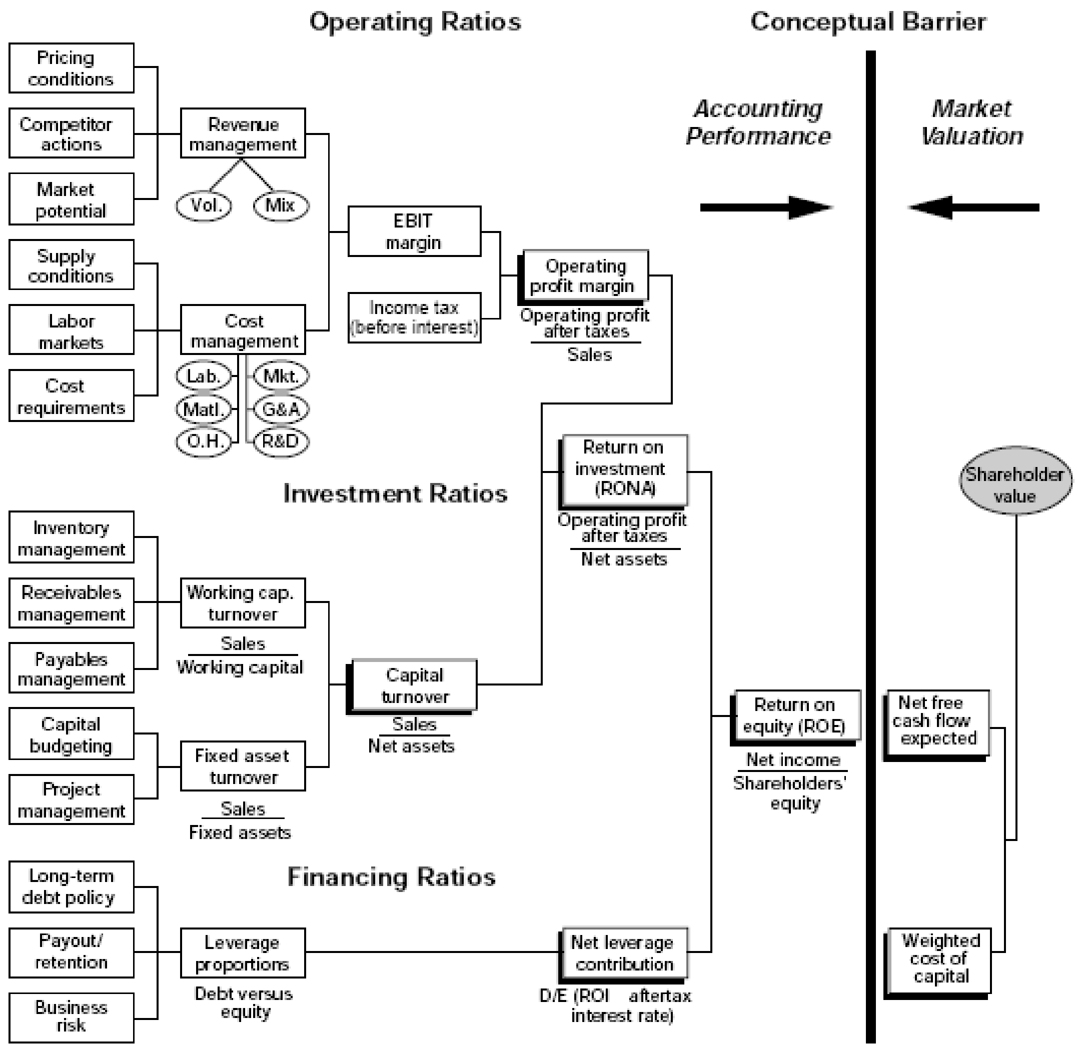


Figure 2.3.2 : A view of accounting vs. cash flow performance, (Source: Helfert, 2001).

Elton and Gruber (1995), studied and explained in detail multiple assets and risk, types of marketable financial securities, the return characteristics of alternative security types, trading mechanics, the average outcome, a measure of dispersion, the shape of the portfolio possibilities curve, the efficient frontier with riskless lending and borrowing, average correlation models, short sales allowed with riskless lending and borrowing, characteristics of the single-index model, mixed models, fundamental multi-index models, the economic properties of the utility functions, utility and the investor horizon, maximizing the geometric mean return, stochastic dominance, skewness and portfolio analysis, the world portfolio, the risk of foreign securities, the assumptions underlying the standard capital asset pricing model, the arbitrage pricing model APT, tests of return predictability, announcement and price return, discounted cash flow models, cross-sectional regression analysis, earnings estimation, option pricing theory, evaluation of portfolio performance, evaluation of security analysis, managing stock portfolios.

Advani (2006), presented information about financing options, entrepreneurship and investor, handling of a gift, handling of a loan, handling of an equity investment, preparing business plan, deciding loan terms, seeking equity capital, formalizing a loan with a promissory note, participating in the preparation of the stock purchase agreement and so forth.

Luenberger (1998), presented very detail information in his book about cash flow investments and markets, typical investment problems, the basic theory of interest, fixed income securities, the yield curve, forward rates, capital budgeting, optimal portfolios, optimal management, the Harmony Theorem, the Markowitz Model, the CAPM and arbitrage in premium models as equilibrium models, utility functions, forwards, futures and swaps, options theory, the investment wheel and so forth. The performance measures or the performance factors were defined in his study as present value, future value, IRR, NPV, annual worth, total return which was the ratio of amount received to amount invested.

Couper (2003), explained in detail the subjects such as business plans, sources of funds, debt versus equity financing, financial statements, fixed capital investment, offsite capital, allocated capital, working capital, start-up expenses, estimation of operating expenses, time value of money, depreciation, depletion, amortization and taxes, cash flow concept, minimum acceptable rate of return, sensitivity analysis, uncertainty analysis, feasibility analysis, incremental analysis. The performance measures or the performance factors were defined in his study as gross profit margin, net operating margin, profit margin on sales, return on net worth, return on total assets, fixed assets turnover, total assets turnover, inventory turnover, dept to total assets, EBIT, Turnover Ratio, ROI, Return on Average Investment (ROAI), Payout

Period (POP), Payout Period with Interest (POPI), NPW, Net Present Worth Index (NPWI), IRR, Overall Rate of Return (ORR), Net Rate of Return (NRR).

Tracy (1999), studied in detail cash flows, the balance sheet, income statement, sales revenue, accounts receivable, income tax expense, depreciation expense, cost of goods sold expense, accounts payable, operating expenses, fixed assets, accumulated depreciation, interest expense, net income, retained earnings, earnings per share, cash flows from investing and financing activities, the cost of credibility, the financial reports, ratios for creditors and investors, accounting methods, quality of earnings, depreciation dilemmas, a look inside management accounting and so forth. The performance measures or the performance factors were defined in his study as operating earnings or EBIT, Earnings Per Share, the acid test ratio, debt to equity ratio, return on sales ratio, Return on Equity ratio (ROE), ROA, Price/Earnings ratio (P/E).

In investment analysis classification study, forty papers and books are in detail studied. The oldest study is published in 1988 and the newest study is published in 2007, which makes the literature review appropriate to show the improvements in this subject, furthermore half of the studies are later than 2000, which is good to fit the latest investment analysis philosophy presentation ability. There are two sub groups, which are highly classified as mathematical and statistical methods and industry applications and properties. Most of the studies are in society level and concentrate on individuals. The effective period of the reviewed studies are mostly in long term. The journal or publisher origin of this investment analysis classification study is presented in Figure 2.3.3.

Continents	Number of Studies
North America	40
South America	0
Europe	0
Asia	0
Africa	0
Australia	0
Antarctica	0
Total	40

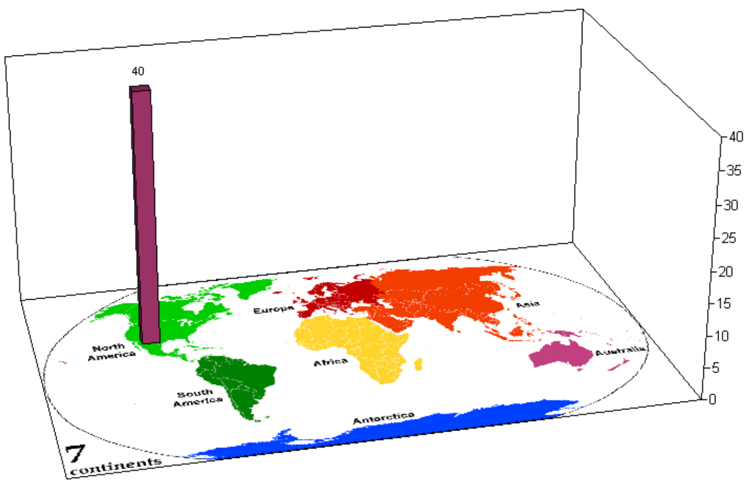


Figure 2.3.3 : Journal or Publisher Origin.

The literature review of investment analysis is presented by a table in Appendix C. During and after literature review on investment analysis, it is clearly realized that there are only three methods that are widely applied in the industry applications. In the current study, the pros and cons study is performed for these three widely used methods as presented in Table 2.3.1.

Table 2.3.1: Pros and cons analysis of existing investment analysis approaches.

Name of Approach	Pros	Cons
Internal Rate of Return	-The widely used method -The consensus on the performance measure -The widely usage in the ranking of investment alternatives	* Deterministic approach * It should be supported by other factors * It should be compared with value of MARR
Net Present Worth	-The widely used method for the very first decision making	* Deterministic approach * Only a measure of cash flow negativity or positivity * Interest rate or inflation rate estimation should be correct
Payback Period	- Measure of risk	* Deterministic approach * Roughly figures

In current study, the performance factors and the performance objectives or in other words the attributes pool and the objectives pool, in the location free investment analysis are selected and defined as:

- After Tax Profit Margin: "A financial performance ratio, calculated by dividing net income after taxes by net sales" (Url-5).

$$After\ Tax\ Profit\ Margin = \frac{After\ Tax\ Net\ Income}{Net\ Sales} \quad \textbf{(2.3.16)}$$

- AGI (Adjusted Gross Income): "A measure of income used to determine how much of your income is taxable. Adjusted gross income (AGI) is calculated as your gross income from taxable sources minus allowable deductions, such as unreimbursed business expenses, medical expenses, and alimony and deductible retirement plan contributions" (Url-5).
- APV (Adjusted Present Value): "The Net Present Value (NPV) of a project if financed solely by equity plus the Present Value (PV) of any financing benefits (the additional effects of debt)" (Url-5).
- ATOI (After Tax Operating Income):

$$ATOI = Operating\ Income - Taxes \quad \textbf{(2.3.17)}$$

- BCR (Benefit Cost Ratio): “A ratio attempting to identify the relationship between the cost and benefits of a proposed project” (Url-5).
- CFPS (Cash Flow Per Share): “A measure of firm financial strength” (Url-5):

$$CFPS = \frac{(Operating\ Cash\ Flow - Preferred\ Dividends)}{Common\ Shares\ Outstanding} \qquad \textbf{(2.3.18)}$$

- DCF (Discounted Cash Flow): “A valuation method used to estimate the attractiveness of an investment opportunity” (Url-5).

$$DCF = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \ldots + \frac{CF_n}{(1+r)^n} \qquad \textbf{(2.3.19)}$$

- EBT (Earnings Before Tax):

$$EBT = Revenue - Expenses\ (excluding\ tax) \qquad \textbf{(2.3.20)}$$

- EBIT (Earnings Before Interest and Tax) (operating earnings, operating profit, operating income):

$$EBIT = Revenue - Operating\ Expenses \qquad \textbf{(2.3.21)}$$

- EBIDA (Earnings Before Interest, Depreciation and Amortization):

$$EBIDA = Net\ Income + Interest\ Expense + Depreciation + Amortization \qquad \textbf{(2.3.22)}$$

- EBITD (Earnings Before Interest, Tax and Depreciation):

$$EBITD = Revenue - Expenses\ (excluding\ taxes,\ interest\ and\ depreciation) \qquad \textbf{(2.3.23)}$$

- EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortization):

$$EBITDA = Revenue - Expenses\ (excluding\ tax,\ interest,\ depreciation\ and\ amortization) \qquad \textbf{(2.3.24)}$$

- EBITAE (Earnings Before Interest, Tax, Amortization and Exceptional Items):

$$EBITAE = Revenue - Expenses^{*} \left(\begin{array}{l} expenses\ that\ exclude\ interest,\ taxes, \\ amortization\ of\ intangible\ assets \end{array} \right) \qquad \textbf{(2.3.25)}$$

- EBITDARM (Earnings Before Interest, Taxes, Depreciation, Amortization, Rent and Management Fees):

$$EBITDARM = \mathrm{Re}venue - Expenses** \qquad \textbf{(2.3.26)}$$

- EVA (Economic Value Added)

$$EVA = NOPAT - (Capital * Cost\ of\ Capital) \qquad \textbf{(2.3.27)}$$

- FCF (Free Cash Flow): "A measure of financial performance calculated as operating cash flow minus capital expenditures" (Url-5).

$$FCF = \frac{NetIncome + Amortization}{Depreciation - Changes\ in\ Working\ Capital - CapitalExpenditures} \qquad \textbf{(2.3.28)}$$

- FCFF (Free Cash Flow For The Firm):

$$\begin{aligned} FCFF &= Operating\ Cash\ Flow - Expenses - Taxes \\ &- Changes\ in\ NWC\ (Net\ Working\ Capital) \\ &- Changes\ in\ Investments \end{aligned} \qquad \textbf{(2.3.29)}$$

- FCFPS (Free Cash Flow Per Share):

$$FCFPS = \frac{Free\ Cash\ Flow}{\#Shares\ Outs\tan ding} \qquad \textbf{(2.3.30)}$$

- FCFY (Free Cash Flow Yield): "An overall return evaluation ratio of a stock, which standardizes the free cash flow per share of a company is expected to earn against its market price per share" (Url-5).

$$ATOI = \frac{Free\ Cash\ Flow\ per\ Share}{Current\ Market\ \mathrm{Pr}ice\ per\ Share} \qquad \textbf{(2.3.31)}$$

- Gross Income
- Gross Earnings
- Gross Margin: "A company's total sales revenue minus its cost of goods sold, divided by the total sales revenue, expressed as a percentage" (Url-5).

$$Gross\ M\arg in(\%) = \frac{\mathrm{Re}venue - Cost\ of\ Goods\ Sold}{\mathrm{Re}venue} \qquad \textbf{(2.3.32)}$$

- IFO (Income From Operations): "The profit realized from a business own operations" (Url-5).

- IRR (Internal Rate of Return): "The discount rate often used in capital budgeting that makes the net present value of all cash flows from a particular project equal to zero" (Url-5).
- MIRR (Modified Internal Rate of Return): "While the internal rate of return (IRR) assumes the cash flows from a project are reinvested at the IRR, the modified IRR assumes that all cash flows are reinvested at the firm's cost of capital" (Url-5).
- Net Sales: "The amount of sales generated by a company after the deduction of returns, allowances for damaged or missing goods and any discounts allowed" (Url-5).
- Net Margin: "The ratio of net profits to revenues for a company or business segment, typically expressed as a percentage, that shows how much of each dollar earned by the company is translated into profits" (Url-5).

$$Net\ Margin = \frac{Net\ Profit}{Revenue} \qquad \textbf{(2.3.33)}$$

- NI (Net Income)
- NOI (Net Operating Income): "A company's operating income after operating expenses are deducted, but before income taxes and interest are deducted. If this is a positive value, it is referred to as net operating income, while a negative value is called a net operating loss (NOL)" (Url-5).
- NOPAT (Net Operating Profit After Tax):

$$NOPAT = Operating\ Income\ x\left(1 - Tax\ Rate\right) \qquad \textbf{(2.3.34)}$$

- NPV (Net Present Value): "The difference between the present value of cash inflows and the present value of cash outflows" (Url-5).
- OCF (Operating Cash Flow): "The cash generated from the operations of a company, generally defined as revenues less all operating expenses, but calculated through a series of adjustments to net income" (Url-5):

$$OCF = EBIT + Depreciation - Taxes \qquad \textbf{(2.3.35)}$$

- OPEX (Operating Expense): "A category of expenditure that a business incurs as a result of performing its normal business operations. One of the typical responsibilities that management must contend with determining how low operating expenses can be reduced without significantly affecting the firm's ability to compete with its competitors” (Url-5).

- Operating Income: “The amount of profit realized from a business's own operations, but excluding operating expenses (such as cost of goods sold) and depreciation from gross income” (Url-5).

$$Operating\ Income = Gross\ Income - Operating\ Expenses - Depreciation \qquad \textbf{(2.3.36)}$$

- Operating Margin: “A ratio used to measure a company's pricing strategy and operating efficiency“ (Url-5).

$$Operating\ Margin = \frac{Operating\ Income}{Net\ Sales} \qquad \textbf{(2.3.37)}$$

- Payback Period: “The length of time required to recover the cost of an investment” (Url-5).

$$Payback\ Period = \frac{Cost\ of\ Project}{Annual\ Cash\ Inflows} \qquad \textbf{(2.3.38)}$$

- PEG Payback Period: “A key ratio that is used to determine the time it would take for an investor to double their money in a stock investment” (Url-5).
- Profit Margin: “A ratio of profitability calculated as net income divided by revenues, or net profits divided by sales” (Url-5).
- Profitability Index: “An index that attempts to identify the relationship between the costs and benefits of a proposed project through the use of a ratio calculated as” (Url-5).

$$Profitability\ Index = \frac{PV\ of\ Future\ Cash\ Flows}{Initial\ Investment} \qquad \textbf{(2.3.39)}$$

- REVs (Revenue): “The amount of money that a company actually receives during a specific period, including discounts and deductions for returned merchandise” (Url-5).
- Revenue Per Employee

$$Revenue\ Per\ Employee = \frac{Revenue}{\#\ of\ Employee} \qquad \textbf{(2.3.40)}$$

- ROIC (Return On Investment Capital)

$$ROIC = \frac{Net\ Income - Dividends}{Total\ Capital} \tag{2.3.41}$$

- SVA (Shareholder Value Added)

$$SVA = NOPAT - Cost\ of\ Capital \tag{2.3.42}$$

- Taxable Income: “The amount of income that is used to calculate an individual’s or a company’s income tax due” (Url-5).

The location free investment analysis attributes pool and the location free investment analysis objectives pool are generated. These both pools contains all the necessary performance factors or performance measures.

2.4 Industry Applications and Properties

The study, which has been undergone within this subtitle or main group, which is structured different than other sub-groups, aims to give detailed information about the industry applications and industry properties of shipbuilding, port logistics - management and some other sectors, which are defined as major investment based industries. General information about the industries and future forecasting of the industries shall be given in this subtitle.

The first study, which was summarized in this topic, was by Colton (2006). In his presentation some figures about the shipbuilding industry was given. The world wide fleet records was given as 40.000 cargo vessels, 18.000 working vessels, 24.000 fishing vessels, 26.500 naval vessels, 7.500 passenger vessels. The renewal percentage of the fleet was presented as 3.3% per year and the growth rate of the cargo fleet was given as 2.8% per year. The main market sectors were given as LNG Carriers, tankers, bulkers and containerships as shown in Figure 2.4.1.

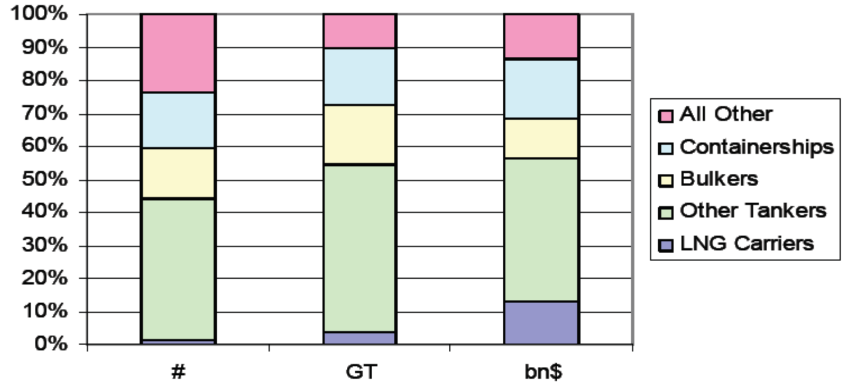


Figure 2.4.1 : The main market sector segmentation, (Source: Colton, 2006).

The big shipbuilders were presented as in Japan IHI Marine Imabari (2), Kawasaki Koyo Dockyard, Mitsubishi Mitsui, Namura Oshima, Sanoyas Sasebo, Sumitomo Tsuneishi (2), Universal (3); in Korea Daewoo, Hanjin, Hyundai, Samho, Samsung; in China (6) Dalian, Hudong, Jiangnan, Liaoning, Nantong, Waigaoqiao; Europe (9) Aker-Turku (Finland), Atlantique (France), Fincantieri (Italy) (3), IZAR (Spain), Meyer Werft (Germany), Odense (Denmark), Brodosplit (Croatia); Other (4) Avondale (U.S.), NASSCO (U.S.), Newport News (U.S.), China SB (Taiwan).

The big shipbuilding companies were presented with the performance measures:

Hyundai was as shown in Figure 2.4.2 with revenues (2005) \$16.1 billion, net profit \$188 million, backlog \$ 25 billion, employees 25.000, subcontractors 10.000, ships/year 80, number of docks/ways 9, biggest dock 640 m × 92 m;

Figure 2.4.2 : Hyundai Heavy Industries, (Source: Colton, 2006).

Samsung was as shown in Figure 2.4.3 with revenues (2005) $5.5 billion, net profit $73 million, backlog $ 18 billion, employees 12.000, subcontractors 8.000, ships/year 45, number of docks/ways 4, biggest dock 640 m × 98 m;

Figure 2.4.3 : Daewoo Shipbuilding, (Source: Colton, 2006).

Daewoo was as shown in Figure 2.4.4 with revenues (2005) $ 4.8 billion, net profit $ 8 million, backlog $ 16 billion, employees 10.000, subcontractors 10.000, ships/year 45, number of docks/ways 5, biggest dock 529 m × 131 m;

Figure 2.4.4 : Samsung Heavy Industries, (Source: Colton, 2006).

The total current order book of Hyundai Heavy Industries (Ulsan) was given as in 2006, 75; in 2007, 79; in 2008, 79; in 2009, 3 and in 2010, 2; and the total current order book of Daewoo Shipbuilding & Marine Engineering (Geoje) was given as in

2006, 41; in 2007, 40; in 2008, 39; in 2009, 10; and the total current order book of Samsung Heavy Industries (Geoje) was given as in 2006, 44; in 2007, 45; in 2008, 40; in 2009, 8.

Colton (2006), was also presented information about LNG Carrier production and scheduling and moreover he gave detailed information about production techniques.

The second study, which was summarized in this topic, was by Karakoulakis (2007). In his presentation, some figures about the shipping and the paper market was given. He underlined that China's iron ore imports was the key determining factor for the Cape market. The China's iron ore imports versus Cape ship deliveries were presented by a figure in his presentation as shown in Figure 2.4.5.

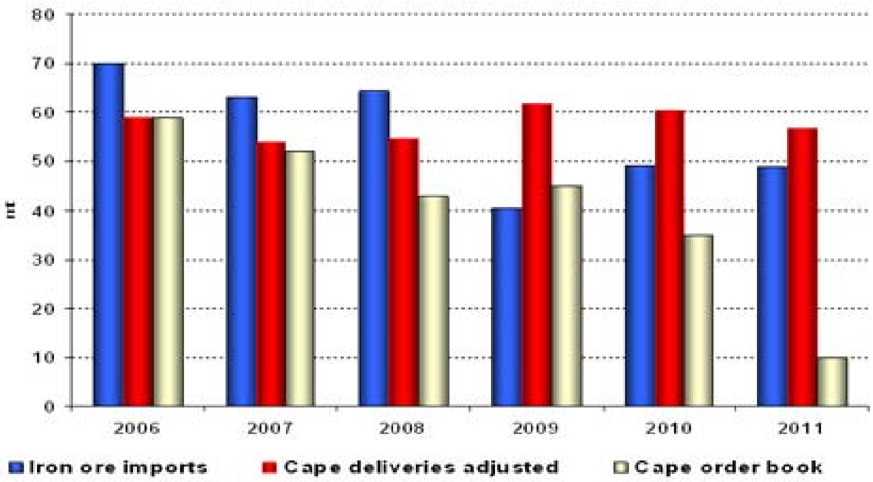


Figure 2.4.5 : China's iron ore imports vs Cape ship deliveries, (Source: Karakoulakis, 2007).

He mentioned that the Atlantic-Pacific and Pacific-Atlantic iron ore, coking and steam coal trade would be in longer term imbalance and the forecasts proved that this would be opening up with increased inefficiencies which supported stronger freight as shown in Figure 2.4.6.

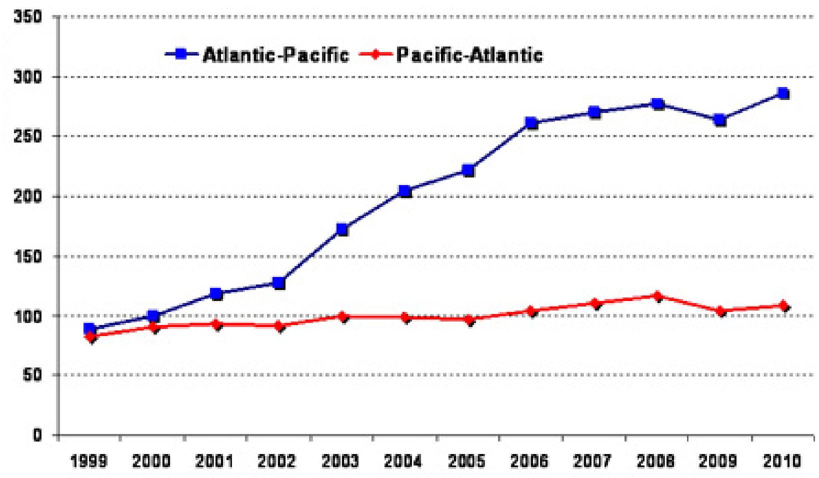


Figure 2.4.6 : Atlantic-Pacific and Pacific-Atlantic iron ore, coking and steam coal trade forecast, (Source: Karakoulakis, 2007).

He concluded his presentation defining the below points:

- "Cape:
  - ✓ Still very strong market over the next couple of years
  - ✓ New building prices and second hand prices very high
  - ✓ Scrapping to remain low at expected freight rates
  - ✓ Tonne-mile growth to further support freight rates
- Panamax
  - ✓ High cape freight rates would encourage Indian iron ore spot trade to China, although limited
  - ✓ Increased coal demand would be satisfied by many Panamax-based ports (Russia, Indonesia, Columbia)
  - ✓ Strong grain exported from Latin and North America
  - ✓ Fleet expansion was higher than Capes, whilst demand fundamentals were slightly weaker
  - ✓ If the spread between Capes and Panamax widen cargoes would be split which would support Panamax rates
- Handles
  - ✓ World economy positive

- ✓ Steel and cement exports from China to remain buoyant, albeit at a lower rate-USA economic indicator points towards expansion in the second half of the year
- ✓ Fleet expansion was high for handymax but declining for handysize" (Karakoulakis, 2007).

Rubia (2008), presented the relationship between the Asian Economy and World Economy. He also mentioned the future forecasts for the economic growth and gave the answer whether the Asian economic power would push the world economy ahead or not. He finalized his presentation by the figure as shown in Figure 2.4.7.

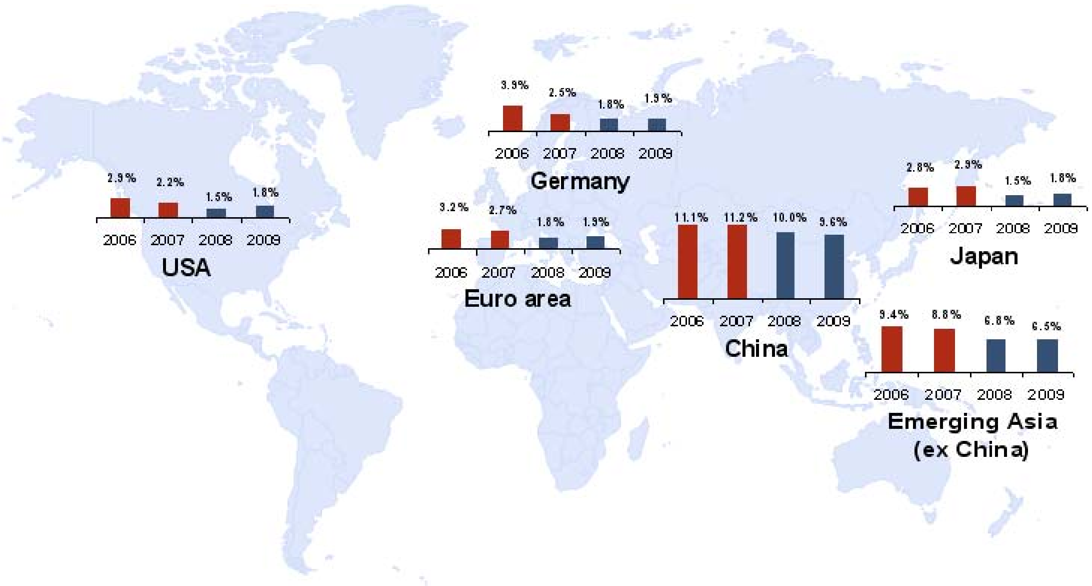


Figure 2.4.7 : World economy: only moderate slowdown, (Source: Rubia, 2008).

One of the great contributions to this sub-subject was by Rogers (2008). The seaborne dry bulk trade in 2007 was presented as shown in Figure 2.4.8. The forecast until 2015 for the world seaborne dry bulk trade was also given as shown in Figure 2.4.9. The age profile of the dry bulk fleet which showed huge change in fleet structure coming in next 3 years was also presented as shown in Figure 2.4.10. The world oil demand between 1974 and 2012 was also presented as shown in Figure 2.4.11. He finalized his presentation by showing the relation between the world oil demand and the tanker fleet growth.

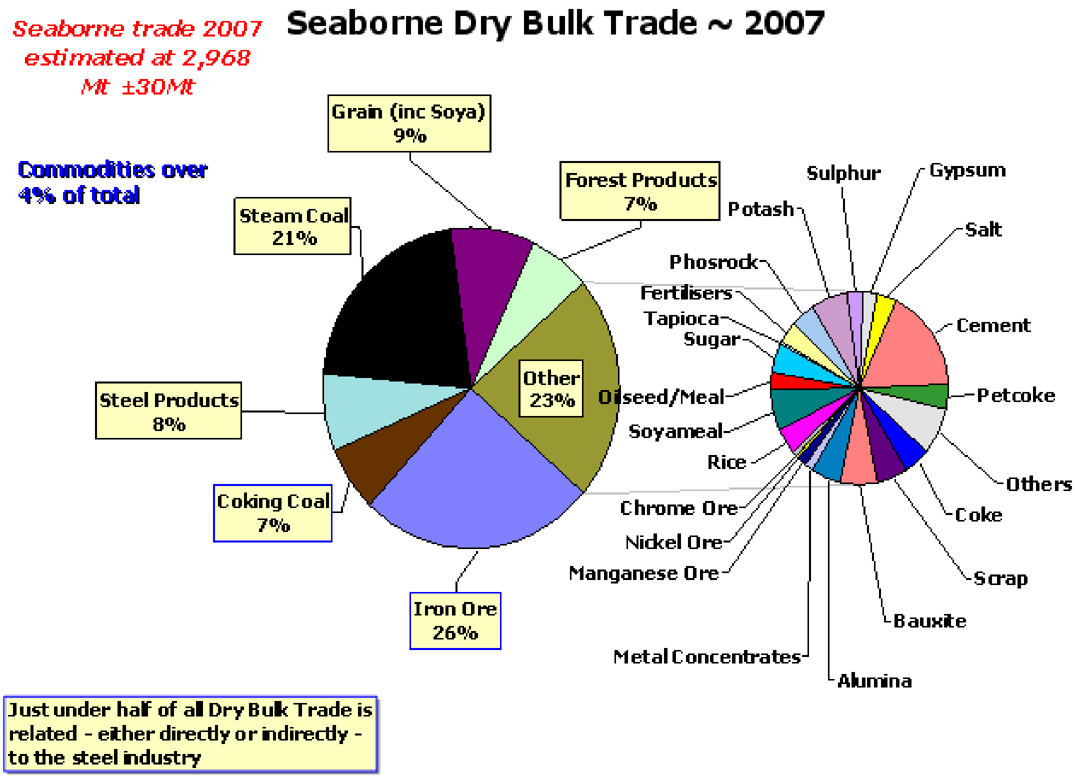


Figure 2.4.8 : 2007 Seaborne dry bulk trade, (Source: Rogers, 2008).

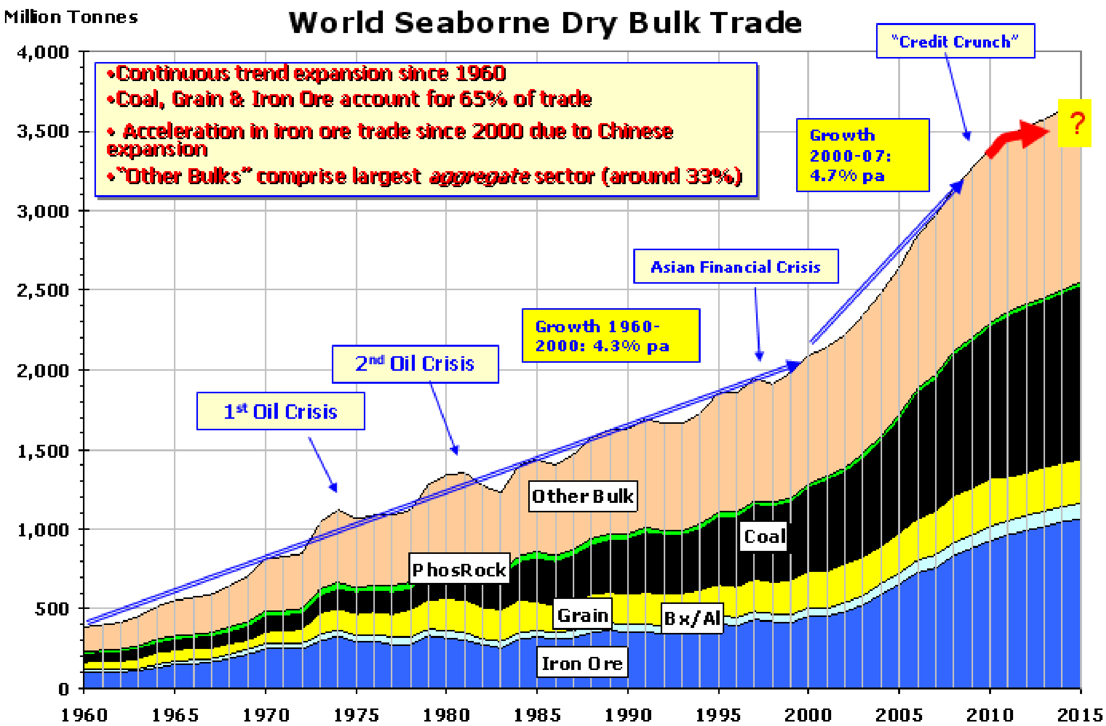


Figure 2.4.9 : World seaborne dry bulk trade, (Source: Rogers, 2008).

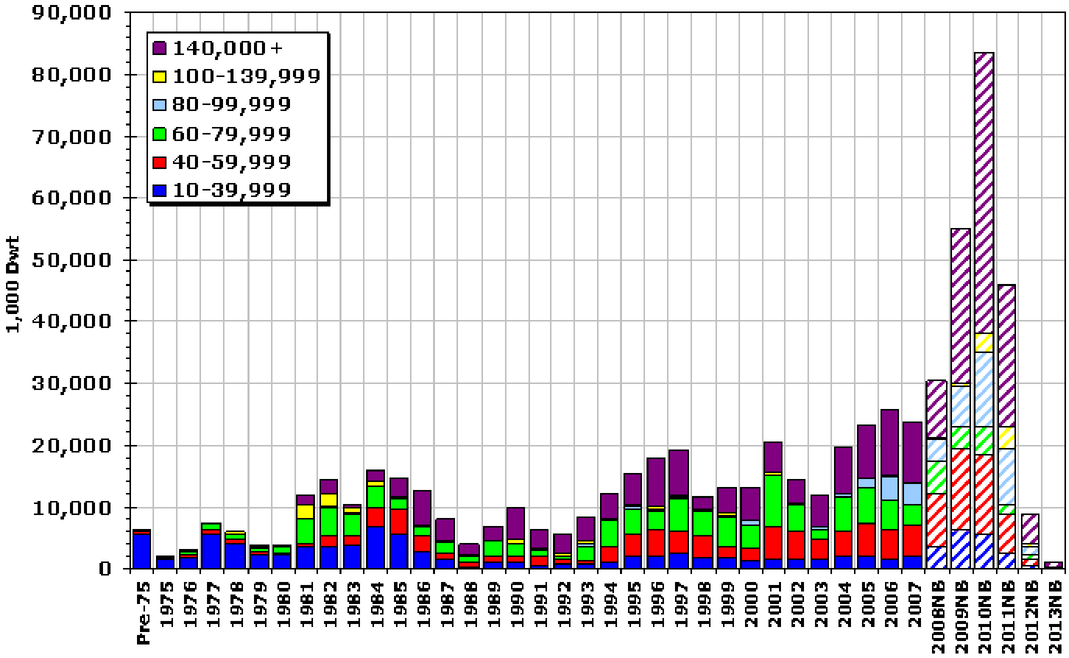


Figure 2.4.10 : Age profile of dry bulk fleet at 1st January 2008, (Source: Rogers, 2008).

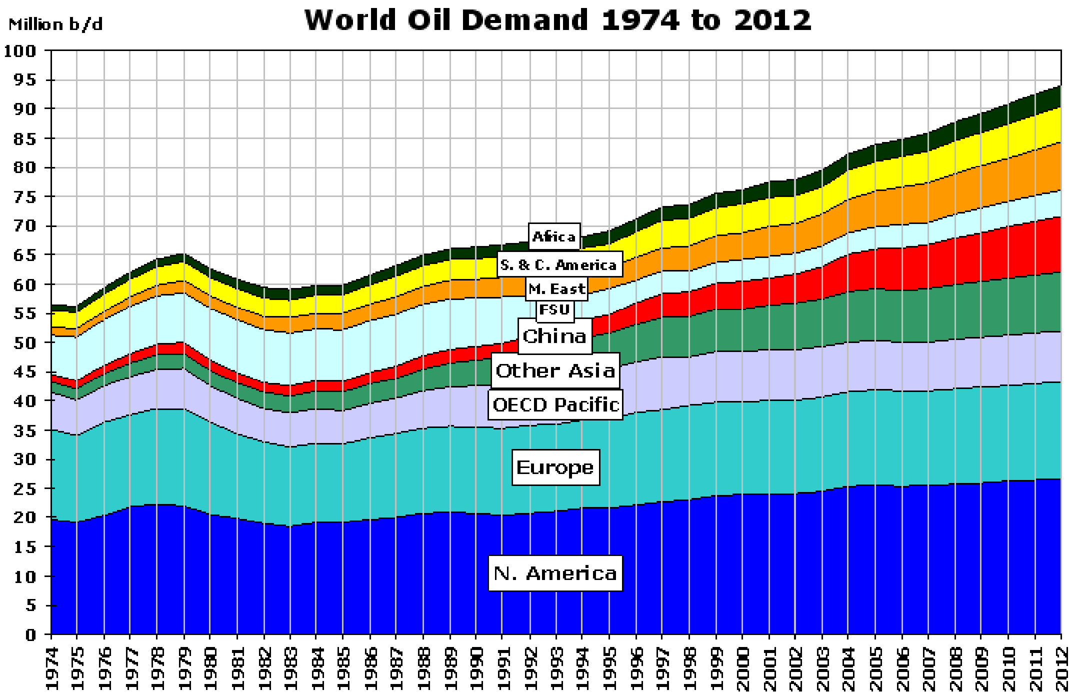


Figure 2.4.11 : World oil demand, (Source: Rogers, 2008).

Khalid (2007), presented important figures about maritime transportation, shipping and shipbuilding. Khalid (2007), underlined that demand for new buildings between 2000 to 2010 estimated around US$ 4.5 billion. In 2004, Korea with %40 of the share, China with %14 of the share and Japan with %24 of the share contributed 80%

of the global new building. Top 10 largest fleets by country were also given as Greece (166 Mil. DWT), Japan (138 Mil. DWT), Germany (81 Mil. DWT), China (67 Mil. DWT), Norway (46 Mil. DWT), US (45 Mil. DWT), HK (China) (44 Mil. DWT), Korea (31 Mil. DWT), Singapore (24 Mil. DWT), UK (22 Mil. DWT). VLCC estimated prices were also given starting from 1991 to 2006 as shown in Figure 2.4.12.

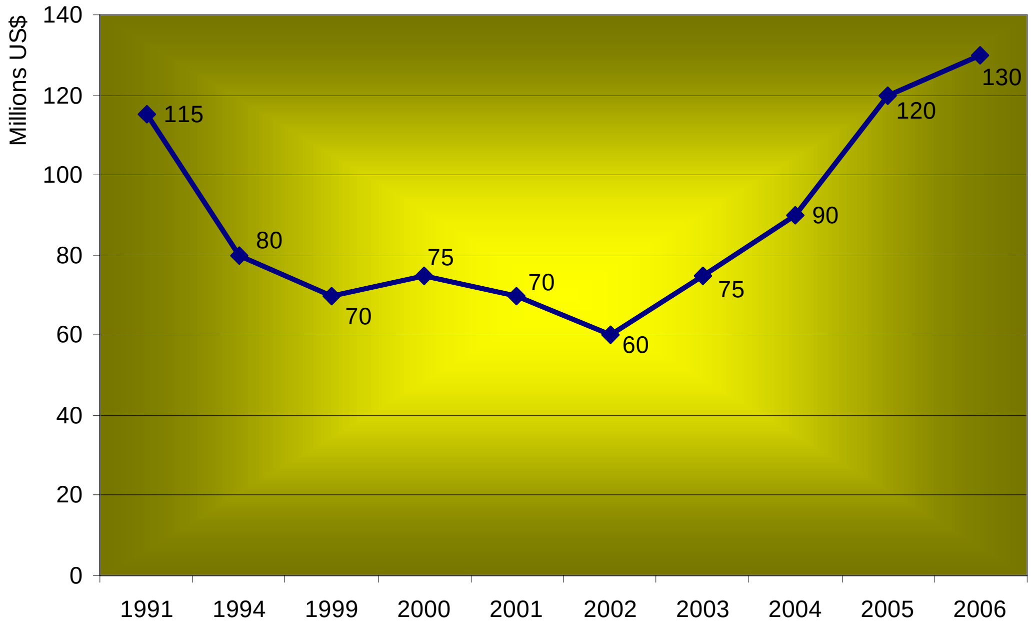


Figure 2.4.12 : Estimated prices of VLCC, (Data Source: Khalid, 2007).

In the study, which was funded by The Under Secretary of Defense named as First Marine International (2005), the major shipyards financial performance were presented as shown in Figure 2.4.13 - Figure 2.4.25.

Shipyard brief information, shipyard financial summary and descriptive figures were directly taken from the report of First Marine International (2005). These one sheet information booklets were not reviewed or revised, but these one sheet information booklets were directly taken from the reference and presented in current reseach.

Aker Yards had performed \$212 millions in 2002, \$226 millions in 2003, \$131 millions in 2004 in EBITDA, which was quite remarkable values, however there was a sudden decrease in 2004. Aker Finnyards performance was also presented.

AKER FINNYARDS (FORMERLY KVAERNER MASA-YARDS)

Aker Finnyards (Subsidiary of Aker Yards ASA)
Locations: Helsinki, Rauma, and Turku, FINLAND
Employees: 4,000

Aker Finnyards and Kvaerner Masa-Yards merged in 2004. Since January 2005 their three shipyards, the largest ones in Finland, have been working together as Aker Finnyards. It is one of four shipyard groups (Others: Aker Ostsee, Aker Brattvaag, and Aker Brevik) of Aker Yards ASA.

- **Major Businesses:** Aker Finnyards is a leading designer and builder of cruise vessels and ferries, and the leading ferry builder in the world. During the last ten years, over 25% of the world's cruise ships have been built by the company's shipyards. In addition, Aker Finnyards is the principal yard for the Finnish navy and an expert in multipurpose ice breakers.
- **Order book:** Aker Finnyards' order book includes the world's three largest cruise vessels for Royal Caribbean International, one cruise ferry for Tallink, three container carriers for Baltic Container Shipping, an ice breaking supply vessel for Fesco, an arctic container vessel for Norilsk Nickel, two missile boats and a conversion for the Finnish Navy and the lengthening of a cruise vessel.

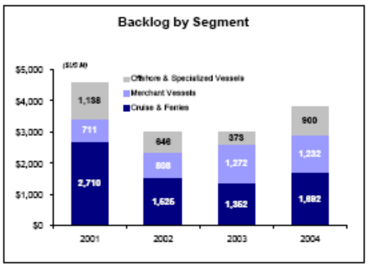
AKER YARDS — ORGANIZATION AND BACKLOG

Cruises/Ferries
Primary: Aker Finnyards
Secondary: Aker Brattvaag, Aker Ostsee, Aker Brevik

Merchant Vessels
Primary: Aker Ostsee, Aker Brattvaag

Offshore Vessels
Primary: Aker Brattvaag, Aker Brevik
Secondary: Aker Finnyards

Specialized Vessels
Primary: Aker Finnyards
Secondary: Aker Ostsee



Voyager of the Seas Cruise Ship

Hamina Finnish Navy

Arcticaborg Ice-going Vessel

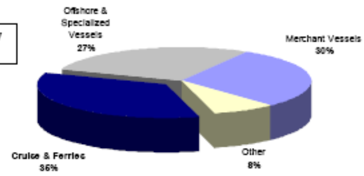
Turku shipyard

AKER FINNYARDS (CRUISE/FERRIES)[a] VS. REST OF AKER YARDS — FINANCIAL SUMMARY

Revenue

($US in millions)	2001	2002	2003	2004
Cruise/Ferries	**$2,082**	**$1,721**	**$1,295**	**$726**
% Growth	*N/A*	*-17%*	*-25%*	*-44%*
Merchant Vessels	501	456	579	617
Offshore & Specialized Vessels	663	809	698	567
Other	92	54	52	159
Revenue	**$3,339**	**$3,040**	**$2,624**	**$2,070**
% Growth	*N/A*	*-9%*	*-14%*	*-21%*

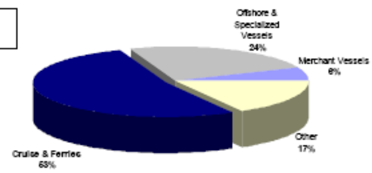
2004 Revenues by Segment



EBITDA

($US in millions)	2001	2002	2003	2004
Cruise/Ferries	**$37**	**$125**	**$172**	**$103**
Cruise/Ferries EBITDA Margin	*2%*	*7%*	*13%*	*14%*
% Growth	*N/A*	*237%*	*38%*	*-40%*
Merchant Vessels	4	4	30	12
Offshore & Specialized Vessels	61	72	99	48
Other	14	11	(34)	(33)
EBITDA	**$115**	**$212**	**$266**	**$131**
EBITDA Margin	*3%*	*7%*	*10%*	*6%*
% Growth	*N/A*	*84%*	*26%*	*-51%*

2004 EBITDA by Segment



[a]Aker Finnyards is the primary manufacturer for the Cruise and Ferries Division

Results are converted from Norwegian Kroner to US Dollars using the exchange rate as of December 31, 2004 (NOR 1.00 = US$ 0.16540)
Source: Company public documents, Company website, and Alfred Berg ABN AMRO (2004)

Figure 2.4.13 : Aker Finnyards financial summary, (Source: First Marine International, 2005).

Aker Yards had performed $212 millions in 2002, $226 millions in 2003, $131 millions in 2004 in EBITDA, which was quite remarkable values, however there was a sudden decrease in 2004. Aker Ostsee performance was also presented.

Aker Ostsee – Company Overview

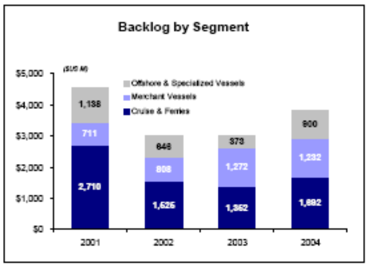
Aker Ostsee (Subsidiary of Aker Yards ASA)
Headquarters: Wismar, GERMANY
Locations: Aker MTW (Wismar) and Aker Warnemünde
Employees (2003): 2,631

Aker Ostsee was established in September 2002, combining Aker MTW and Aker Warneünde shipyards, and it is Aker Yards primary manufacturer of merchant vessels. It is one of four shipyard groups (other: Aker Finnyards, Aker Brattvaag, and Aker Brevik) of Aker Yards ASA, headquartered in Oslo, Norway.

– **Major Businesses:** Aker Ostsee shipyards represent the competence center of Aker Yards ASA for merchant vessels. Today's product range comprises container vessels, product, chemical, gas and shuttle tankers, ice-breaking tankers, and medium-sized passenger vessels, as well as steel construction.

– **Capacity:** The yards are currently subject to EU output capacity restrictions of 197,000 cubic gross tons (CGT) per annum (106,000 CGT at Aker MTW and 91,000 CGT at Aker Warnemünde). This is around 30 percent less than the yard's full operating capacity. The restrictions will be removed year-end 2005.

Aker Yards — Organization and Backlog



Wismar Shipyard

Container Vessel

Container Vessel

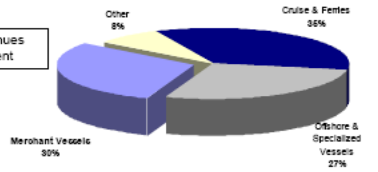
Container Vessel

Warnemünde Shipyard

Aker Ostsee (Merchant Vessels)[a] vs. Rest of Aker Yards — Financial Summary

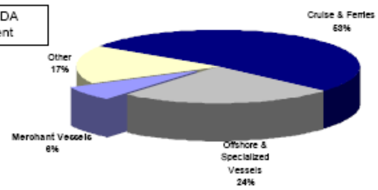
Revenue ($US in millions)	2001	2002	2003	2004
Cruise/Ferries	$2,082	$1,721	$1,295	$726
Merchant Vessels	**501**	**456**	**579**	**617**
% Growth	*N/A*	*-9%*	*27%*	*7%*
Offshore & Specialized Vessels	663	809	698	567
Other	92	54	52	159
Revenue	**$3,339**	**$3,040**	**$2,624**	**$2,070**
% Growth	*N/A*	*-9%*	*-14%*	*-21%*

2004 Revenues by Segment



EBITDA ($US in millions)	2001	2002	2003	2004
Cruise/Ferries	$37	$125	$172	$103
Merchant Vessels	**4**	**4**	**30**	**12**
Merchant EBITDA margin	*1%*	*1%*	*5%*	*2%*
% Growth	*N/A*	*0%*	*723%*	*-59%*
Offshore & Specialized Vessels	61	72	99	48
Other	14	11	(34)	(33)
EBITDA	**$115**	**$212**	**$266**	**$131**
EBITDA margin	*3%*	*7%*	*10%*	*6%*
% Growth	*N/A*	*84%*	*26%*	*-51%*

2004 EBITDA by Segment



[a]Note: Aker Ostsee is the primary shipyard in the Merchant Vessel segment

Results are converted from Norwegian Kroner to US Dollars using the exchange rate as of December 31, 2004 (NOR 1.00 = US$ 0.16540)
Source: Company public documents, Company website, and Alfred Berg ABN AMRO (2004)

Figure 2.4.14 : Aker Ostsee financial summary, (Source: First Marine International, 2005).

Chantiers de L'Atlantique had performed $39 millions in 2002, $15 millions in 2003, $49 millions in 2004 in EBIT, which was quite remarkable values, however there was a sudden decrease in 2003.

CHANTIERS DE L'ATLANTIQUE – COMPANY OVERVIEW

Chantiers de L'Atlantique (Subsidiary of Alstom)
Headquarters: Levallois, FRANCE
Employees: 4,000

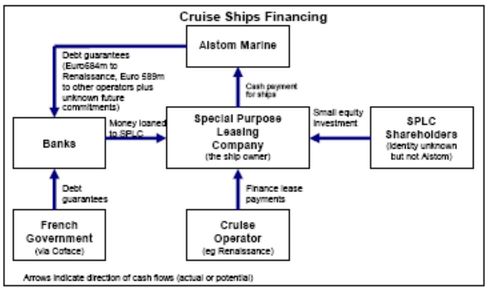
Chantiers de L'Atlantique, created in 1861, has been part of Alstom since 1984 and comprises its Marine Division (Chantiers also owns a substantially smaller subsidiary Leroux Naval, that manufactures sophisticated ships up to 140m). The company offers a wide range of vessels: cruise liners; car-ferries – RO-RO; LNG tankers; high-speed ferries; and warships and other military vessels. Over the last few years Chantiers de l'Atlantique has turned into one of the world leaders in cruise ship manufacturing. However, financial difficulties make the future of Chantiers de L'Atlantique uncertain.

– **Major Businesses:** Cruise-liners, high-speed ferries and large private yachts; LNG (liquefied natural gas) carriers and FPSO (Floating Production, Storage and Offloading) vessels; surface naval vessels; and research and scientific vessels.

– **Capacity:** Tenth largest shipbuilder in the world with shipyard capacity of 458,000 cubic gross tons (CGT).

CHANTIERS DE L'ATLANTIQUE — OFF-BALANCE SHEET CUSTOMER FINANCING

- During the cruise ship boom, some Marine customers requested financing assistance in connection with the purchase of new cruise-ships. While these cases of customer financing allowed Marine to increase the number of its customers in the past, they have also resulted in increased financial exposure.
- Alstom historically provided vendor financing to several customers. This financing was carefully structured using special purpose entities (SPEs). Alstom held no shares in these SPEs (but provided significant funding and guarantees) and as a result they were unconsolidated under French GAAP.
- The extent of the vendor financing became clear when Renaissance, which had acquired six cruise ships with Alstom's assistance, filed for bankruptcy in September 2001. Another customer, Festival, which had acquired three ships with Alstom's assistance found itself in financial difficulty in January 2004.



Queen Mary 2

High-speed Ferry

Saint Nazaire Shipyard

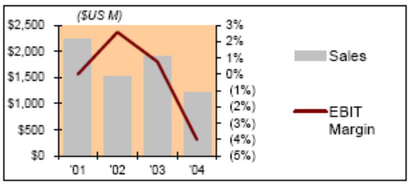
LNG Carrier

Offshore Platform

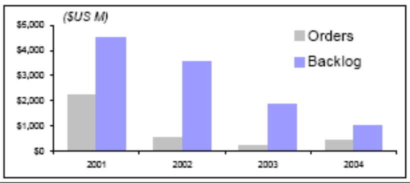
Frigate Vendemiaire

CHANTIERS DE L'ATLANTIQUE — FINANCIAL SUMMARY

($US M) Year ended 31 Mar	2001	2002	2003	2004
Sales:	**$2,241**	**$1,509**	**$1,909**	**$1,214**
Sales growth:	*40%*	*(33%)*	*26%*	*(36%)*
EBIT:	0	39	15	(49)
EBIT margin:	*0%*	*3%*	*1%*	*(4%)*
Revenue per employee:	$303,408			



($US M) Year ended 31 Mar	2001	2002	2003	2004
Orders	$2,234	$562	$198	$464
Order growth:	*13%*	*(75%)*	*(65%)*	*134%*
Backlog	4,511	3,564	1,854	995



Results are converted from Euros to US Dollars using the exchange rate as of March 31, 2004 (€ 1.00 = US$ 1.2172)
Source: Company public documents and Company website

Figure 2.4.15 : Chantiers De L'Atlantique financial summary, (Source: First Marine International, 2005).

Daewoo Shipbuilding & Marine Engineering Co., Ltd. had performed $264 millions in 2002, $337 millions in 2003, $59 millions in 2004 in EBIT, which was quite remarkable values, however there was a sudden decrease in 2004.

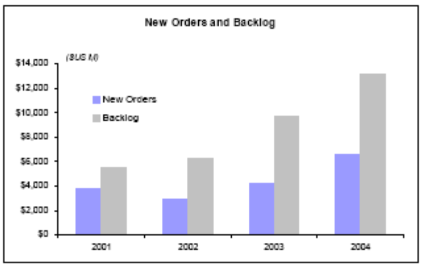
Daewoo Shipbuilding – Company Overview

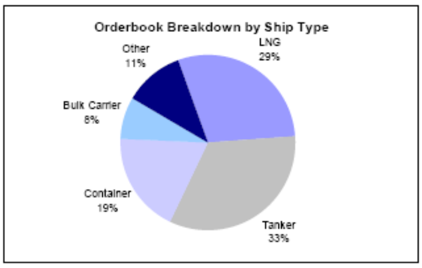
Daewoo Shipbuilding & Marine Engineering Co., Ltd.
Korea Stock Exchange – Ticker: 042660.KS
Headquarters: Seoul, SOUTH KOREA
Employees: 20,000

Daewoo Shipbuilding & Marine Engineering, established in 1973, is one of the world's premier specialized shipbuilding and offshore contractor that building vessels, offshore platforms, drilling rigs, floating oil production units, submarines, and destroyers. Daewoo has established itself as the top LNG carrier builder in the world, winning 34% and 43% of LNG ship orders in the world market in 2002 and 2003, respectively.

– **Major Businesses:** Commercial Shipbuilding & Repair, Offshore Plant Construction, and Specialty Ship Manufacturing
– **Capacity:** Third largest shipbuilder in the world with shipyard capacity of over 1.5 million cubic gross tons (CGT)

Daewoo Shipbuilding & Marine Engineering — Orders and Backlog





LNG Carrier

Crude Oil Carrier

RO-RO Carrier

209 Class SSK Submarine

Offshore Plant

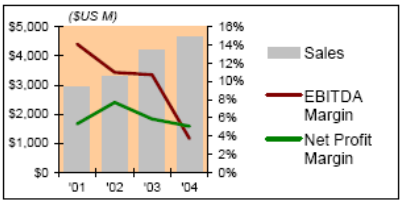
Drilling Rig

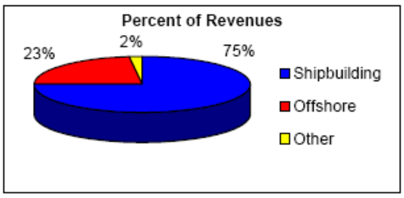
Daewoo Shipbuilding & Marine Engineering — Financial Summary

($US M) Year ended 31 Dec.	2001	2002	2003	2004
Sales:	$2,941	$3,284	$4,223	$4,642
Sales growth:	*286%*	*12%*	*29%*	*10%*
EBITDA:	415	361	454	172
EBITDA margin:	*14%*	*11%*	*11%*	*4%*
EBIT:	285	264	337	59
EBIT margin:	*10%*	*8%*	*8%*	*1%*
Net Profit:	157	253	248	236[a]
Net Profit margin:	*5%*	*8%*	*6%*	*5%*

Revenue per employee: $232,079

Stock price:	$18.03 (as of 5/3/2005)
52 week high:	$21.84
52 week low:	$9.67
Shares outstanding:	191.0 million
Market capitalization:	$3,444
Net Debt:	($309)
Total capitalization:	$3,135
Total cap/EBITDA:	18.2x





[a]Note: 2004 net income is inclusive of foreign currency gain

Results are converted from South Korea Won to US Dollars using the exchange rate as of December 31, 2004 (KRW 1.00 = US$ 0.000975)
Source: Company public documents, Company website, JPMorgan (2005), UBS (2005), and Deutche Bank (2004)

Figure 2.4.16 : Daewoo Shipbuilding & Marine Engineering financial summary, (Source: First Marine International, 2005).

Fincantieri Cantieri Navali Italiani SPA. had performed $77 millions in 2002, $93 millions in 2003, $101 millions in 2004 in net profit, which was quite remarkable values, moreover there was a steady increase in net profit.

FINCANTIERI – COMPANY OVERVIEW

Fincantieri Cantieri Navali Italiani SPA (state-owned / Italy)
Headquarters: Trieste, ITALY
Employees: 9,490

Fincantieri is a state-owned Italian shipbuilder with eight shipyards. The company designs, builds and markets cruise ships, ferries, surface combatants, auxiliary ships and submarines. The company has consolidated its world leadership in the construction of cruise ships and large ferries, with market shares of over 50% in both business areas, and has made further progress in the construction of naval vessels such as aircraft carriers, submarines and latest generation frigates.

– **Major Businesses:** Cruise ships and ferries, merchant vessels, and naval surface vessels
– **Privatization:** In 2004, an effort to take Fincantieri private fell through. That proposal, the product of two years of discussion, would have seen Fincantieri merge with the non-military businesses of defense giant Finmeccanica, itself recently privatized at the time, in a new holding to be floated in Milan or otherwise sold off to a corporate buyer. In April 2005, amid rumors of another privatization possibility, Luigi Angeletti, the secretary of Italian trade union UIL, said the privatization of Italian state-owned shipbuilding group Fincantieri will not be possible because there are no private entrepreneurs in Italy, who have the money, desire and possibility to manage and develop a company like Fincantieri.

FINCANTIERI — SHIPYARDS

Monfalcone: Primary yard for luxury cruise shipbuilding

Marghera: Passenger ships and cruise ferries

Sestri Ponente: Built a series of merchant ships, petrol tankers, gas tankers, car-carriers, oil platforms and ferries

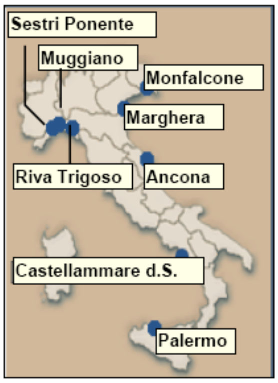
Ancona: A range of ships have been built here including: ocean liners, naval vessels of all types, tugs, numerous tankers, refrigerated cargo ships, container vessels, and the more recent chemical tankers

Palermo: Built scores of cargo vessels, ferries, tankers, Ro-Ros and a series of car-carriers, as well as working on ship conversions and repairs

Castellammare: Recent constructions include numerous tankers and refrigerated cargo ships, container ships and various bulk-carriers

Muggiano: Primary naval vessel shipyard, currently building two U212A class submarines

Riva Trigoso: Builds naval vessels to be fitted out in Muggiano shipyard



Carnival Victory Cruise Ship

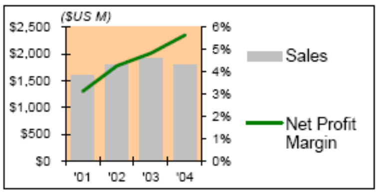
Monfalcone Shipyard

Cruise Ferry RO-PAX

Aircraft Carrier

FINCANTIERI — FINANCIAL SUMMARY

($US M) Year ended 31 Dec	2001	2002	2003	2004
Sales:	**$1,602**	**$1,797**	**$1,925**	**$1,788**
Sales growth:	*2%*	*12%*	*7%*	*(7%)*
Net profit:	$50	$77	$93	$101
Net profit margin:	*3%*	*4%*	*5%*	*6%*
Revenue per employee:	$188,408			



Results are converted from Euros to US Dollars using the exchange rate as of March 31, 2004 (€ 1.00 = US$ 1.2172)
Source: Company public documents and Company website

Figure 2.4.17 : Fincantieri financial summary, (Source: First Marine International, 2005).

Hanjin Heavy Industries & Construction Co., Ltd. had performed $156 millions in 2002, $115 millions in 2003, $105 millions in 2004 in EBITDA, which was quite remarkable values, however there was a sudden decrease in 2003.

HANJIN HEAVY INDUSTRIES – COMPANY OVERVIEW

Hanjin Heavy Industries & Construction Co., Ltd.
Korea Stock Exchange – Ticker: 003840.KS
Headquarters: Pusan, South Korea
Employees: 3,793

Hanjin Heavy Industries and Construction, established in 1937 and the first shipbuilding company in Korea, builds medium to large container carriers, LNG carriers, chemical tankers, reefer carriers, RO-RO carriers, naval ships, and other special ships. Hanjin has become one of the world's top 10 shipbuilders. Its construction division operations include development of plants both for foreign and domestic, plant design, building engineering, equipment installation and smooth test operation for steel mills, industrial and environmental facilities, power generating facilities, cranes and transportation equipment and steel structures, as well as various infrastructure and construction projects such as the construction of Incheon International Airport, Yeongjong Grand Bride, Seoul-Pusan High-Speed Rail and others.

– **Major Businesses:** Shipbuilding & Repair, Infrastructure/Architecture/Engineering, Plants & Logistics Equipment Manufacturing
– **Capacity:** Ninth largest shipbuilder with shipyard capacity of 473,000 cubic gross tons (CGT)

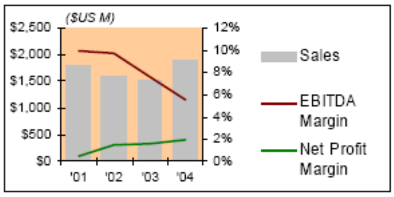
HANJIN HEAVY INDUSTRIES & CONSTRUCTION CO. — NEW ORDERS AND BACKLOG TRENDS

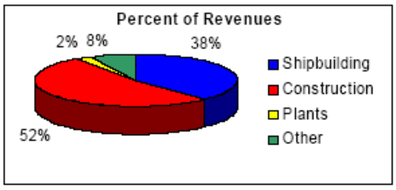
Hanjin Brussels · *MSC Diego* · *Youngdo Shipyard* · *Tongyong Grand Bridge* · *Neptune Frigate* · *Inha Univ. Hospital*

HANJIN HEAVY INDUSTRIES & CONSTRUCTION CO. — FINANCIAL SUMMARY

($US M) Year ended 31 Dec.	2001	2002	2003	2004
Sales:	**$1,788**	**$1,596**	**$1,506**	**$1,905**
Sales growth:	*(5%)*	*(11%)*	*(6%)*	*27%*
EBITDA:	177	156	115	105
EBITDA margin:	*10%*	*10%*	*8%*	*6%*
EBIT:	137	120	83	49
EBIT margin:	*8%*	*8%*	*6%*	*3%*
Net Profit:	9	23	24	36
Net Profit margin:	*1%*	*1%*	*2%*	*2%*

Revenue per employee:	$502,178
Stock price:	**$11.21** (as of 5/3/2005)
52 week high:	$14.62
52 week low:	$4.03
Shares outstanding:	64.8 million
Market capitalization:	**$727**
Net Debt:	($421)
Total capitalization:	**$306**
Total cap / EBITDA:	**2.9x**





Note: Results are converted from South Korean Won to US Dollars using the exchange rate as of December 31, 2004 (KRW 1.00 = US$ 0.000975). EBITDA based on Samsung Securities (2005) estimates.
Source: Company public documents, Company website, JPMorgan (2005), UBS (2005), and Deutche Bank (2004)

Figure 2.4.18 : Hanjin Heavy Industries & Construction Co. financial summary, (Source: First Marine International, 2005).

IZAR Construcciones Navales, S.A. had performed €1,4 billion in 2005 annual revenues.

IZAR Construcciones Navales, S.A. – Company Overview

IZAR Construcciones Navales, S.A. (state-owned / Spain)
Rolled up into Navantia in April 2005
Headquarters: Madrid, SPAIN

IZAR, Spain's largest shipbuilding company, consisted of four main businesses prior to the liquidation in April 2005 (see "Recent News"): Shipbuilding, Repair and Refit, Propulsion and Energy, and Systems and Weapons. With a history of over 250 years, IZAR was founded in December 2000 following the merger of Astilleros Españoles S.A. (AESA) and Empresa Nacional Bazán.

- **Shipbuilding:** construction of merchant and naval vessels (aircraft carriers and special units such as shuttle tankers, submarines, dredgers, hospital ships and speedboats);
- **Repair and Refit:** five repair centers strategically sited on the Spanish peninsula both for merchant and naval ships;
- **Propulsion and Energy:** engines and turbines; collaborates with large engine manufacturers (MAN-BW, MTU, Caterpillar) and turbine manufacturers (General Electric, Mitsubishi); and
- **Systems and Weapons:** consists of the San Fernando factory, which specializes in combat systems and naval armaments, and the Cartagena factory, which specializes in control and management systems. San Fernando has a wealth of experience in the development of combat systems and currently collaborates with Lockheed Martin in the installation of Aegis systems for Spanish and Norwegian frigates. Cartagena specializes in the design and development of computerized ship-control systems (navigation, engines, etc) and modern systems of management and marine safety.

Ferrol Shipyard

F-310 Frigate

Patiño

LNG Tanker

Recent News

In April 2005, IZAR began liquidation after the European Commission ordered in 2004 that it repay €1.2 billion ($1.6 billion) it had received in EU aid that Brussels regarded breached fair competition rules.

In 2004, a proposal by IZAR's owners, the state holding company Sociedad Estatal de Participaciones Industriales (SEPI), called for the separation of the company's military construction unit (six yards), its most profitable venture, from the civilian operation (four yards), which would be partially privatized. Navantia was formed in January 2005 with the initiation of the transfer of all of IZAR's military shipbuilding activities to the newly formed company and subsequent purchase by SEPI. The shipbuilding sector in Spain had been struggling in the face of tight competition from Asia. Navantia, now Spain's leading state-owned shipbuilding firm, focuses primarily on the military market but will be allowed to dedicate up to 20 percent of its overall activity to the commercial sector. Navantia has an orderbook worth €3.6 billion and estimates annual revenues of €1.4 billion.

Figure 2.4.19 : IZAR Construcciones Navales, S.A. financial summary, (Source: First Marine International, 2005).

Kawasaki Heavy Industries, Ltd. had performed $599 millions in 2002, $588 millions in 2003, $519 millions in 2004 in EBITDA, which was quite remarkable values, however there was a sudden decrease in 2004.

KAWASAKI HEAVY INDUSTRIES – COMPANY OVERVIEW

Kawasaki

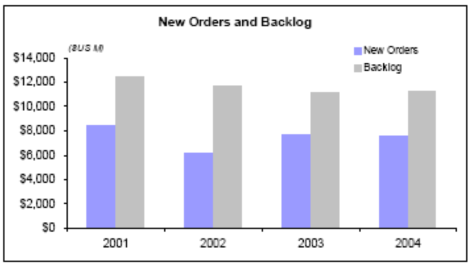
Kawasaki Heavy Industries, Ltd.
Tokyo Stock Exchange – Ticker: 7012.T
Headquarters: Kobe, JAPAN and Tokyo, JAPAN
Employees: 29,306

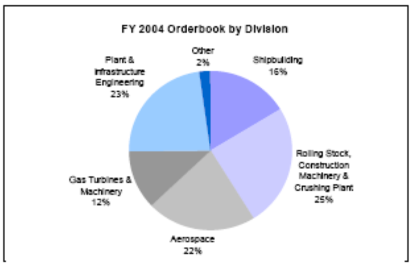
Kawasaki Heavy Industries, Ltd. (KHI), founded in 1878, is a leading global comprehensive manufacturer of transportation equipment and industrial goods. With a broad technological base that encompasses the land, sea, and air, KHI manufactures ships, rolling stock, aircraft and jet engines, gas turbine power generators, refuse incinerators, industrial plants, steel structures, and a wide range of manufacturing equipment and systems. KHI also produces such world-famous consumer products as Kawasaki brand motorcycles and jet ski watercraft.

– **Business Segments:** Consumer Products and Machinery; Plant and Infrastructure Engineering; Aerospace; Gas Turbines and Machinery; Rolling Stock; Construction Machinery and Crushing Plant; Shipbuilding; Other
– **Shipbuilding Capacity:** Ranked 12th largest shipbuilding company in the world with shipyard capacity of 440,000 CGT
– **Shipbuilding Main Products:** LNG and LPG carriers, container ships, VLCC, bulk carriers, high speed vessels, submarines, maritime application equipment

Over fiscal 2004, shipbuilding comprised over 8 percent of KHI's total sales. While total orders increased, shipbuilding sales declined from the previous year by 10 percent to roughly $900 mm and operating profitability decreased by $36 mm to a loss of $23 mm due to losses on construction contracts.

KAWASAKI HEAVY INDUSTRIES — ORDERS AND BACKLOG



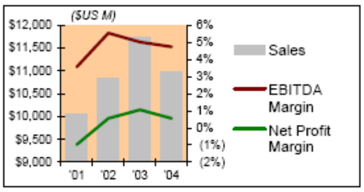


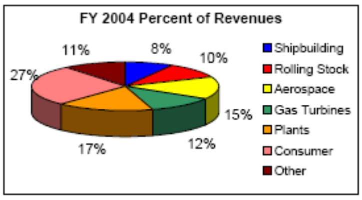
ZX-6RR *LNG Carrier* *LPG Carrier* *E2-1000 Train* *Embraer 170* *Marine steam turbine*

KAWASAKI HEAVY INDUSTRIES — FINANCIAL SUMMARY

($US M) Year ended 31 Mar.	2001	2002	2003	2004
Sales:	**$10,042**	**$10,838**	**$11,738**	**$10,986**
Sales growth:	*(8%)*	*8%*	*8%*	*(6%)*
EBITDA:	358	599	588	519
EBITDA margin:	*4%*	*6%*	*5%*	*5%*
EBIT:	42	296	289	211
EBIT margin:	*0%*	*3%*	*2%*	*2%*
Net Profit:	(98)	59	123	60
Net Profit margin:	*(1%)*	*1%*	*1%*	*1%*

Revenue per employee:	$374,887
Stock price:	**$1.91** (as of 5/3/2005)
52 week high:	$1.98
52 week low:	$1.38
Shares outstanding:	1,443.4 million
Market capitalization:	**$2,761**
Net Debt:	$3,375
Total capitalization:	**$6,136**
Total cap/EBITDA:	**11.8x**





Results are converted from Japanese Yen to US Dollars using the exchange rate as of March 31, 2004 (¥ 1.00 = US$ 0.009469)
Source: Company public documents and Company website

Figure 2.4.20 : Kawasaki Heavy Industries, Ltd. financial summary, (Source: First Marine International, 2005).

Mitsui Engineering & Shipbuilding Co., Ltd. had performed $119 millions in 2002, $255 millions in 2003, $270 millions in 2004 in EBITDA, which was quite remarkable values, moreover there was a steady increase in net profit.

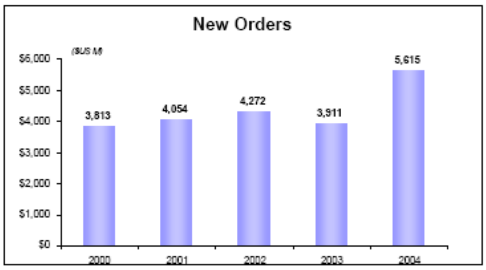
Mitsui Engineering & Shipbuilding – Company Overview

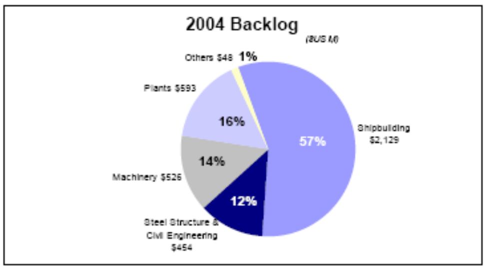
Mitsui Engineering & Shipbuilding Co., Ltd.
Tokyo Stock Exchange – Ticker: 7003.T
Headquarters: Chuo-Ku, JAPAN
Employees: 11,409

Mitsui Engineering & Shipbuilding (MES) was established in 1917 as Mitsui & Co.'s shipbuilding division and separated from the latter in 1937. Although about 40% of the company's sales come from shipbuilding (oil carriers and hull tankers), MES also makes machinery (engines, boilers, gas turbines, and robotic systems) and builds plants (for water treatment, oil refining, waste treatment facilities, gas chemistry, and chemicals). Other divisions build steel structures such as bridges, watergates, and penstocks, and also manufacture electronic appliances.

– **Major Businesses:** Shipbuilding, Machinery, Plants, and Steel Structures/Construction
– **Shipbuilding:** Fifteenth largest shipbuilder in the world with shipyard capacity of 384,000 cubic gross tons (CGT). MES has the world's largest market share of LNG tankers and double hull tankers. Shipbuilding also includes destroyers, patrol vessels, and survey vessels.

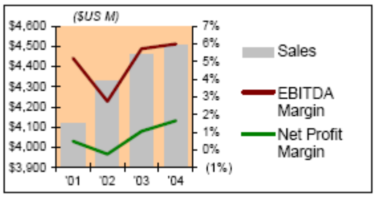
Mitsui Engineering & Shipbuilding — Orders and Backlog



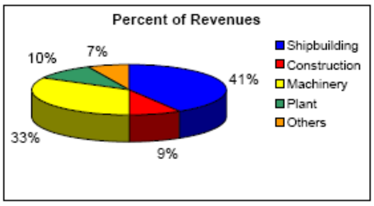


Mitsui Engineering & Shipbuilding — Financial Summary

($US M) Year ended 31 Mar.	2001	2002	2003	2004
Sales:	**$4,115**	**$4,331**	**$4,458**	**$4,509**
Sales growth:	*(5%)*	*5%*	*3%*	*1%*
EBITDA:	214	119	255	270
EBITDA margin:	*5%*	*3%*	*6%*	*6%*
EBIT:	159	192	240	175
EBIT margin:	*4%*	*4%*	*5%*	*4%*
Net Profit:	20	(10)	47	75
Net Profit margin:	*0%*	*(0%)*	*1%*	*2%*



Revenue per employee:	$395,223	
Stock price:	**$2.16**	(as of 5/3/2005)
52 week high:	$2.18	
52 week low:	$1.46	
Shares outstanding:	831.0	million
Market capitalization:	**$1,794**	
Net Debt:	$1,435	
Total capitalization:	**$3,229**	
Total cap/EBITDA:	**11.9x**	



Results are converted from Japanese Yen to US Dollars using the exchange rate as of March 31, 2004 (¥ 1.00 = US$ 0.009469)
Source: Company public documents, Company website, and Mitsubishi Securities (2005)

Figure 2.4.21 : Mitsui Engineering & Shipbuilding Co., Ltd. financial summary, (Source: First Marine International, 2005).

Samsung Heavy Industries Co., Ltd. had performed $358 millions in 2001, $286 millions in 2002, $266 millions in 2003 in EBITDA, which was quite remarkable values, moreover there was a steady decrease.

SAMSUNG HEAVY INDUSTRIES – COMPANY OVERVIEW

Samsung Heavy Industries Co., Ltd.
Korea Stock Exchange – Ticker: 010140.KS
Headquarters: Seoul, SOUTH KOREA
Employees: 8,572

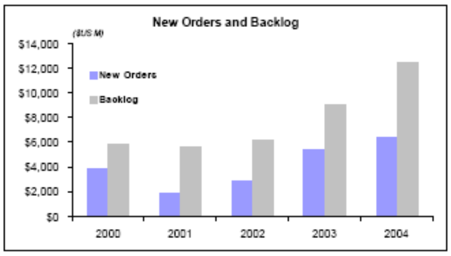
Samsung Heavy Industries (SHI) is a core affiliate of Samsung and was established in 1974. SHI manufactures commercial and industrial ships, cruise ships and ferries, and offshore platforms for oil drilling. The company also offers engineering and construction services for everything from industrial plants and office buildings to residential facilities and airports.

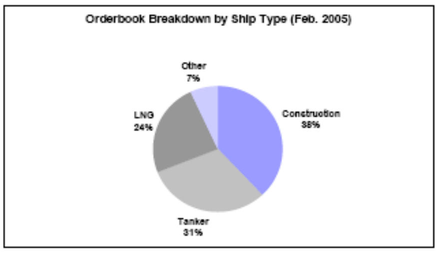
– **Major Businesses:** Commercial Shipbuilding & Repair, Industrial Construction, and Offshore Plant Construction

– **Capacity:** Second largest shipbuilder in the world, after Hyundai Heavy Industries, with shipyard capacity of over 1.8 million cubic gross tons (CGT)

– **Dock Turnover:** SHI's Geoje Shipyard boasts the world's highest dock turnover rate; and SHI's overall dock turnover is 10-20% higher than its peers.

Samsung Heavy Industries – ORDERS AND BACKLOG





Tanker


FPSO


Container Vessel

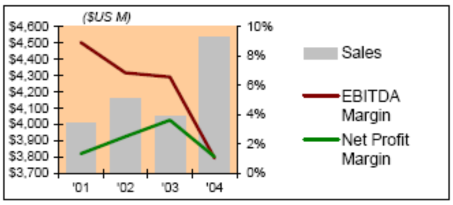

Passenger Ferry


Geoje Shipyard


Offshore Plant


SAMSUNG HEAVY INDUSTRIES – FINANCIAL SUMMARY

($US M) Year ended 31 Dec.	2001	2002	2003	2004
Sales:	**$4,008**	**$4,158**	**$4,048**	**$4,540**
Sales growth:	*15%*	*4%*	*(3%)*	*12%*
EBITDA:	358	286	266	47
EBITDA margin:	*9%*	*7%*	*7%*	*1%*
EBIT:	100	142	204	(106)
EBIT margin:	*3%*	*3%*	*5%*	*(2%)*
Net Profit:	54	104	147	52
Net Profit margin:	*1%*	*2%*	*4%*	*1%*
Revenue per employee:	$529,628			
Stock price:	**$7.79** (as of 5/3/2005)			
52 week high:	$10.28			
52 week low:	$4.49			
Shares outstanding:	231.00 million			
Market capitalization:	**$1,799**			
Net Debt:	($1,490)			
Total capitalization:	**$309**			
Total cap/EBITDA:	**6.5x**			



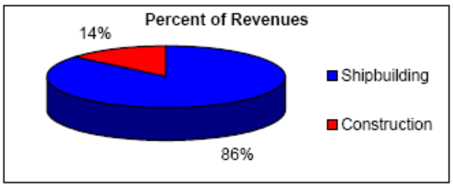


Figure 2.4.22 : Samsung Heavy Industries Co., Ltd. financial summary, (Source: First Marine International, 2005).

In the study, which was funded by The American Association of Port Authorities, named as Transportation Infrastructure Finance & Innovation Act (2006), The Federal Credit Assistance for Ports & Finance Seminar was in detail presented. In this seminar, the detailed financial information for ports including design principles and details of these ports were given. The planned ports and their investments with TIFIA assistance were presented as shown in Figure 2.4.23.

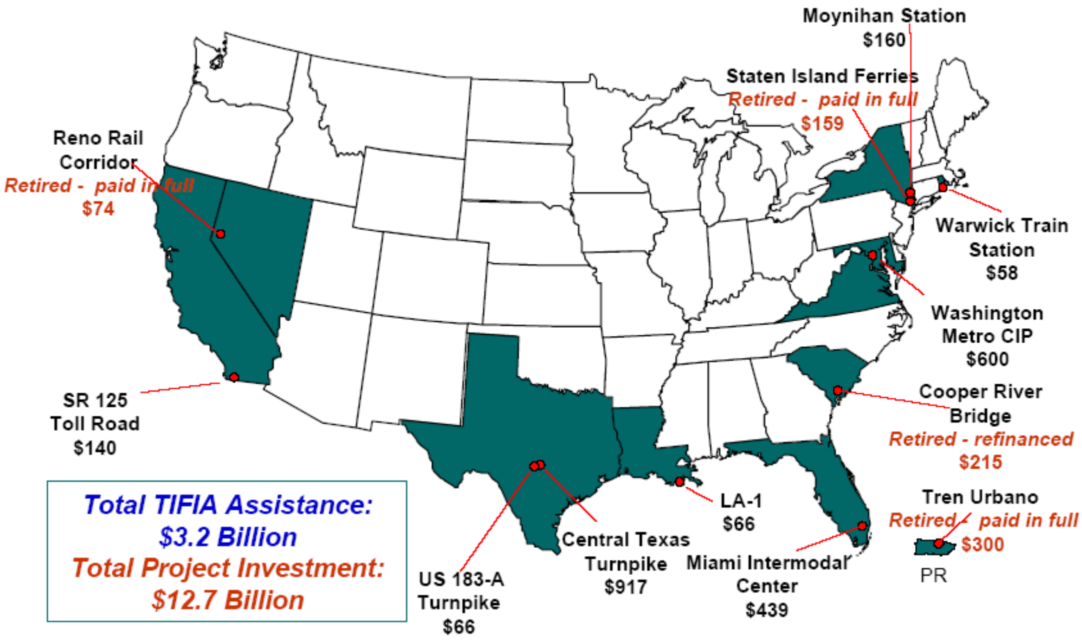


Figure 2.4.23 : Approved projects (federal credit assistance in millions), (Source: American Association of Port Authorities, 2006).

In industry applications and properties subtitle, sufficient number of studies are in detail studied. The oldest study is published in 2005 and the newest study is published in 2008, which makes the literature review appropriate to show the newest improvements and the newest forecasts in this subject, furthermore the detailed information about key market players are also in detail given.

The structure and organization of this subgroup is different than the organization and structure of other subgroups because in other subgroups such as decision making or software and coding, the classification study is important due to the fact of presenting the improvements in the scientific area, on the other hand in industry applications and properties, the aim is to introduce the industries which will be studied in case study and present the major players and what the key industry players use for the key financial performance measures to make the base for the case study.

Hence in this subtitle there is not any classification study but the literature survey as general is performed.

2.5 Mathematical and Statistical Methods

The study which has been undergone within this subtitle or main group aims to make a classification study that will guide the thesis within this main group. The table, which is purposed to group the literature review in Appendix D, has been filled in by information supplied in these summarized studies. The mathematical and statistical methods especially fuzzy logic based methods have been in detailed analysed by help of published studies and the approach of methods have been explained. Moreover brief information is given about the forecasting methods.

There were a lot of studies which used fuzzy logic as a base of the model. Some of them were worthmentioning to be given in current study. Fang and Chen (1990), underlined that uncertainties were better handled by fuzzy sets. Baas and Kwakernaak (1977), Baldwin and Guild (1979), Yager (1978), and Buckley and Chanas (1989) applied techniques based on fuzzy preference relation. Lee and Li (1988) used a generalised mean and standard deviation to rank the fuzzy numbers. Tong and Efstathiou (1982) used the final fuzzy numbers to generate the dominance set. Bellman and Zadeh (1970), Buckley (1985b) and Laarhoven and Pedrycz (1983) extended some methods using fuzzy numbers to obtain the fuzzy utilities. Dubois et. al. (1988) proposed a method, which was based on the fuzzy conjunctive/disjunctive method. Chen and Hwang (1992) published a taxonomic study, which covered the existing methods of fuzzy multi attribute decision making methods. Bellman and Zadeh (1970), Zadeh (1994) and Zimmermann (1987) explained in detail the application of fuzzy set theory in the decision making procedures. In study of Bardossy et. al. (1993), expert opinions were gathered by fuzzy numbers. In paper of Chen and Lin (1995), Chen et al. (1989) and Hsu and Chen (1996), a similarity aggregation method was presented. In study of Ishikawa et. al. (1993), Kacprzyk and Fedrizzi (1988), Kacprzyk et. al. (1992), Lee (1996), the rate of aggregative risk was evaluated in a software development project. In research of Nurmi (1981), collective decision making approaches were presented. In study of Xu and Zhai (1992), expert opinions were gathered by interval value rating. In paper of Chen (1997), the fuzzy opinion in decision making problems were in detail studied and concentrated. Tanino (1984), used fuzzy preference for orderings in group decision making. Liang and Wang (1991), preferred to use fuzzy logic to solve the problem of facility site selection. Karsak (1998), proposed a method based on two fuzzy decision making phases. Machacha and Bhattacharya (2000), proposed a system for selection of database software packages based on fuzzy logic. Chen (1994), developed a method for multi attribute decision making problems based on fuzzy logic principles. Chang and Chen (1994), proposed a decision algorithm based on the fuzzy set theory. Ravi and Reddy (1999), used three kinds of fuzzy membership functions with four kinds of aggregators in coking and non-coking coals of India for industrial use problems. Wang (1997), modelled a valve selection problem by help of fuzzy logic principles. Wang (1999), proposed a new fuzzy outranking approach in the Quality Function Deployment planning. Gungor and Arikan (2000), focused on Turkish energy policy and strategy planning with a fuzzy logic approached model. Maeda and Murakami (1988), developed a new model based on fuzzy logic principles for solving company choice problem. Perego and Rangone (1998), presented a framework and a new approach for Advanced Manufacturing Technologies based on fuzzy logic principles. Azzone and Rangone (1996), published a study which focused on Manufacturing Competence. They developed a framework based on fuzzy logic principles. Ekel (1999), published a study which focused on optimisation problems and the fuzzy logic principles were used not only in the objective functions but also in the constraints. Yoon and Hwang (1985), developed new methods for solving the factory site selection problems and the methods were based on the fuzzy logic principles. Kirkwood (1982), adopted fuzzy logic principles to solve problems of plant selection. Tavana et. al. (1996), proposed a new system which was based on Delphi principles for selection of ranking hospitals in the United States of America. Bellehumeur et. al. (1997), solved sewage sludge management problem by help of a new model based on not only fuzzy logic principles but also ELECTRE method. Dubois and Prade (1980), Ribeiro (1993), Ribeiro and Baldwin (1995) and Ribeiro (1996), in which five different categories were used, had mentioned new multi attribute decision making methods based on fuzzy logic principles. Kwakernaak (1979), used fuzzy weights and fuzzy attribute for alternatives. Dubois and Prade (1983) and Cheng and McInnis (1980), developed new approaches based on fuzzy logic principles. Bonissone (1982), preferred to use trapezoidal fuzzy numbers in his approach for solving decision problems. Ruoning and Xiaoyan (1992), were developed a method based on fuzzy judgments in AHP. Chang (1996), developed a new method based on AHP and fuzzy logic principles. Triangular fuzzy numbers were preferred for the pairwise comparisons. Roy (1977), explained in his study a new method based on classical ELECTRE method. Fuzzy outranking was adopted into ELECTRE method. Siskos et. al. (1984), presented their method which was similar to Roy's method. Brans et. al. (1984), developed a new approached based on PROMETHEE method and fuzzy logic principles. Takeda (1982), developed a new approach which was interactive and based on fuzzy outranking relations. Lee (1990), combined the fuzzy logic principles and heuristic approached and developed a new method. Efstathiou and Rajkovic (1979) and Efstathiou (1979), developed herustic approach based on fuzzy logic principles. Negi (1989), preferred to use fuzzy logic during rating of alternatives. Klir and Yuan (1995), studied in detail theory of fuzzy sets, operations on fuzzy sets, fuzzy relations and fuzzy relation equations, uncertainty, fuzzy systems and so forth. Zadeh et. al. (1975), studied in detail fuzzy logic principles, moreoever explained in detail the applications of fuzzy logic in real life. Sivanandam et. al. (2007), explained the fuzzy logic applications by using MATLAB.

Saralees (2008), studied a new Pareto distribution, which was taken the form of the two Pareto probability density functions for pooling knowledge.

Forecasting, which was discribed as the process of estimation of unknown situations by help of historic data, was one of the most crusial mathematical methods. In stead of forecasting, the term prediction was widely in use in daily life, however these terms did not fully cover the whole meaning of each others. There were four main groups of forecasting methods. These were "time series methods", "judgmental methods", "causal/econometric methods" and "other methods". Time series methods were generally given as moving average method, exponential smoothing method, extrapolation method, linear prediction method, trend estimation method, growth curve method. Moving average methods were the simple moving average method, the cumulative moving average method, the weighted moving average method, the exponential moving average method. These methods were based on statistical techniques which used the set of data points in the historical time. Exponential smoothing methods were the simple moving average method, the weighted moving average method and the exponential moving average method. Extrapolation methods were the linear extrapolation, the polynomial extrapolation, the conic extrapolation, the French curve extrapolation. Causal/econometric methods were the regression analysis which could be divided into two groups as linear regression and non-linear regression, the autoregressive moving average model and the autoregressive integrated moving average model. Judgmental methods were composite forecasts, surveys, Delphi method, scenario building, technology forecasting, forecast by analogy and other methods were probabilistic forecasting, simulation, prediction market, ensemble forecasting, reference class forecasting.

Bierens (2004), presented detail information in his book about probability and measure, Borel Measurability, integration, mathematical expectations, conditional expectations, distributions and transformations, the multivariate normal distribution, modes of convergence, dependent laws of large numbers, Central Limit Theorems and Maximum Likelihood Theory.

Campbell et. al. (1997), presented detail information in their book about the marginal, conditional and joint distribution of returns market efficiency, the random walk hypotheses, the predictability of asset returns, nonsynchronous trading, bid-ask spread, modeling transactions, data recent empirical findings, measuring and analyzing abnormal returns, analysis of power, nonparametric tests, cross-sectional models, the capital asset pricing model, multifactor pricing models, present value relations, intertemporal equilibrium models, derivative pricing models, fixed income securities, term structure models, univariate tests for nonlinear structure, univariate models, multivariate models, Kernel Regression, Optimal Bandwidth Selection, Average Derivative Estimators, Artificial Neural Networks, Overfitting and Data-Snooping.

Kutsurelis (1998), presented detail information in his thesis, which was principally advised by Mr. Katsuaki Terasawa about neural networks, finance, time series analysis, forecasting, artificial intelligence. The major achivement in his thesis was the use of neural networks as a forecasting tool. In his thesis, a neural network's ability for prediction of future trends was specifically tested and the accuracy of this forecasting tool was compared and cross-checked by traditional forecasting methods and also multiple linear regression analysis.

Hansen (2007), prepared a thesis that would help the Phd students and gave detail information about conditional density and mean, regression equation, conditional variance, linear regression, best linear predictor, technical proofs, least squares estimation, normal regression model, Gauss-Markov Theorem, asymptotic normality, covariance matrix estimation, Wald Tests, F Tests, normal regression model, generalized least squares, testing for Heteroskedasticity, forecast intervals, nonlinear least squares, least absolute deviations, Quantile Regression, testing for omitted nonlinearity, omitted variables, irrelevant variables, model selection, The Bootstrap, the empirical distribution function, Nonparametric Bootstrap, Bootstrap estimation of bias and variance, percentile intervals, percentile-t equal-tailed interval, symmetric percentile-t intervals, asymptotic expansions, one-sided tests, symmetric two-sided tests, percentile confidence intervals, Bootstrap methods for regression models, generalised method of moments estimator, distribution of generalised method of moments estimator, non-parametric likelihood, asymptotic distribution of empirical likelihood estimator, overidentifying restrictions, endogeneity, Bekker Asymptotics, Univariate Time Series, stationarity and ergodicity, autoregressions, asymptotic distribution, Bootstrap for Autoregressions, trend stationarity, testing for omitted serial correlation, multivariate time series, Vector Autoregressions, Restricted Vector Autoregressions, Single Equation from a Vector Autoregression, testing for omitted serial correlation, selection of Lag length in a Vector Autoregression, Granger Causality, cointegration, cointegrated Vector Autoregressions, dynamic panel regression, Kernel Density Estimation, asymptotic mean-squared error for Kernel Estimates.

Mills (1999), presented detail information in his book about the stochastic processes, ergodicity and stationarity, autoregressive moving average model processes, non-stationary processes and autoregressive integrated moving average model, forecasting using autoregressive integrated moving average model, martingales, random walks and non-linearity, stochastic volatility, autoregressive heteroskedastic model processes, descriptive analysis of three return series, two models for return distributions, empirical evidence on tail indices, regression models, autoregressive heteroskedastic model in mean regression models, misspecification testing, robust estimation, the multivariate liner regression model, vector autoregressions, spurious regression, cointegrated process, testing for cointegration in regression, estimating cointegrating regressions, vector autoregressions with integrated variables, causality testing in vector error correction models, fully modified vector autoregression estimation, estimating permanent and transitory components of a vector error correction models, present value models, excess volatility and cointegration, generalisations and extensions of cointegration and error correction models.

Gao (2007), gave detail information in his book about the semiparametric series estimation, semiparametric Kernel estimation, semiparametric single-index estimation, testing for parametric mean models, testing for semiparametric variance models, testing for other semiparametric models, semiparametric cross-validation method, semiparametric penalty function method, nonparametric and semiparametric estimation, semiparametric specification empirical comparisons, Gaussian semiparametric estimation, simultaneous semiparametric estimation, long-rangé dependent stochastic volatility models.

Mishkin (2004), presented detail information in his book about financial markets (understanding interest rates, the behavior of interest rates, the risk and term structure of interest rates, etc.), financial institutions (an economic analysis of financial structure, banking and the management of financial institutions, nonbank finance, etc.), central banking and the conduct of monetary policy (structure of central banks and the federal reserve system, multiple deposit creation and the money supply process, determinants of the money supply, tools of monetary policy, conduct of monetary policy: goals and targets), international finance and monetary policy (the foreign exchange market, the international financial system, monetary policy strategy: the international experience), monetary theory (the demand for money, the Keynesian framework and the investment saving/liquidity preference money supply model, monetary and fiscal policy in the investment saving/liquidity preference money supply model, aggregate demand and supply analysis, transmission mechanisms of monetary policy: the evidence, money and inflation, rational expectations: implications for policy). The most impressive contribution of this study was the research on the banking crises study throughout the world. In one of the chapters, this subject was given in detail and summarized by a Figure as shown in Figure 2.5.1.

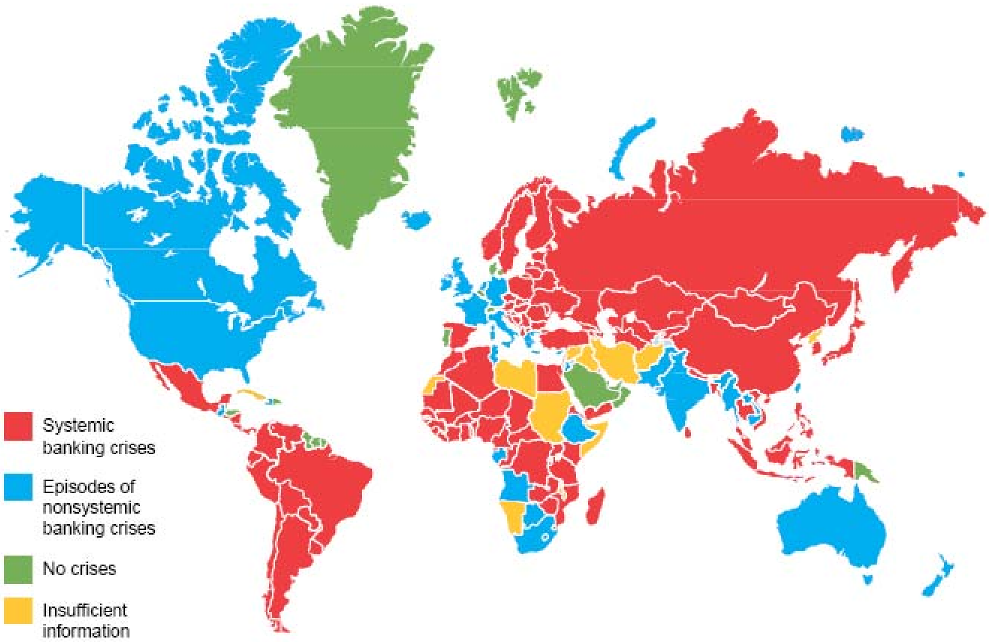


Figure 2.5.1 : Banking crises throughout the world since 1970, (Source: Caprio and Klingebiel, 1999).

In mathematical and statistical methods classification study, sixty three papers and books are in detail studied. The oldest study is published in 1970 and the newest study is published in 2008, which makes the literature review appropriate to show the improvements in this subject, furthermore half of the studies are later than 1990 which is good to fit the latest mathematical and statistical methods philosophy presentation ability. There are only one sub group which are highly classified as decision making. Most of the studies are in society level and concentrate on groups. The effective period of the reviewed studies are mostly in long term. The journal or publisher origin of this management systems classification study is presented in Figure 2.5.2.

Continents	Number of Studies
North America	63
South America	0
Europe	6
Asia	1
Africa	0
Australia	0
Antarctica	0
Total	70

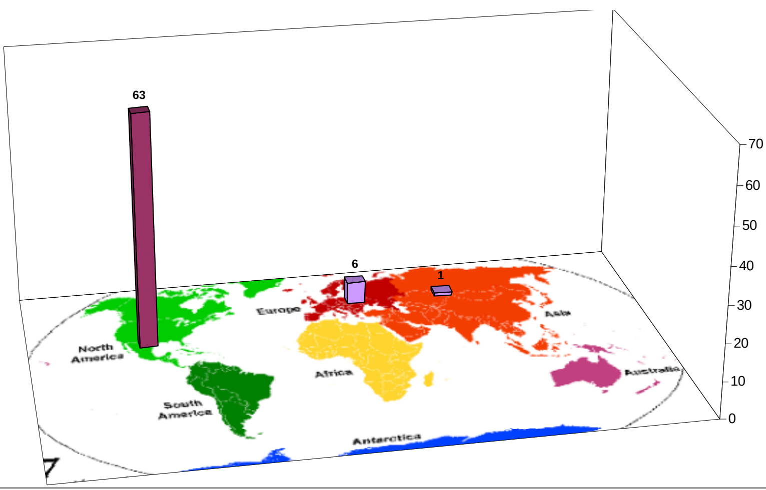


Figure 2.5.2 : Journal or Publisher Origin.

The literature review of mathematical and statistical methods is presented by a table in Appendix D.

2.6 Software and Coding

The study which has been undergone within this subtitle or main group aims to make a classification study that will guide the thesis within this main group. The table, which is purposed to group the literature review in Appendix E, has been filled in by the information supplied in these summarized studies. The on the shelf software packages for the current research topic and the coding tools have been in detailed analysed by help of published studies and the approach of methods have been explained briefly.

The first study, which executed an on the shelf software package, was by Olcer et. al. (2006). In their study, the multi-objective design optimisation was performed by help of an on the shelf software package, named as modeFRONTIER. This software could be used either single-objective or multi-objective in optimizing a design or system. The main role of the optimization algorithm in this software was the power of identifying the solutions on the trade-off curve, known as the Pareto Frontier. Moreover the software was capable of a decision support tool based on Multi-Criteria Decision Making (MCDM). The algorithms actually available in the modeFRONTIER software were Linear MCDM, GA MCDM, Hurwicz, Savage MADM. The official web site was http://www.esteco.it.

Figueira et. al. (2005), focused on the shelf software packages executing ELECTRE Methods. The reference methods were named with the software names as Electre IS, which run on a IBMcompatible computer on Windows 98 and higher; Electre III-IV, which run on Windows 3.1, 95, 98, 2000, Me and XP; Electre Tri, that run on Microsoft Windows 3.1, 95, 98, Me, 2000, XP and NT; IRIS using a variant of ELECTRE TRI, that developed with Delphi Borland and run on Windows 98, Me, 2000, NT and XP and finally the UTA PLUS and SRF, that was developed with the Delphi Borland 3.0 and run on Windows 98, Me, 2000 and XP were available in the market. The official web site was http://www.lamsade.dauphine.fr/ .

Martel and Matarazzo (2005), study presented on the shelf software packages for some outranking methods. An algorithm was implemented for QUALIFLEX method named as Micro-QUALIFLEX. The Micro-QUALIFLEX was in detail studied by Ancot (1988). The software application of REGIME method was implemented in a system to support decision making procedure on a finite set of alternatives named as DEFINITE. The software named as DEFINITE was in detail explained by Janssen (1992). Martel and Matarazzo (2005), presented the name of a software package called M&P, which was used to rank alternatives by help of method MAPPAC and PRAGMA. They underlined that the software had lots of options so that it could be described as very flexible in the preference modeling.

Brans and Mareschal (2005), focused on the shelf software packages executing PROMETHEE Methods. In the study, two different software were mentioned as PROMCALC, that was developed by Brans and Mareschal (2005) and the current software named as DECISION LAB, which replaced by the PROMCALC software. The DECISION LAB was capable of giving opportunity for defining and for inputting the relevant data by the user related to the PROMETHEE methods, such as evaluations, preference, functions and weights. The PROMETHEE and GAIA computations were real-time applications and were displayed in separate windows as shown in Figure 2.6.1. The official web site was http://www.visualdecision.com.

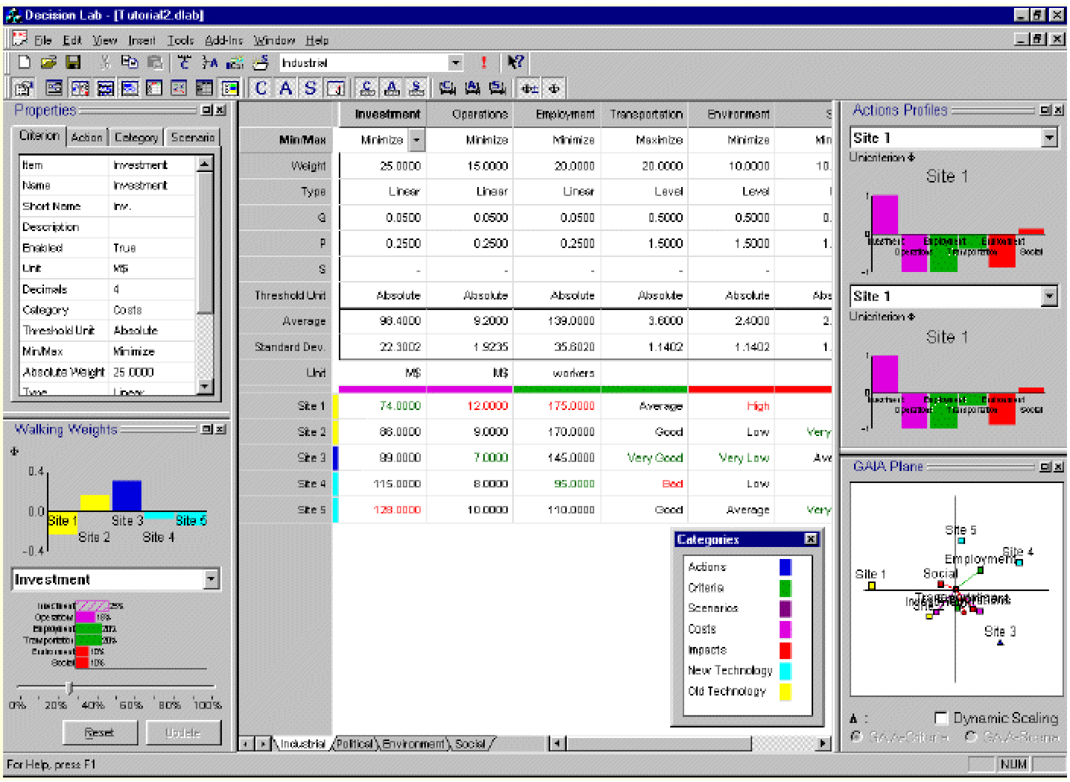


Figure 2.6.1 : PROMETHEE rankings, action profiles, GAIA plane, (Source: Brans & Mareschal, 2005).

The DECISION LAB could produce tailor-made reports including special tables and graphics required by the user.

White and Palocsay (1999), briefly gave information about the software named as Decision Explorer, which was developed for organizing and mapping or re-mapping qualitative information for very complex, complicated and ill-structured problems. The official web site was http://www.banxia.com.

Haerer (2000), provided detail information about the Criterium Decision Plus 3.0 (CDP) software. The Criterium Decision Plus 3.0 made complex decisions among alternatives involving multiple criteria. The Criterium Decision Plus 3.0 supported the two leading methodologies, which were AHP and SMART. The screenview of The Criterium Decision Plus 3.0 was shown as in Figure 2.6.2. The official web site was http://www.infoharvest.com.

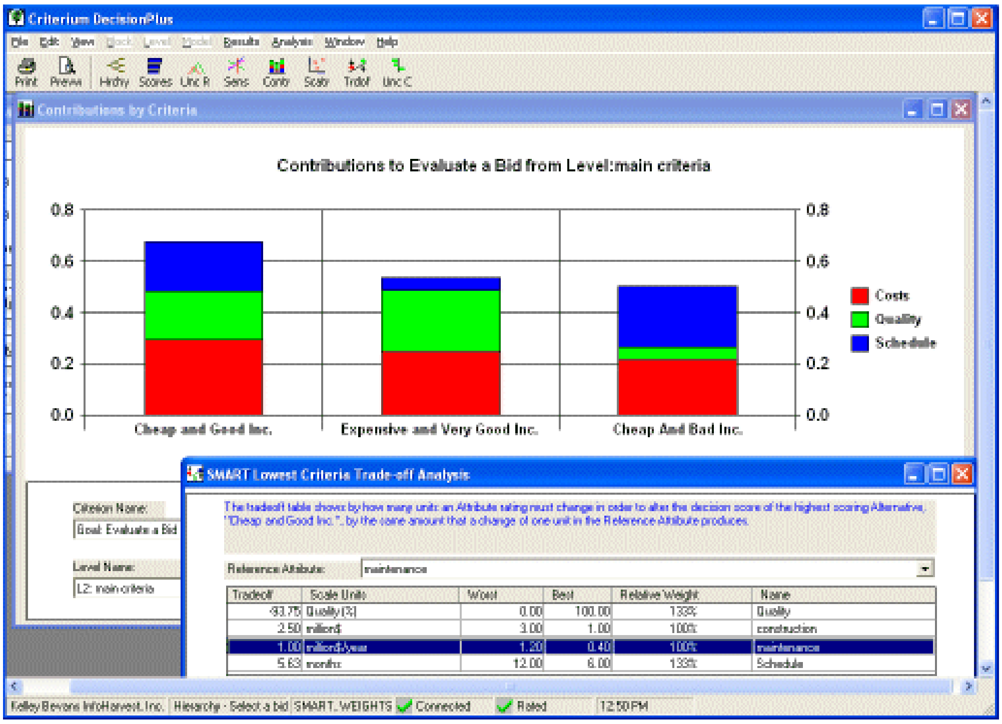


Figure 2.6.2 : Criterium DecisionPlus 3.0 choice suggestion screenview, (Source: Haerer, 2000).

Fernandez (1996), reviewed in detail the Expert Choice software, which was closely identified by AHP. The Expert Choice software employed AHP method as its core methodology. This software package was capable of group decision support and it was an user friendly screen view as shown in Figure 2.6.3 and the official web site was http://www.expertchoice.com.

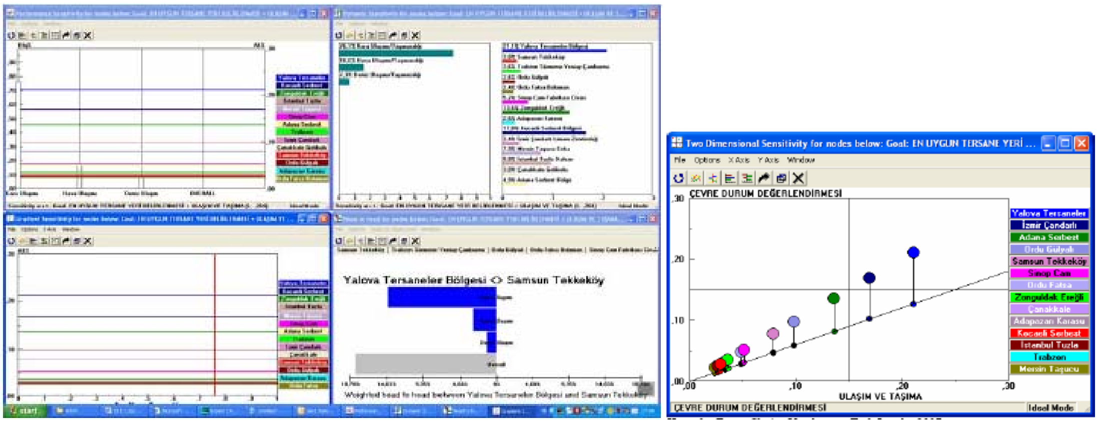


Figure 2.6.3 : Expert Choice screenview, (Source: Fernandez, 1996).

Zopounidis and Doumpos (1998), developed and presented a system named as FINCLAS, which was a multicriteria decision support system for financial modeling. The official web site was http://www.dpem.tuc.gr/fel/.

Korhonen (1988), developed and presented a visual multicriteria decision support system for multi attribute decision making problems, which was named as VIMDA. The official web site was http://www.numplan.fi/vimda/vimdaeng.htm.

Costa and Chagas (2004), used and gave information about M-MACBETH software, which was developed based on Measuring Attractiveness by a Categorical Based Evaluation Technique. In this technigue semantic judgments about the differences in attractiveness of several stimuli was performed. The screen views of the software were shown in Figure 2.6.4. The official web site was http://www.m-macbeth.com/.

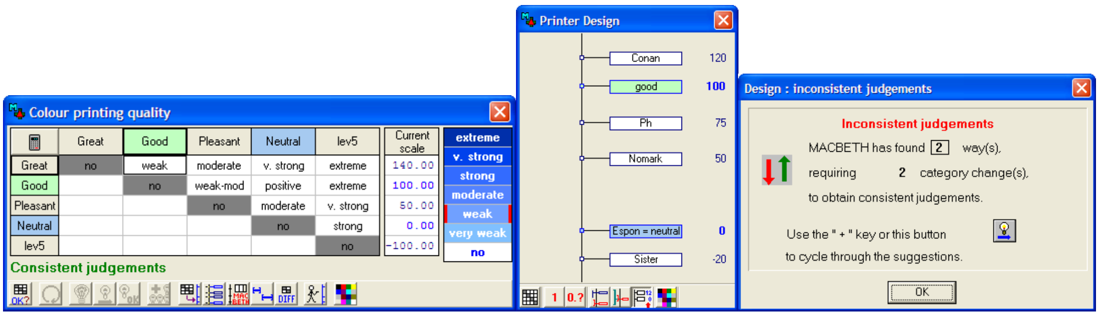


Figure 2.6.4 : M- MACBETH screenviews, (Source: Url-6).

Tavares (1999), explained in detail a software, which was developed at the Instituto Superior Técnico in Lisbon, named as MacModel that was a decision tree based software to solve multicriteria problems. The screenviews of the software were presented in Figure 2.6.5. and the official web site was http://www.civil.ist.utl.pt/ .

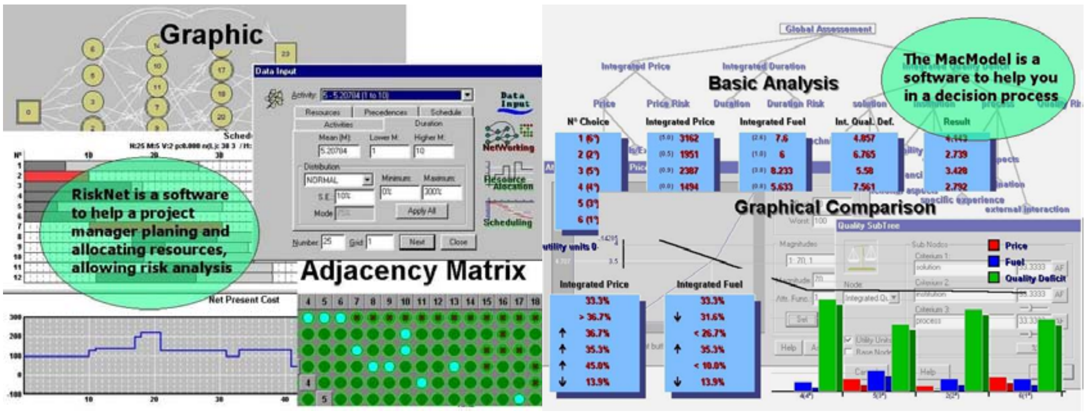


Figure 2.6.5. MacModel screenviews, (Source: Url-6).

Siskos et. al. (1999), developed a software tool named as MIIDAS (The Multicriteria Interactive Intelligence Decision Aiding System) based on the UTA II method. MIIDAS software used base methods as artificial intelligence, visual procedures and data analysis techniques.

Joint Research Center of the European Commission (1996), developed a software named as NAIADE (Novel Approach to Imprecise Assessment and Decision Environments). The NAIADE software could handle crisp data, stochastic data, fuzzy measurements of alternatives with respect to evaluation factors. The official web site was http://alba.jrc.it/ulysses/voyage-home/naiade/naisoft.htm.

Krysalis Ltd. developed a software package named as OnBalance, which was based on simple weighting approach. The method appeared to be very similar to AHP. The screenshots of the software were presented in Figure 2.6.6. and the official web site was http://www.krysalis.co.uk.

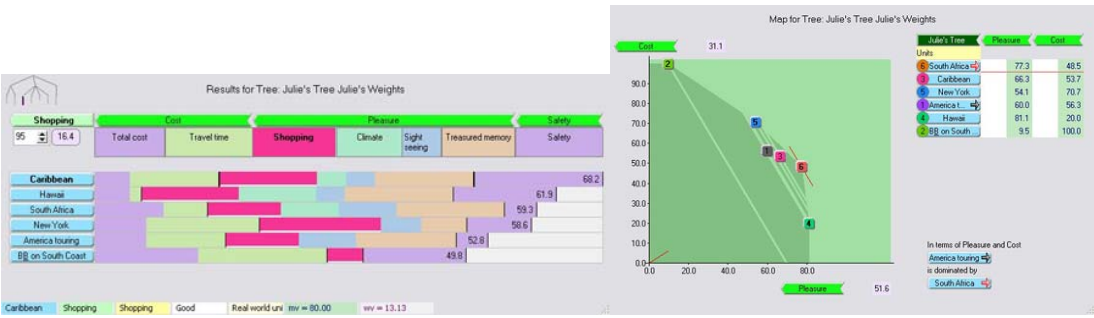


Figure 2.6.6.: OnBalance screenviews, (Source: Url-7).

Lotov et. al. (2001), in detail analysed the Feasible Goals Method and the software package named as Feasible Goals Method (FGM). The software was capable of exploring all possible results of the feasible solution set. The official web site was http://www.ccas.ru/mmes/.

Papadrakakis et. al. (2003), clearly identified that the method of visualization for models by projection, was differed from other multiple objective methods. They prefered to use and gave information about Multistat Optimizer Software Package. The screenshots of the software was presented in Figure 2.6.7 and the official web site was http://www.multistat.com.

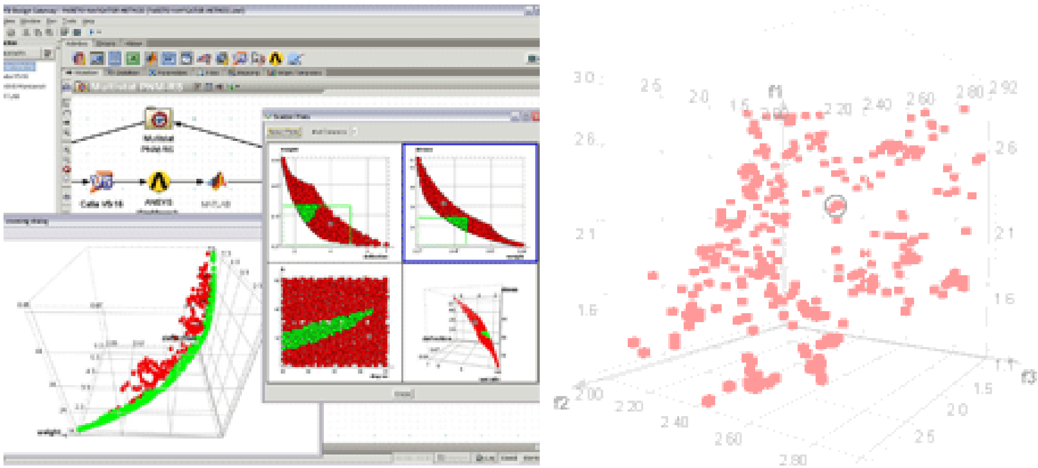


Figure 2.6.7 : Multistat Optimizer screenshots, (Source: Url-9).

Potapov and Kabanov (1994), developed and presented, SOLVEX which easily could easily solve nonlinear constrained optimization problems, multi-variable global optimization problems and nonlinear multicriteria problems. It was based on Fortran coding. The official web site was http://www.ccas.ru/pma/product.htm.

Lotov et. al. (2001), developed a software named as Feasible Set in Criterion Space (FSCS), which allowed visulization of the feasible set in the criterion space of nonlinear problems. This software was coded as an add-in for MS Excel. The official web site was http://www.ccas.ru/mmes/mmeda .

Weber (1991), developed a software named as AutoMan which was a sort of AHP based support system. The official web site was http://www.ntis.gov.

In software and coding classification study, fourty papers and books are in detail studied. The oldest study is published in 1986 and the newest study is published in 2007, which makes the literature review appropriate to show the improvements in this subject, furthermore half of the studies are later than 2000 which is good to fit the latest software and coding philosophy presentation ability. There are two sub-groups, which are highly classified as software and coding and decision making. Most of the studies are in society level and concentrate on groups. The effective period of the reviewed studies are mostly in long term. The journal or publisher origin of this management systems classification study is presented in Figure 2.6.8.

Continents	Number of Studies
North America	21
South America	0
Europe	18
Asia	1
Africa	0
Australia	0
Antarctica	0
Total	40

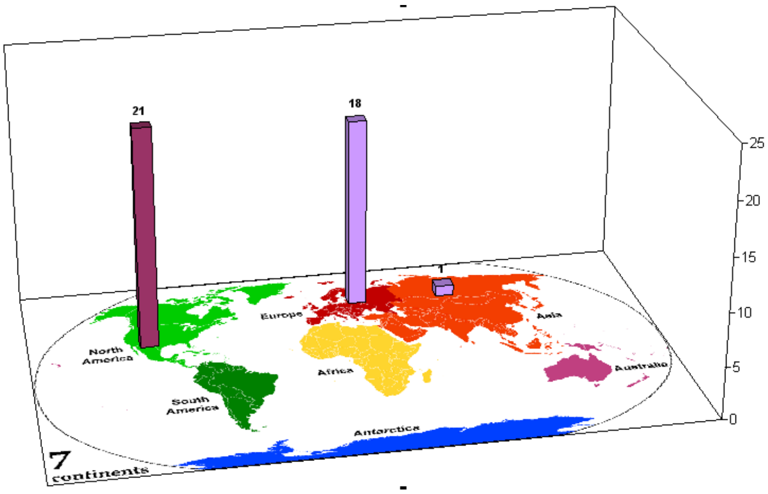


Figure 2.6.8 : Journal or Publisher Origin.

The literature review of software and coding systems is presented by a table in Appendix E.

During and after literature review on software and coding it is clearly realized that there are several software opportunities depending on the decision making methods and problem types. In current study for the crisp data evaluation for the multiattribute decision making *Super Decisions* software is selected. This software is based on ANP method. Moreover *modeFRONTIER* software and/or *MS Excel* is selected for the multi objective analysis.

3. PROPOSED METHOD AND ITS METHODOLOGY

In this chapter, a new generic method for large investment analysis in industry, which is based on multi-objective optimisation and fuzzy multi attribute decision making, shall be explained, furthermore the new generic method shall be illustrated by executing in a special case study. The proposed method has three main phases respectively named as pre-decision phase in which definition and description of investment decision model is executed, decision phase in which collection and analyse of investment decision is executed and post-decision phase in which analyse and conclusion is executed as shown in Figure 3.1. The new algorithm is explained as in the following stages below. In Figure 3.1. AT stands for applied techniques, EG stands for expert group, FI stands for for instance, AS stands for applied software, E stands for expert, I stands for investors.

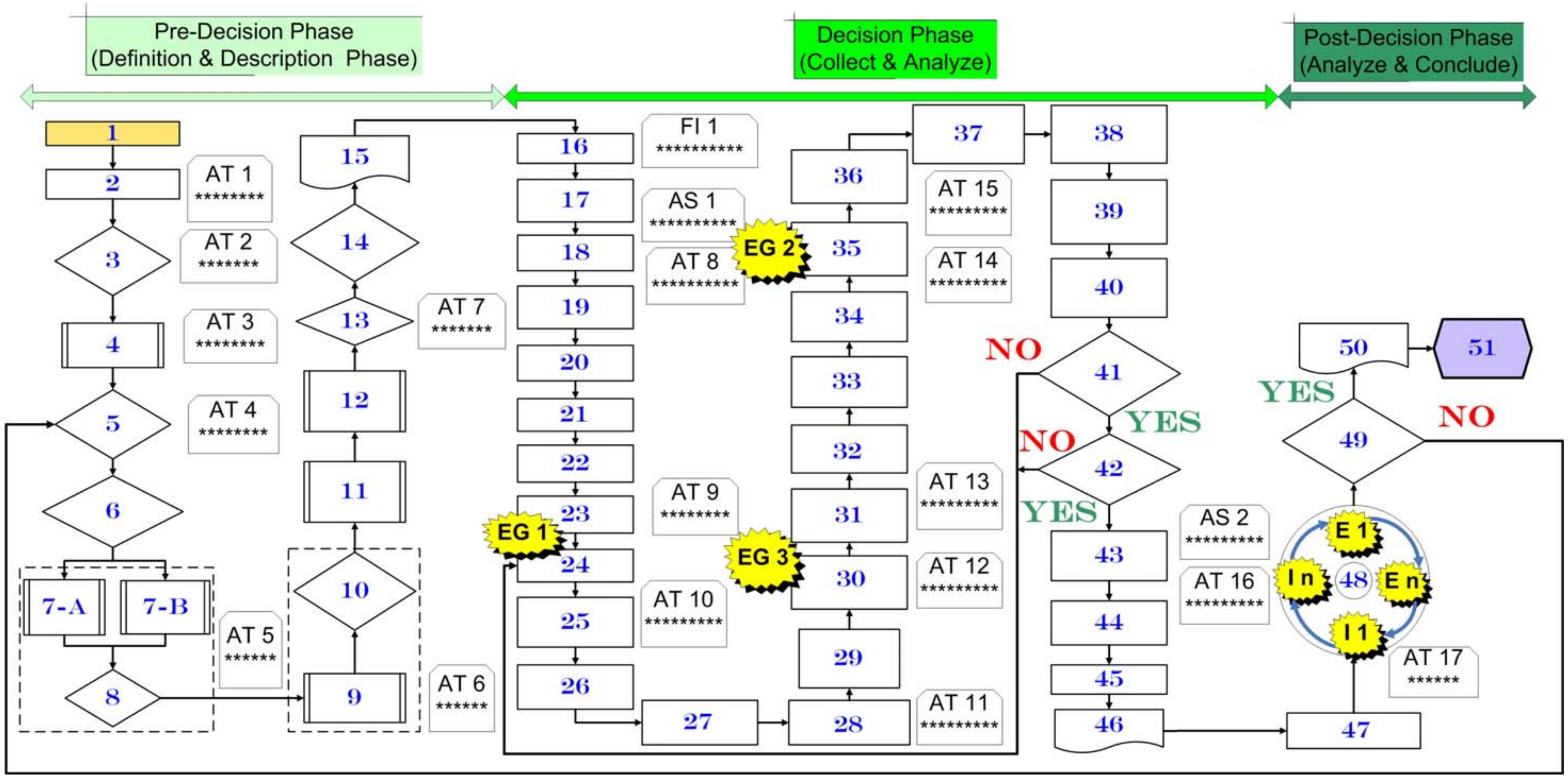


Figure 3.1 : The proposed generic method.

3.1 Pre-Decision Phase

The pre-decision phase has 15 main steps. This phase is started with the notification and intention for and of an investment. This notification and intention for and of the investment necessity, which provokes for the execution of the new generic method for large investment analysis, consistently occurs when the 10-year governmental bond has been fairly stable in the three economic territories which are Euro Area, the United States and Japan as presented in Figure 3.1.1 until 2007. In this stable earning condition, investors start to look for new earning opportunities.

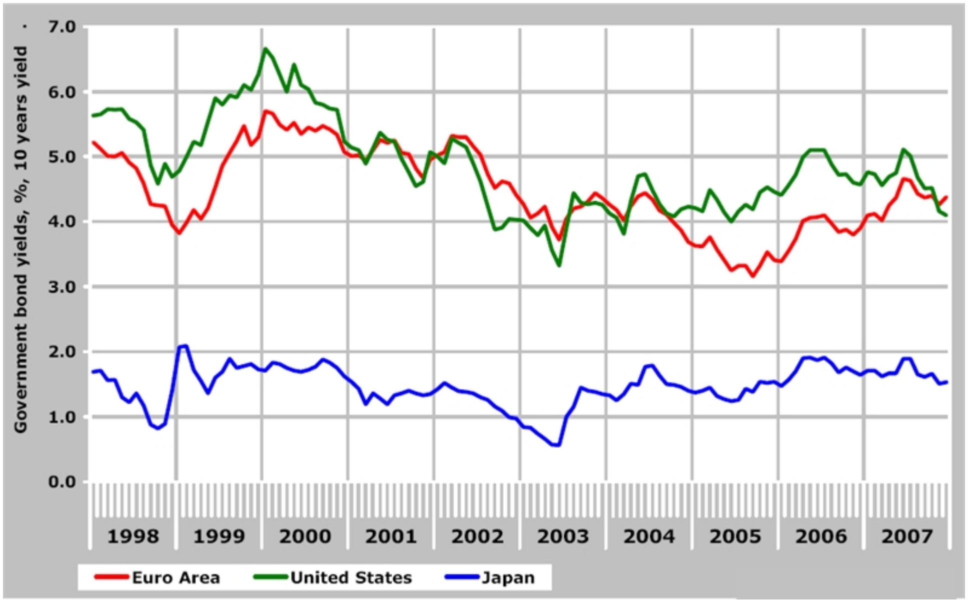


Figure 3.1.1 : 10-year governmental bond, (Source: Shipbuilding Market Forecast No:58).

After this notification and intention for and of the investment necessity, information from several resources for different industries starts to be collected. Generally in this step the information is accumulated by *"by ear"*, mining on news, conferences, forums and several open book resources such as periodical sector magazines. The third step is the selection of the industries, which are on the screen to access in the market. Investors or managers do make their selection in this step by instinctive decision making or emotional decision making. The forth step is the review process of the several sources, which publish, present or distribute the market forecasts of the selected industries. According to the forecasts, the investor or the manager shall select, which industries should be studied in detail and for which industries the model should be run. In this step, in which sector the forecast predicts the major growth respect to total earnings should firstly be selected to be run in the model. If the investors considers to access several industries at the same time or the forecasts for the different industries predicts approximately the same earnings, the model should be run for several industries at the same time. The sixth step is making the decision of the investment whether the investment is a location free investment or location oriented investment. The location oriented investments are the investments, that the location selection is one of the key issues of the investment decision. The location selection affects the performance measures of the legal entity in the location oriented investments. The location free investments are the investments, that the location selection is not important regarding several factors of the investments such as the profitability. Although in some cases the investment is one of a kind of the location oriented investment, if the location is already selected or the location area is already available on the assets of the investors or the legal entity, these investments can be treated as location free investments. The seventh step is generation of location free and location oriented attributes depending on the investment type. During this phase if the investment is related to several legal entities and several professional fields' special techniques should preferably be used. The eight step is the selection of attributes step. In this step any selection method including multi attribute decision making methods can easily be adopted, however the simple, daily decision method is selection of the attributes by the investment analyst from the attribute pool by instinctive decision making, on the other hand the best way is executing the following technique.

One of the special techniques for execution of step 7 and step 8, that could be easily used and adopted to this method was developed by Saracoglu et. al. (2009). In this special technique, there are three main steps. The first main step of this special technique start with a literature survey to sufficiently gather information and enhance knowledge about the factors or attributes in previous studies. All factors, which are found in the literature survey, should be listed by the method of cross tabulation and the frequency tables should be presented. This shall present the common factors that used in different studies and help to overview them with ease. This sub step shall be followed by expert opinions learning by help of in-depth interviews. At least three experts should be chosen and in depth interviews should be performed. All these new information should be recorded. In depth interview results should be summarized and with help of these interviews a questionnaire for the survey should be prepared. At this stage, contact information database for the questionnaire survey should be developed. In addition to these questions in the survey, multiple response variable questions should be asked. By completing this sub-step the first stage is finalized and next step can be started. The second stage starts by sending questionnaires via e-mail to the contacts in the database. Chief executive officers, general managers, strategic development managers, business development managers should be included in this sub-step. The replies can easily be gathered by e-mails. Text mining should be preferred for analyzing of this sub-step. After performing this sub-step with each respondent, informal discussions and interviews by practicing face-to-face talks should be conducted. The interviews should be performed in three cycles, which shall give the respondent to remap his mind about the topics discussed and the factors decided to help to track a scientific, systematic path. In each cycle, on regular basis like a brainstorming team, questions should be reasked to interviewers individually and answers should be collected. By finalizing this sub-step, the next step is started. In the third substage, all factors that are gathered and analyzed in the previous one should be listed by the method of cross tabulation and the frequencies should be devoted the frequency tables. All factors should be studied in detail if one of them is someway-somehow having correlation with another or not. Then each criteria is listed in main groups and subgroups. These factors are once more discussed with experts to gather expert opinions, afterwards the factors are represented by a table to show, which factors are subjective and which are objective. By finalizing this step the special technique is finalized.

The location free attributes pool shall be generated if and only if the investment is a location free investment, the location oriented attributes pool shall be generated if and only if the investment is a location oriented investment. The location oriented attributes pool is usually a superset of the location free attributes pool. There are two types of attributes: subjective attributes and objective attributes. The objective attributes are crisp and identical for all experts of the problem. The ninth step is generation of objectives, parameters, constraints pool. During this phase if the investment is related to several legal entities and several professional fields' special techniques such as literature review, face to face in-depth interviews, text mining and so forth could be used. The tenth step is the selection of objectives, parameters and constraints step. In this step any selection method could easily be adopted, however the simple, daily one is selection of the attributes by the investment analyst from the objectives, parameters and constraints pool by instinctive decision making, on the other hand the best way is executing the following technique. One of the special techniques for execution of step 9 and 10, that could be easily adopted to this method was developed by Saracoglu et. al. (2009). The eleventh step is the cross check step of the objectives, parameters, constraints, attributes step. In investment analysis, there could easily be confusion between attributes and objectives due to the fact of investment analysis nature. Some objectives can easily be treated as attributes because these objectives can also be used for selection of the alternatives. Henceforth the cross check step is one of the important steps. The twelfth step is the generation of the expert pool who will be involved to the decision phase. The thirteenth step is the selection of experts step. In this step, any assignment method could easily be adopted, however the simple, daily one is selection of the expert by the relation of the investment subject and position in the organization by instinctive decision making. The fourtenth step is the decision of investors names, who will attend the investment study. In this step if none of the investors do not want to attend the study and give the whole power to the experts than in the following stages and steps, which is related to investors, these steps should be skiped. The last step is the reporting step which is important for the progress of the second phase.

The pre-decision phase is shown in Figure 3.1.2.

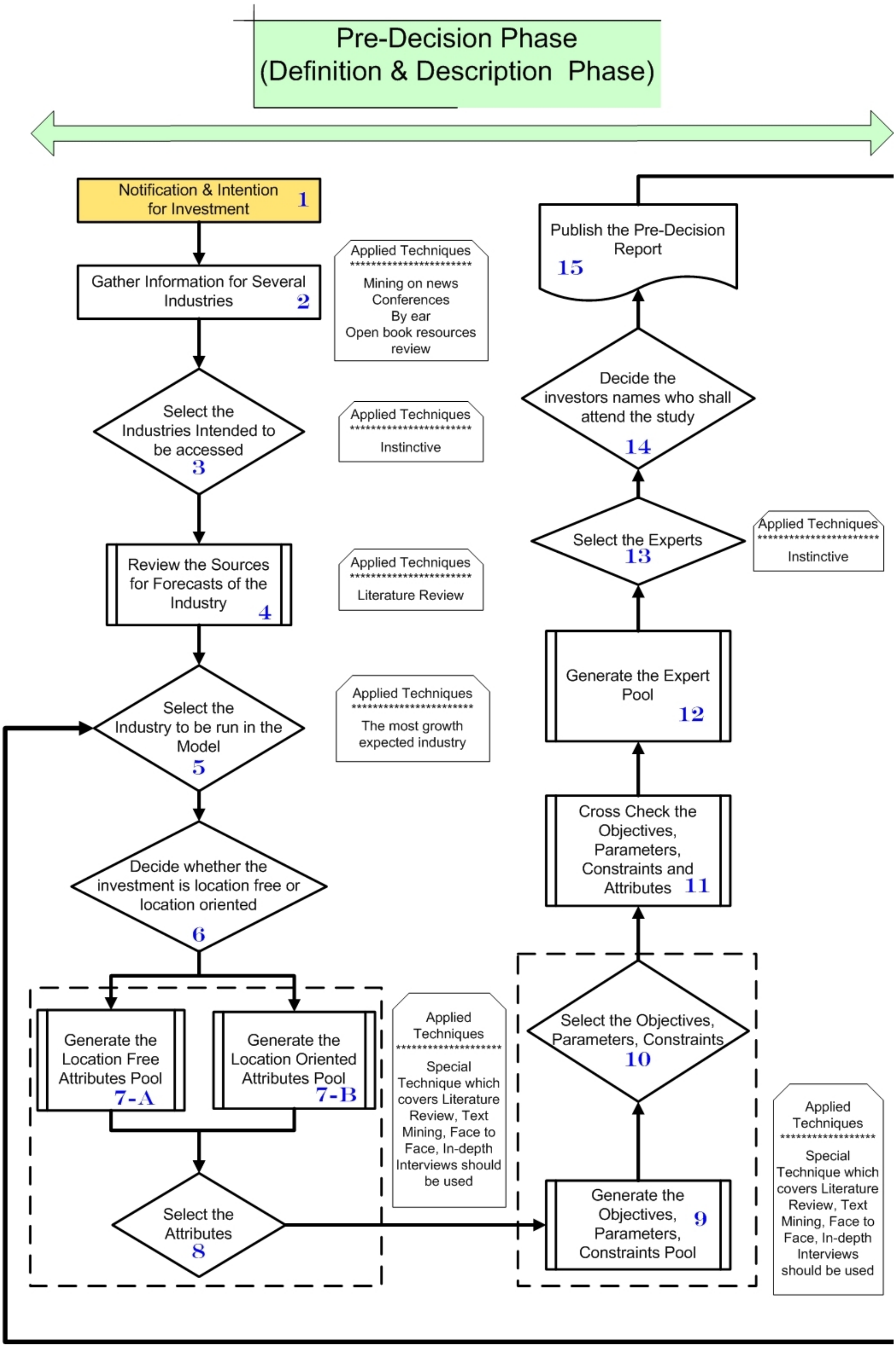


Figure 3.1.2 : The proposed generic method – pre-decision phase.

3.2 Decision Phase

The decision phase has 31 main steps. This phase is started with the collection of data for investment analysis step. In this step, the necessary data such as cost items for cost work breakdown structure (CWBS), data for the depreciation calculations, credibility status of the legal entity or the people from records and banks should be in detail collected. The second step is the filtering of this data and entering into the model and calculations. Sometimes the collected data should not necessarily be entered into the model. This is due to the fact of the capabilities of the hardware and modelling ability of the mediator. The third step is the generation of Pareto optimal design alternatives based on the parameters, the constraints and the objectives, which are defined in the previous phase. The Pareto optimal design alternatives mentality is based on two important, strong, independent mindeds in the current thesis. These are Pareto Optimality and design concept. These terms should be taken in a general global philosophy, certainly not limited to economics or physical plans or so forth. However, in this step physical plans can be created and the Pareto Optimality can be used as in the limits of economics. The current generic method is capable of performing these issues without any diffuculty and it is free from any constraints. These two steps are developed in the current generic method based on Olcer et. al. (2006) study. In this step one of the multi objective optimization software such as modeFRONTIER could be used for modelling and reporting or if the mediator prefers or the investors prefer to adopt MS EXCEL or other softwares, these softwares could also be used. The algorithms, which could be selected from the software package such as modeFRONTIER, are Multi-Objective Genetic Algorithm (MOGA), which has main features as supporting geographical selection and directional cross-over, implementing elitism for multi objective search, enforces user defined constraints by objective function penalization, allowing generational or steady state evolution, allowing concurrent evaluation of independent individuals; or ARMOGA which has main features as implementing range adaptation for efficient search, allowing design table for range adaptation, supporting feasible-infeasible boundary search, FMOGA-II which has main features as supporting geographical selection and directional cross-over, enforcing user defined constraints by objective function penalization, allowing concurrent evaluation of independent individuals. Above these standart algorithms special algorithms according to the software that will be used, could easily be built. The fourth step is the filtering step, in this step the unfeasible, feasible and error table should be presented and Pareto optimal alternatives should be extracted. The fifth step is the assigment of the investors weight by their share power. By this step and the following four steps, the investors direct thoughts on the investment decision shall be provided. The sixth step is the normalization step of the weights. The seventh step is the collection of the investors opinion for each expert. The eight step is the assigning the expert weight according to the investors point of view. In this step comparetively simple methods such as simple additive method should be used. In general the investors do not want to directly involve all the detailed steps on the analysis and the methods, however they do want to involve in short period of time with very simple methods without any disturbing complex questions and with proving their power. The ninth step is the collection of expert opinion for each expert. The best technique for gathering this data is using questionnaires. The information or the pairwise comparison of experts is highly subjective hence fuzzy logic principles should be adopted. The tenth step is the transformation of fuzzy data into fuzzy membership function for each weight assignment of each expert. Triangle fuzzy numbers or other membership functions such as trapezoidal fuzzy numbers could easily be used. Despite the fact that any fuzzy membership functions so any fuzzy numbers could be adopted, in application of the current generic method, in the pairwise comparison of experts, triangular fuzzy numbers to express their preferences are preferred. Comparable to the scale of 1-9 of Saaty (1980) and Mohanty et. al. (2005), a scale of M1 to M9 can be defined for triangular fuzzy numbers.

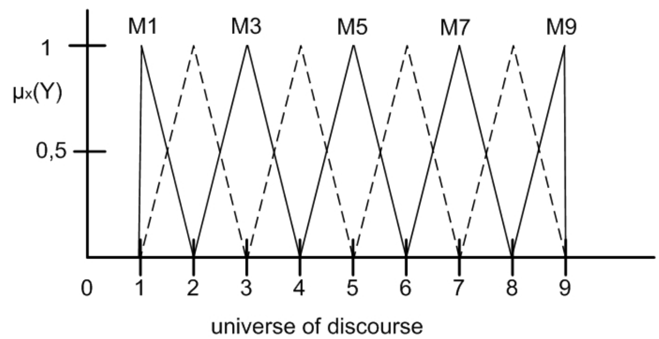


Figure 3.2.1 : Membership functions of the triangular numbers, adapted from (Saaty, 1980 and Mohanty et. al., 2005).

The comparison of expert i with expert j by expert k, a scale of M_1 to M_9 is used such that "M_1 represents equality among the compared experts"; "M_3 represents a moderate preference of i over j"; "M_5 represents a strong preference of i over j"; "M_7 represents a very strong preference of i over j"; "M_9 represents the absolute preference of i over j" (Saaty, 1980 and Mohanty et. al., 2005), where

$M_i = (l_i, m_i, n_i)$, i=1, 2, ………., 9.

The eleventh step is the synthesizing fuzzy membership function and finding the value of the fuzzy synthetic degree, the twelth step is the defuzzifying the synthetic degrees to calculate each weight assignment of each expert. These two steps are developed in the current generic method based on Mohanty et. al. (2005) study as such: "if there are m objects for pairwise comparison in a matrix, m extent analysis values for each object can be obtained as follows:" (Mohanty et. al., 2005)

$X^1_{gi}, X^2_{gi}, X^3_{gi}, \ldots\ldots, X^m_{gi},$ i = 1, 2, 3, 4,………, n where

X^j_{gi} (j = 1, 2, 3,……., m) are triangle fuzzy numbers.

A "synthetic evaluation" is made (Zadeh, 1965 and Zadeh et. al., 1975 and Zadeh, 1976 and Mohanty et. al., 2005). The term "synthetic means the process of evaluation in which several individual elements and components of a matrix are synthesized into an aggregate form" (Zadeh, 1965 and Zadeh et. al., 1975 and Zadeh, 1976 and Mohanty et. al., 2005). The value of the fuzzy synthetic degree with respect to the ith object:

$$D_i = \sum_j^m X^j_{gi} \otimes \left[\sum_i^n \sum_j^m X^j_{gi} \right]^{-1} \qquad \textbf{(3.2.1)}$$

The fuzzy synthetic values for each level of the hierarchy can be obtained using the above definition,

$$D^k{}_i = \sum_{j=1}^n a^k_{ij} \otimes \left[\sum_{i=1}^n \sum_{j=1}^n a^k_{ij} \right]^{-1}, \qquad \text{i = 1, 2, 3, 4,………, n where} \qquad \textbf{(3.2.2)}$$

$D^k{}_i$ are the "fuzzy synthetic degree" values of each element i in the kth level, and $a^k{}_{ij}$ is an element of the fuzzy judgement matrix of the kth element. Afterwards the "synthetic values are defuzzyfied and the weights are obtained" (Zadeh, 1965 and Zadeh et. al., 1975 and Zadeh, 1976 and Mohanty et. al., 2005) by

$$w_i = \frac{l_i + 2m_i + n_i}{4} \qquad \textbf{(3.2.3)}$$

The thirtenth step is comparision of the expert weight of investors and expert weights of experts and adjustment of the expert weights. In this step, the investors' thoughts on experts and experts' thoughts on experts are compared. The final weight of the experts are calculated with the weighted sum of both values. The investors opinions are multipled by an α value and than the sum with the expert weights and the total weight of experts are found. The α value is calculated as the weighted sum of the each investor decision on α value. The fourtenth step is the normalization of the weight of experts to calculate the weight assignment of each expert. By this step the degree of importance of expert E_k (k=1, 2,……., M) is we_k calculated by

$$we_k \in [0,1] \text{ and } \sum_{k=1}^{M} we_k = 1 \qquad \textbf{(3.2.4)}$$

The fiftenth step is the collection of expert opinion for each attribute to assign the relative importance of each attribute. The best technique for gathering this data is using questionnaires. The information or the pairwise comparison of attribute weights is highly subjective hence fuzzy logic principles should be adopted. The sixtenth step is the transformation of fuzzy data into fuzzy membership function for each weight assignment of each attribute. Triangle fuzzy numbers or other membership functions such as trapezoidal fuzzy numbers could easily be used. Despite the fact that any fuzzy membership functions so any fuzzy numbers could be adopted, in application of this generic method, in the pairwise comparison of relative importance of attributes, triangular fuzzy numbers to express their preferences are preferred. Comparable to the scale of 1-9 of Saaty (1980) and Mohanty et. al. (2005), a scale of M1 to M9 can be defined for triangular fuzzy numbers as presented in Figure 3.2.1.

The comparison of attribute i with attribute j by expert k, a scale of M_1 to M_9 is used such that "M_1 represents equality among the compared attributes"; "M_3 represents a moderate preference of i over j"; "M_5 represents a strong preference of i over j"; "M_7 represents a very strong preference of i over j"; "M_9 represents the absolute preference of i over j" (Saaty, 1980 and Mohanty et. al., 2005), where

$M_i = (l_i, m_i, n_i)$, i=1, 2, ……….., 9

The sevententh step is the synthesizing fuzzy membership function and finding the value of the fuzzy synthetic degree, the eightenth step is the defuzzifying the synthetic degrees to calculate each weight assignment of each attribute. These two steps are developed in the current generic method based on Mohanty et. al (2005) study as such: “if there are m objects for pairwise comparison in a matrix, m extent analysis values for each object can be obtained as follows:” (Mohanty et. al., 2005)

X^1_{gi}, X^2_{gi}, X^3_{gi},……………., X^m_{gi},   i = 1, 2, 3, 4,………, n where

X^j_{gi} (j = 1, 2, 3,……., m) are triangle fuzzy numbers. A “synthetic evaluation” is made. The term synthetic means “the process of evaluation in which several individual elements and components of a matrix are synthesized into an aggregate form” (Zadeh, 1965 and Zadeh et. al., 1975 and Zadeh, 1976 and Mohanty et. al., 2005). The value of the fuzzy synthetic degree with respect to the ith object is calculated by applying Equation (3.2.1).

The fuzzy synthetic values for each level of the hierarchy can be obtained using the above definition, by applying Equation (3.2.2).

D^k_i are the “fuzzy synthetic degree” values of each element i in the kth level, and a^k_{ij} is an element of the fuzzy judgement matrix of the kth element. Afterwards the “synthetic values are defuzzyfied and the weights are obtained” (Zadeh, 1965 and Zadeh et. al., 1975 and Zadeh, 1976 and Mohanty et. al., 2005) by applying Equation (3.2.3).

The nineteenth step is the normalization of the weight of attributes to calculate the weight assignment of each expert. By this step the degree of importance of attribute A_k (k=1, 2,……., M) is wa_k calculated by

$$wa_k \in [0,1] \text{ and } \sum_{k=1}^{M} wa_k = 1 \qquad \textbf{(3.2.5)}$$

The twentyth step is the collection of each expert opinion for each PODA with respect to each objective attributes. The best technique for gathering this data is using questionnaires. The twenty first step is the collection of each expert opinion for each PODA with respect to each subjective attribute. The best technique for gathering this data is using questionnaires. The information or the pairwise comparison of expert opinion for each PODA with respect to each subjective attribute is highly subjective hence fuzzy logic principles should be adopted. The twenty second step is the transformation of fuzzy data into fuzzy membership function for each expert opinion for each PODA with respect to each subjective attribute. Triangle fuzzy numbers or other membership functions such as trapezoidal fuzzy numbers could easily be used. Despite the fact that any fuzzy membership functions so any fuzzy numbers could be adopted, in application of this current generic method, in the pairwise comparison of relative importance of attributes, triangular fuzzy numbers to express their preferences are preferred. Comparable to the scale of 1-9 of Saaty (1980) and Mohanty et. al. (2005), a scale of M1 to M9 can be defined for triangular fuzzy numbers as presented in Figure 3.2.1.

The comparison of expert opinion for PODA i with expert opinion for each PODA j by expert k with respect to each subjective attribute, a scale of M_1 to M_9 is used such that "M_1 represents equality among the compared attributes"; "M_3 represents a moderate preference of i over j"; "M_5 represents a strong preference of i over j"; "M_7 represents a very strong preference of i over j"; "M_9 represents the absolute preference of i over j" (Saaty, 1980 and Mohanty et. al., 2005), where

$M_i = (l_i, m_i, n_i)$, i=1, 2, ………., 9

The twenty third step is the synthesizing fuzzy membership function and finding the value of the fuzzy synthetic degree, the twenty fourth step is the defuzzifying the synthetic degrees to calculate each weight assignment of each attribute. These two steps are developed based on Mohanty et.al (2005) study as such: "if there are m objects for pair-wise comparison in a matrix, m extent analysis values for each object can be obtained as follows:" (Mohanty et. al., 2005)

$X^1_{gi}, X^2_{gi}, X^3_{gi}, \ldots\ldots, X^m_{gi},$ i = 1, 2, 3, 4,………, n where

X^j_{gi} (j = 1, 2, 3,……., m) are triangle fuzzy numbers. A "synthetic evaluation" is made. The term synthetic means "the process of evaluation in which several individual elements and components of a matrix are synthesized into an aggregate form" (Zadeh, 1965 and Zadeh et. al., 1975 and Zadeh, 1976 and Mohanty et. al., 2005). The value of the fuzzy synthetic degree with respect to the ith object is calculated by applying Equation (3.2.1).

The fuzzy synthetic values for each level of the hierarchy can be obtained using the above definition, by applying Equation (3.2.2).

D^k_i are the "fuzzy synthetic degree" values of each element i in the kth level, and a^k_{ij} is an element of the fuzzy judgement matrix of the kth element. Afterwards the "synthetic values are defuzzyfied and the weights are obtained" (Zadeh, 1965 and

Zadeh et. al., 1975 and Zadeh, 1976 and Mohanty et. al., 2005) by applying Equation (3.2.3).

The twenty fifth step is the normalization of the expert opinion for each PODA of subjective attribute to calculate the weight assignment of expert opinion for each PODA. By this step the degree of importance of each PODA for each subjective attribute $PODA_{ik}$ (i=1, 2,……., M, k=1, 2,……., N) is $wpoda_{ik}$ calculated, where

$$wpoda_{ik} \in [0,1] \text{ and } \sum_{i=1}^{M}\sum_{k=1}^{N} wpoda_{ik} = 1. \qquad \textbf{(3.2.6)}$$

The twenty sixth step is the decision step, whether all necessary data are gathered or not. If this data is not gathered than the study should be restarted from the pre-decision stage if the data are gathered than the study should be moved one step for the twenthy seventh step, which is the control step, whether all data are crisp data or not. If any data is not crisp than the defuzzyfication and normalization steps should be performed. If all data are crisp data than the next step should be followed. The twenthy eight step is building the ANP model. The twenthy nineth step is finding the overall ranking values for PODAs followed by the thirtyth step, which is ranking PODAs by the OARs. In these steps, ANP softwares such as Super Decisions can easily be used. The last step in this phase is the publishing of the decision phase report. In this step the final results are calculated by Equation 3.2.7. The overall OAR of each industry, which is taken into consideration or which is studied, is calculated by weight of each case for each industry which is appointed by decision makers, the OAR of each PODA for each industry, which is taken into consideration or which is studied, is calculated as presented by Equation 3.2.7, which is adapted from and by the simple additive method mentality as formulated by Equation 3.2.7.

$$Overall_{OARindustry} = \frac{w_{case_i - industry} * OAR_{PODAs-industry}}{\sum_{industry=0}^{industry=1} w_{case_i - industry} * OAR_{PODAs-industry}} \qquad \textbf{(3.2.7)}$$

The decision phase is shown in Figure 3.2.2.

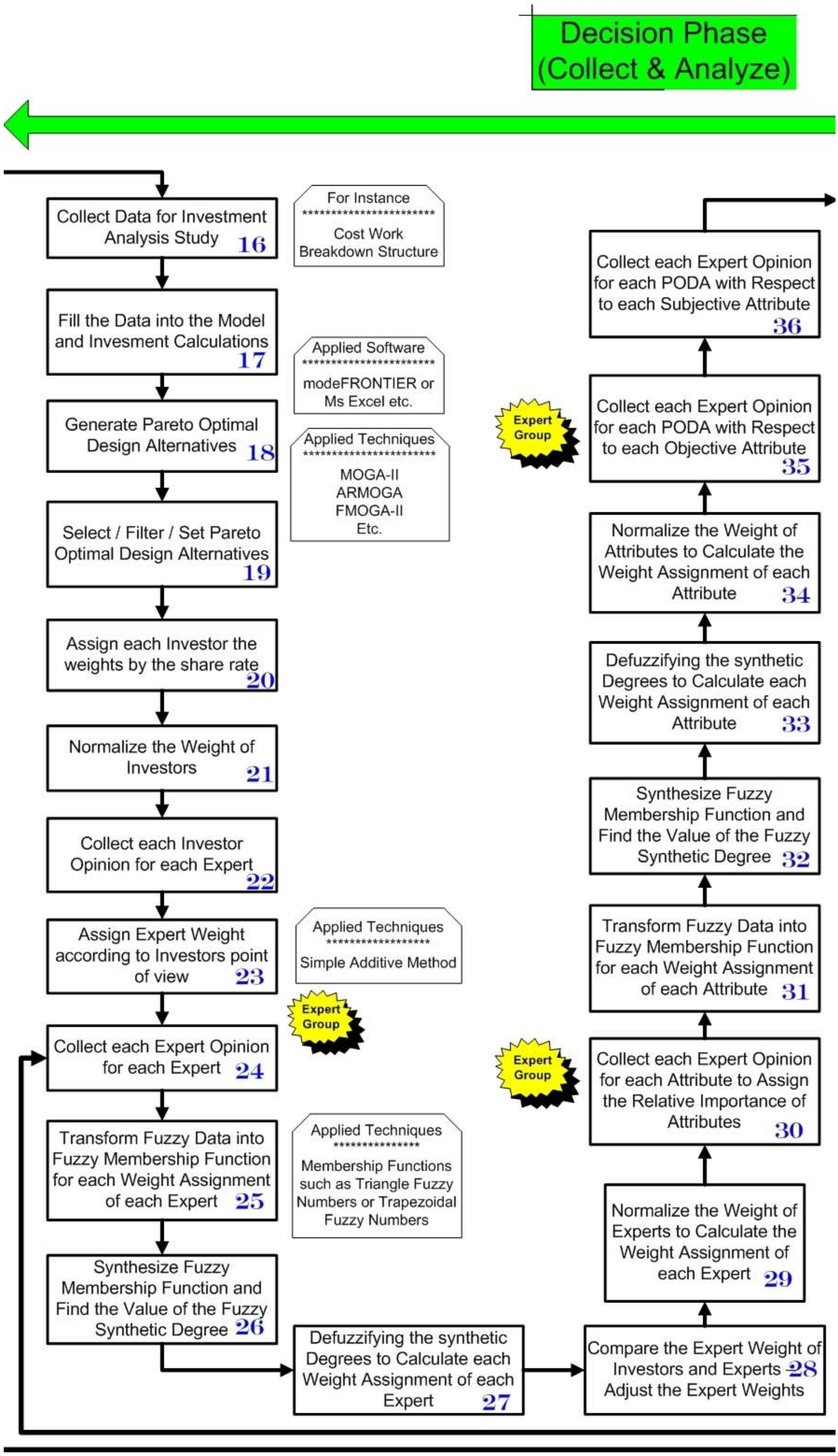


Figure 3.2.2 : The proposed generic method–decision phase (left side).

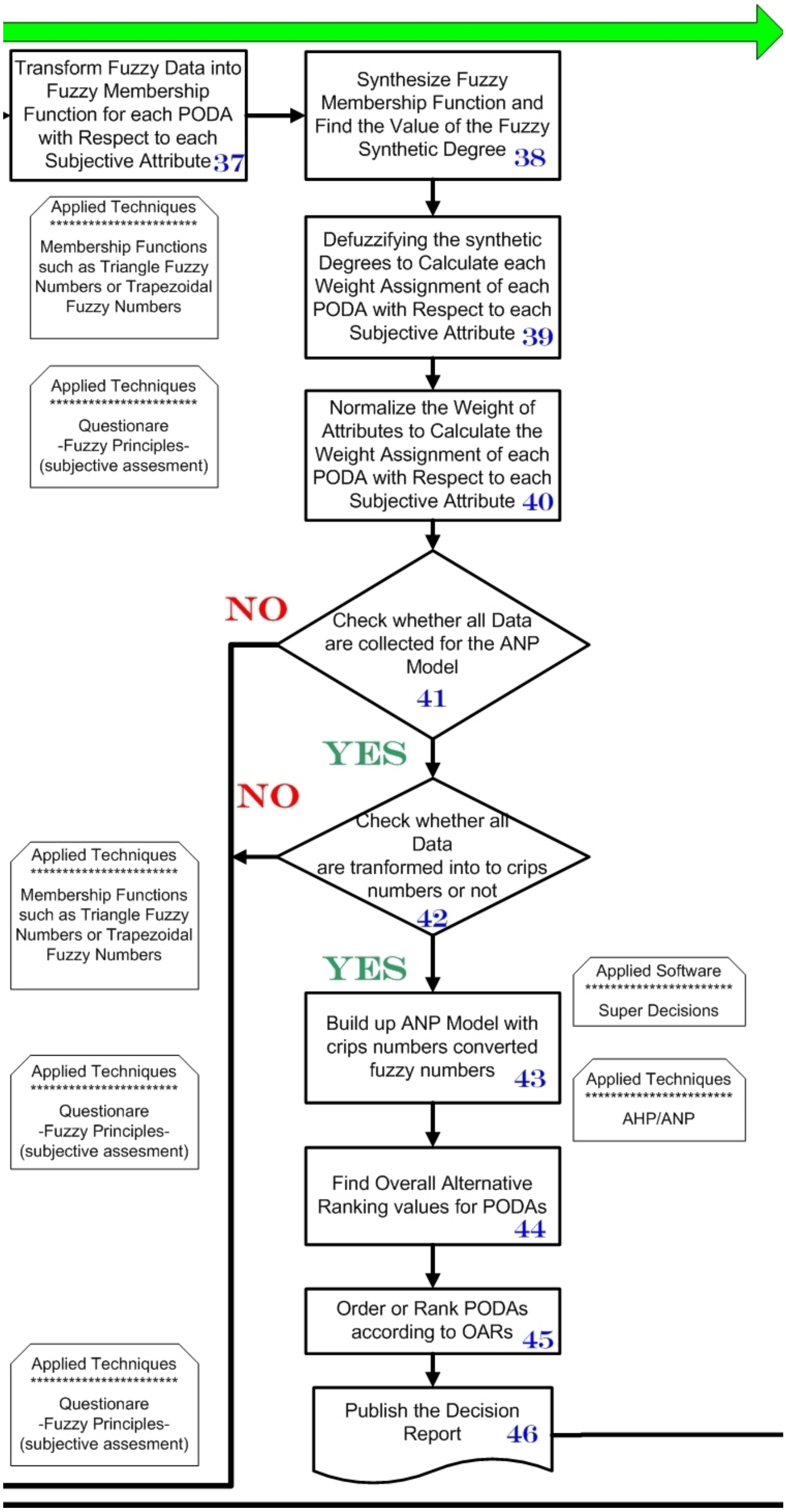


Figure 3.2.2 (continued) **:** The proposed generic method–decision phase (right side).

3.3 Post-Decision Phase

The post-decision phase has 5 main steps. The first step is sending the decision report to investors and experts. This step should preferably performed by e-mailing or other electronic data transfer systems. In the second step, the experts and investors should hold a meeting about the decision report. If there is geographical diversity, which usually does, then video conferencing or e-mail circulation should be done for the final decision. The third step is the consensus decision step. If the consensus is not achieved than the study should be turned back the pre-decision phase and another industry should be selected and run in the model. If the consensus is achieved than the post-decision report should be published in the fourth step. The final step, which is also the final step of all phases, is the starting of the investment according to the decision step. The post-decision phase is shown in Figure 3.3.1.

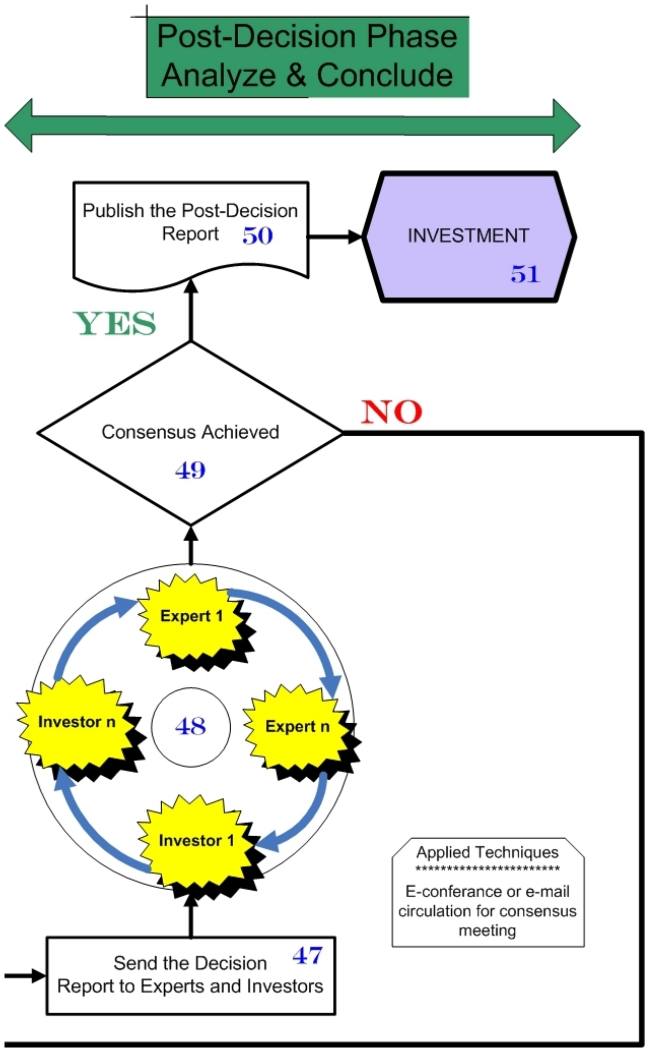


Figure 3.3.1 : The proposed generic method – post - decision phase.

4 CASE STUDIES

This chapter is aimed to demonstrate that the proposed method can be applied to real world investment decisions in shipbuilding industry and other industries such as port and logistics industry or energy industry, which can be characterized as mega-project and mega-investment industries. The current case study is aroused from a feasibility evaluation of Gelibolu Gemi Endustrisi Sanayi ve Ticaret A.S., that is the name of a legal entity of a planned shipyard in Turkey and a virtual feasibility evaluation of a virtual entity of a port and ship repair yard named as Virtual Gelibolu PORREP.

Case Study: "Gelibolu Gemi Endustrisi Sanayi ve Ticaret A.S." and Virtual Gelibolu PORREP Investment Analysis

Step 1: Notification and intention for investment

The investors have been systematically tracking the markets in world wide. The most common indicator for them is the 10-year governmental bond for them. The rates have been stable between 2003 and 2007 as shown in Figure 3.1.1. In Figure 4.1 the recent global interest rates for 10-year government bond is shown. Indonesia has the highest, Japan has the lowest rates. The US has the 8^{th} lowest rate out of the 29 countries. The average of 10-year governmental bond of each country and the maximum and the minumum of these data is the key indicators for the economic stiuation of the world. One of the important issues is the 10-year governmental bond yield of the country that the investors consider to invest to. According to this information the lower the 10-year governmental bond the more attractive the real sector invesment is. Hence according to this rule of thumb Japan, Singapore, Taiwan is highly unlikely to be the non-attractive real sector investment countries. However it should not be forgotten that the 10-year governmental bond yield is not the only indicator for the investment condition of a country.

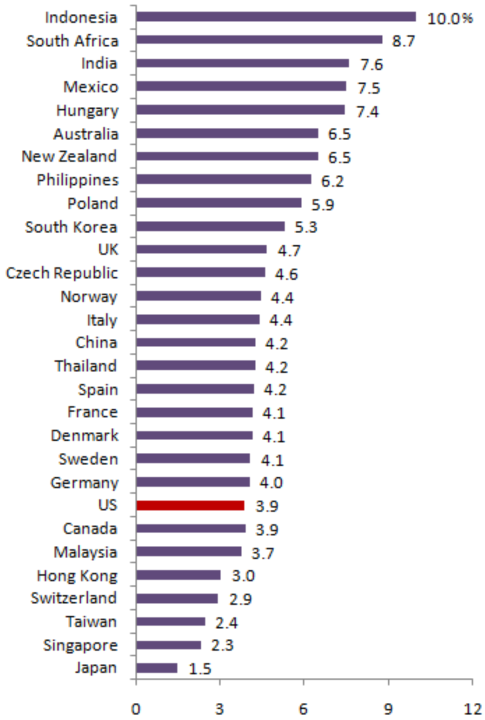


Figure 4.1 : Current 10 year governmental bond yields, (Source: Url-10).

The estimation of the economists is also gathered as shown in Figure 4.2. The most expected rise in government bond yields are in China by the end of 2008. In the US, the expectation is the slightly higher rate than current levels.

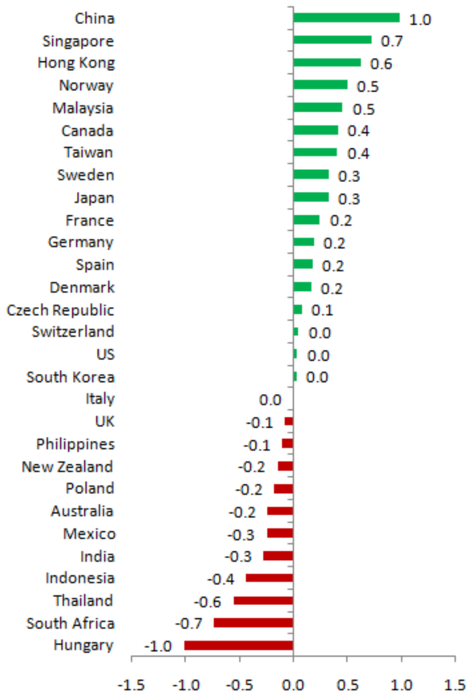


Figure 4.2 : Estimated change in 10 year by year end, (Source: Url-10).

Moreover, the capital is cheap with the given lower interest rates, particularly in the U.S. but also to some extent in Europe as shown in Figure 4.3.

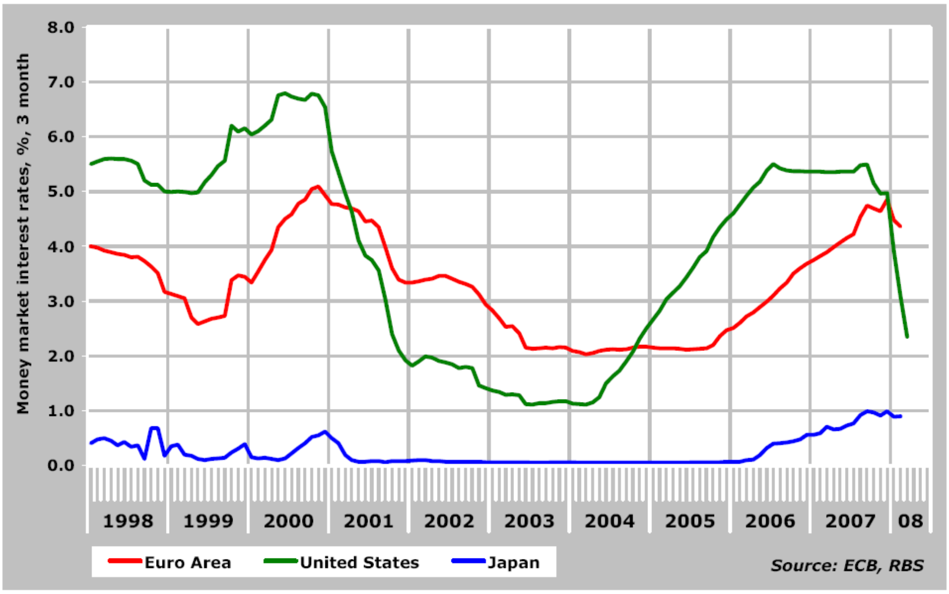


Figure 4.3 : Short term interest rates, (Source: Shipbuilding Market Forecast Issue No.61, May 2008).

In this stable earning condition and low capital interest rates, the investors have been looking for new earning opportunities.

Step 2: Gather information for several industries

After notification and intention, investors and/or their managers have been gathered information from several resources. All share holders are closely related with steel, shipping and shipbuilding industry. In addition to friendship related information gathering such as conversations at dinners or lunches, the conferences and forums are the main sources of this step. The investors of the Gelibolu Gemi Endustrisi Sanayi ve Ticaret A.S. have been used all kinds of information sharing tools such as official and unofficial dinners or lunches, attending to conferences and forums, being subscribed to periodical sector magazines. For instance one of the shareholders of the entity attended to Marine Money Istanbul 2008. Jefferies Shipping Conference, The Ferry Shipping Conference, Artic Shipping Conference, Capital Link Annual Shipping Conference, Short Sea Shipping Conference in Shipping Industry, Posidonia, Lloyd's List Events International Shipbuilding Conference, The Intelligent Shipbuilding Conference & Expo in Shipbuilding Industry, Solar Taiwan, World Resource Investment Conference, International Conference on Construction and Building Technology, Euromoney Turkey Finance & Investment Forum, Energy Talks Ossiach 08, Project Management for Utility Capital Projects in Energy

Industry, Port Finance & Investments are some conferences that can be attended by the investors or managers.

Step 3: Select the industries intended to be accessed

The investors selected to access only the shipbuilding industry due to the fact of the market conditions and familiarity to the sector. Moreover the products were also selected according to the Turkish shipbuilding conditions and capability.

The tankers and bulkers are the main product segments of the shipyard. Hence the shipyard shall be designed and operated according to the principles of the tankers and bulkers product segment.

Although the investors only considered to invest in the shipbuilding industry, according to the decision of case study mediator, a virtual analysis for the port industry mixed with ship repair industry was also accepted as the industries to be accessed in.

Step 4: Review the sources for forecasts of the industry

The shipbuilding industry forecasts especially tankers records and forecasts; bulkers records and forecasts should be reviewed in detail.

In order to analyze the shipbuilding industry some forecasts from other industries such as shipping industry were in detail studied.

The necessary data and figures for the case study in this content are presented in Appendix F.

The virtual analysis data (virtual port and ship repair yard entity) was also gathered.

The necessary data and figures for the case study in this content are also presented in Appendix F, however not all of the information and data is presented in the thesis.

Step 5: Select the industry to be run in the model

The shipbuilding industry was selected to be run in the model by the investors. None of the other industries were selected by investors to be run in the model. The case study mediator recommended and selected port and ship repair sector as the industries that were selected to be invest in by/to investors.

Step 6: Decide whether the investment is location free or location oriented

The headquarters and the shipyard location were already bought by the investor so that this area is private owned land.

The headquarters is in Istanbul and the shipyard is in Gelibolu. The location of the shipyard is shown by Figure 4.4 – Figure 4.5. Hence the investment is the location free investment. The virtual investment will also be based on this location. The virtual entity PORREP and its main design aspect is shown by Figure 4.6. The location of current ports and the PORREP location is shown in Figure 4.7.

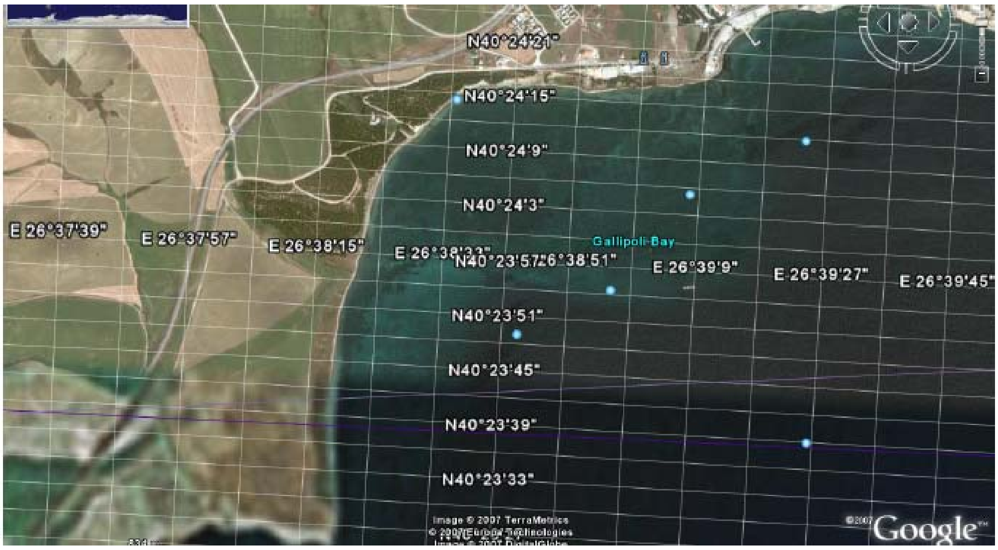


Figure 4.4 : Gelibolu gemi endustrisi sanayi ve ticaret A.S shipyard location, (Source: Google Earth).

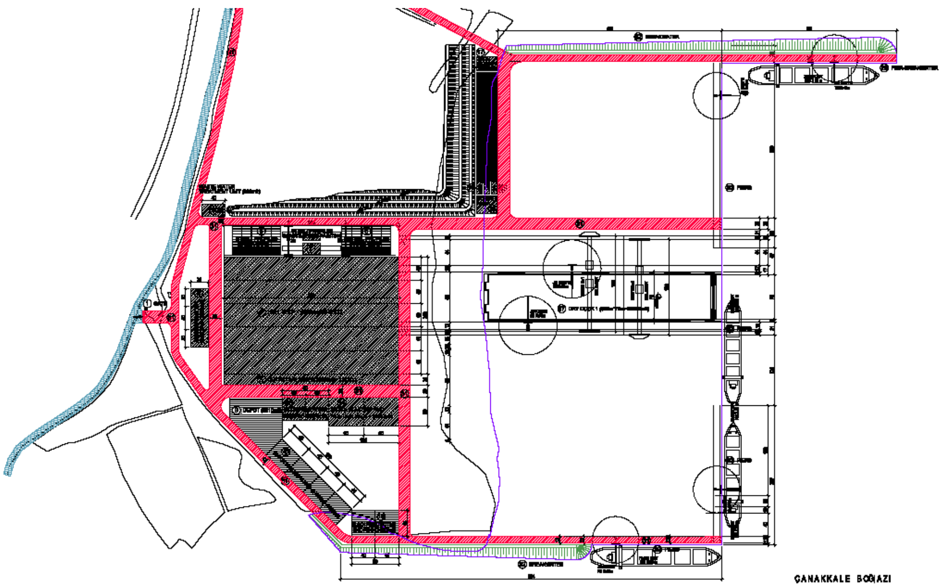


Figure 4.5 : Gelibolu gemi endustrisi sanayi ve ticaret A.S shipyard location.

Figure 4.6 : PORREP location - only port design & its main design aspect presented, adapted from (Vickerman, 2006 and Goethe, 2008).

Figure 4.7 : PORREP location & location of current ports in Turkey, adapted from (Turkish Undersecretariat for Maritime Affairs, 2008).

Step 7 A: Generate the location free attributes pool

The attributes pool was generated as shown in Figure 4.8.

These are after-tax profit margin, AGI (Adjusted Gross Income), APV (Adjusted Present Value), ATOI (After Tax Operating Income), B/C (Benefit Cost Ratio), CFPS (Cash Flow per Share), DCF (Discounted Cash Flow), EBT (Earnings Before Taxes), EBIT (Earnings Before Interest and Taxes), EBIDA (Earnings Before Interest, Depreciation and Amortization), EBITD (Earnings Before Interest, Tax and Depreciation), EBITDA (Earnings Before Tax Interest, Depreciation and Amortization), EBITAE (Earnings Before Interest, Tax, Amortization and Exceptional Items), EBITDARM (Earnings Before Interest, Taxes, Depreciation, Amortization, Rent and Management Fees), EVA (Economic Value Added), FCF (Free Cash Flow), FCFE (Free Cash Flow to Equity), FCFF (Free Cash Flow for the Firm), FCFPS (Free Cash Flow per Share), FCFY (Free Cash Flow Yield), gross income, gross earnings, gross margin, IFO (Income from Operations), IRR (Internal

Rate of Return), MIRR (Modified Internal Rate of Return), net sales, net margin, NI (Net Income), NOI (Net Operating Income), NOPAT (Net Operating Profit after Taxes), NPV (Net Present Value), OCF (Operating Cash Flow), OPEX (Operating Expenses), operating income, operating margin, payback period, PEG payback period, profit margin, profitability index, REVs (Revenue), revenue per employee, ROIC (Return on Investment Capital), SVA (Shareholder Value Added), taxable income, net income, total revenue, total net income, rantability, total EBITDA, average revenue, average net income, ease of funding, ease of joint venturing ability, ease of mergering ability.

Figure 4.8 : Location free attributes pool.

Step 8: Select the attributes

The attributes were selected as:

The total EBITDA (Earnings Before Tax Interest, Depreciation and Amortization) which should have been calculated based on economic life of the shipyard and PORREP (economic life of each investment should be same or replacement model and replacement analysis should have been performed to make the economic life of each investment same), average net income which should have been calculated based on economic life of the shipyard and PORREP, payback period which should have been calculated based on economic life of the shipyard and PORREP, rantability which should have been calculated based on economic life of the shipyard and PORREP, ease of credit funding as shown in Table 4.1.

Table 4.1: Attributes' properties

	Attribute properties		
Attributes	Type of assessment	Type of attribute	
Total EBITDA	Crisp	Benefit	Objective
Average Net Income	Crisp	Benefit	Objective
Payback period	Crisp	Cost	Objective
Rantability	Crisp	Benefit	Objective
Ease of Credit Funding	Linguistic	Benefit	Subjective

Step 9 & Step 10: Generate objectives, parameters, constraints pool & Select the objectives, parameters, constraints

The objectives, parameters and constraints pool were generated and selected.

The first objective is net present value which has to be investigated in the financial analysis of long term projects. In Table 4.2 three options of the net present value are presented.

Table 4.2 : Net present value conditions

If	It means	Then
NPV > 0	The investment has an added value to the firm.	The project may be accepted
NPV < 0	The investment has a negative affect and subtracted value from the firm.	The project should be rejected
NPV = 0	The investment has neither added value nor subtracted value for the firm	The project has no financial gain; the project should be selected according to other factors.

As shown in the Table 4.2 when the net present value is positive the investment can be done or selected according to the other factors conditions. While the net present value is negative, the investment should not be performed in any case. If the net present value equals to zero than the investment can be selected according to other factors conditions. In this objective it should be worthwhile to mention that the larger the net present value does not prove that it is better than the smaller value of the net present value invesment.

Hence the first objective is NPV ≥ 0 (net present value should be equal to or bigger than zero). The maximum of NPV, the most attractive it is.

The second objective is internal rate of return which is a capital budgeting metric highly preferred by firms during decision phase of any investments. In Table 4.3 three options of the internal rate of return are presented.

Table 4.3 : Internal rate of return conditions.

If	It means	Then
IRR > MARR	The investment has an added value to the firm.	The project may be accepted
IRR < MARR	The investment has a negative affect and subtracted value from the firm.	The project should be rejected
IRR = MARR	The investment has neither added value nor subtracted value for the firm	The project has no financial gain; the project should be selected according to other factors.

Hence the second and final objective is IRR ≥ MARR (internal rate of return should be equal to or bigger than minimum attractive rate of return). The maximum of IRR, the most attractive it is.

The first constraint is technology level of the shipyard. There are five major changes so five generations of shipyards according to the steel welding process. (First Marine International Limited, 2000). In current study, the shipyards are divided into six different generations. These generations are

- First Generation Shipyard: ”One of piece-part building was the main construction philosophy of this generation of shipyard. Multiple open inclined slipways or inclined berths were preferred. Large workforce had been employed. Only steel hulls had been launched and afterwards for outfitting purposes towed to quay. Steel manufacturing facilities and outfitting facilities were separated” (First Marine International Limited, 2000). The first generation shipyard is shown in Figure 4.9.

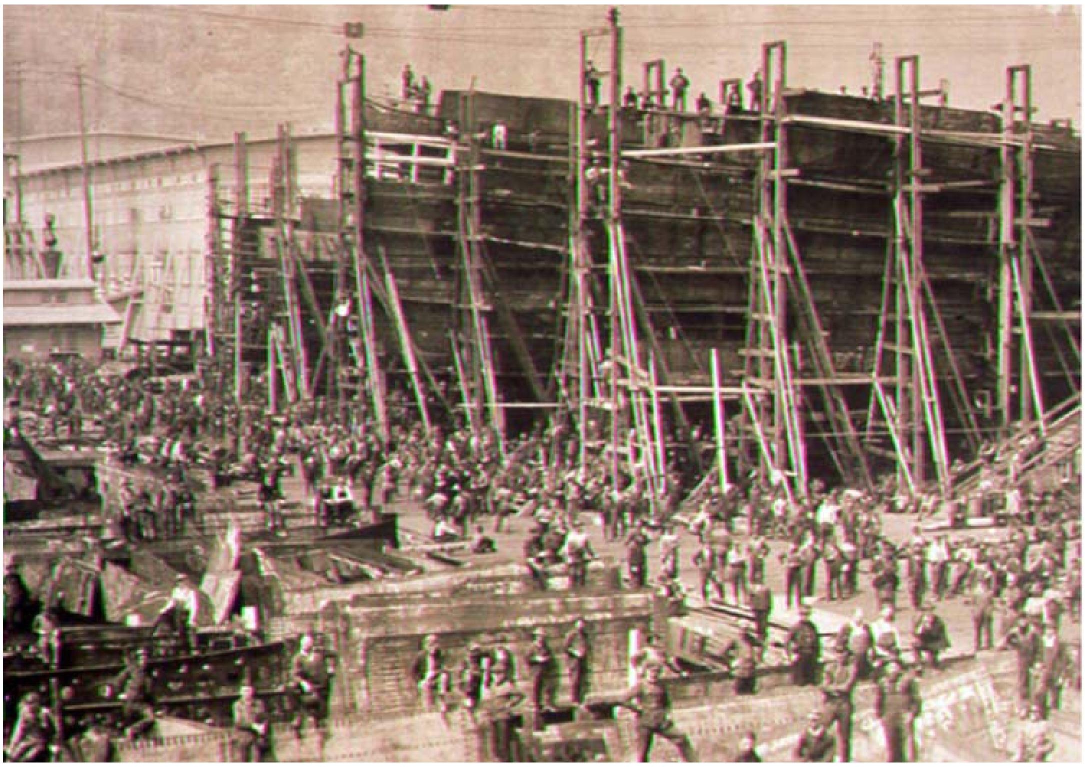


Figure 4.9 : First generation shipyard, (Source: Pacific Northwest Shipyard, Wikipedia).

- Second Generation Shipyard: “The construction philosophy was changed from one of piece-part building to a unit or block building. The number of building berths decreased and two or three building berths were preferred. Large buildings were used for much of the assembly work. However only limited amount of outfitting could be installed prior to launch. Steel manufacturing facilities and outfit facilities were still separated. Outfitting shops were generally located adjacent to quay” (First Marine International Limited, 2000). The second generation shipyard is shown in Figure 4.10.

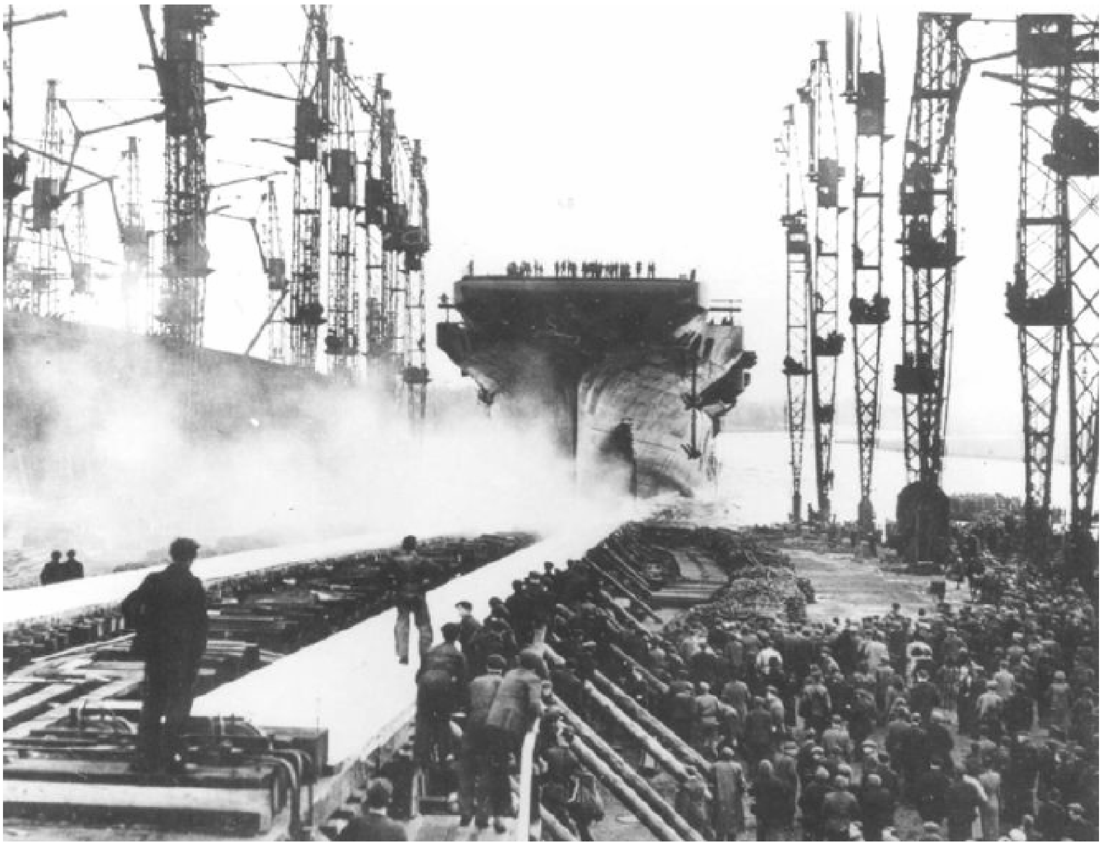


Figure 4.10 : Second generation shipyard, (Source: HMS Indefatigable launching ceremony, Wikipedia).

- Third Generation Shipyard: “The steel manufacturing facilities and the outfitting facilities were still separated. The block mentality in the hull production became mechanized. The first application of the process lines were introduced specially for the midship portion. Hull blocks became larger. Numbers of building berths were reduced. The total construction time was reduced. The pre-outfitting activities were increased. The first application of pre-outfitting activities on blocks was introduced” (First Marine International Limited, 2000).

- Fourth Generation Shipyard: “Steel manufacturing facilities and outfit facilities were still separated. The automation in steel manufacturing was increased. In stead of single production line, several process lines were preferred. These process lines were located under a single roof which makes the shipyard look like a factory. Blocks became much larger. The pre-launch outfitting activities were maximized. The modularization of outfitting was used first time in the history. Construction cycle times were reduced” (First

Marine International Limited, 2000). The fourth generation shipyard is shown in Figure 4.11.

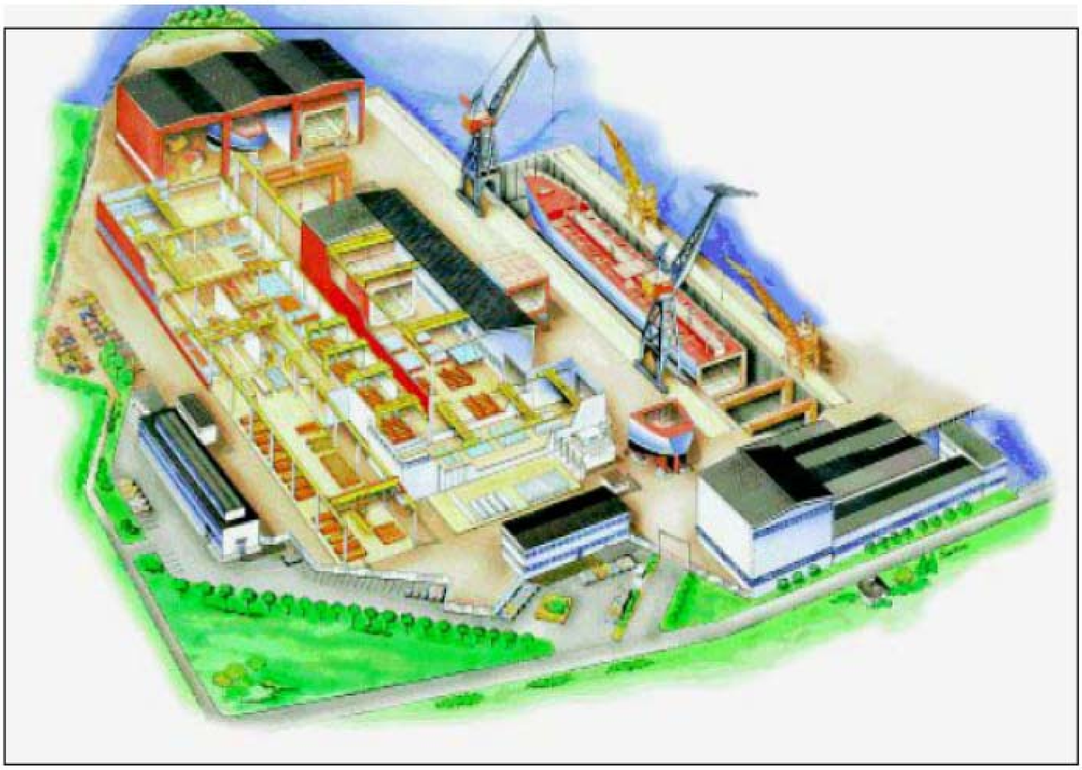


Figure 4.11 : Fifth generation shipyard, (Source: First Marine International Limited, 2000).

- Fifth Generation Shipyard: "This generation of shipyard is still in logic phase or imagination phase. Product oriented philosophy is planned to be adopted. Previous shipyard generation focused on very narrow product range with maximizing efficiency and minimizing cycle times. This shipyard generation is planned to adopt standard interim products and by this philosophy plan to be capable of building a wide variety of end products with the same efficiency and cycle time levels. Steel manufacturing facilities and outfit facilities are fully integrated" (First Marine International Limited, 2000).

- Unclassified - Special Generation Shipyard: There have been some shipyard designs and applications which can not be classified under one of the generations defined above. One of the appropriate examples of this generation is ROTAS (Rotating and Sliding System). This system was adopted in Mitsui Shipbuilding & Engineering Co., Ltd. as shown in Figure 4.12.

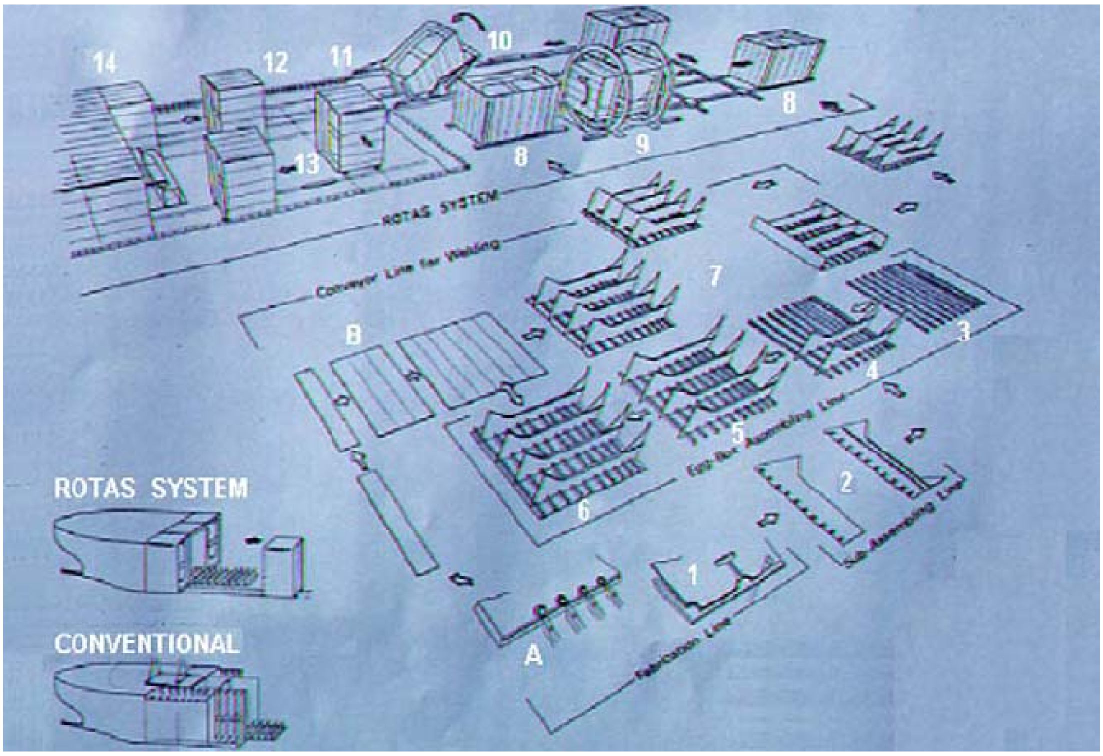


Figure 4.12 : ROTAS, (Source: Url-11).

The first constraint, the technology level or the generation of shipyard effect all production levels, delivery levels, operational expenses, learning curve estimations and so forth, so that all income statements and cost statements.

The first constraint for the virtual PORREP is also the technology level and the design aspects of the shiprepair yard and the port. In the port design *intermodallity* philosophy is taken into consideration. In the virtual PORREP, there is one state of the art container terminal and one state of the art bulker port (liquid and dry bulk). The state of art container terminal is designed based on *container ship-in-a-slip concept and logistics park concept (including intermodal transfer yards)* and the main design dimensions and aspects are taken from *Kitakyusyu Port Hibiki Container Terminal* and *Yangshan Deep Port Logistics Park*. The container terminal is designed to serve vessels start from *Ideal X* upto *Malaccamax*. The state of art bulker port (liquid and dry bulk) is designed based on the main design dimensions and aspects of *Iqaluit Deepwater Port Project*. The repair yard is designed at two segments as to serve upto 100.000 DWT vessels and to serve more than 100.000 DWT vessels.

Hence the first constraint is the generation of the shipyard and in current case this is fourth generation shipyard. The virtual entity is also designed according to state of the art technology.

The second constraint is the total budget constraint. The investors have held several meetings with different financial entities and with different groups on this issue and decided a total budget as 400 mil. USD.

Hence the second constraint is Total Budget = 400 mil. USD (the total budget is four hundred million US Dollars). The budget of both entities are same.

The third constraint is the capital percentage constraint. The investors have held several meetings with different financial entities and decided that the capital percentage of the investment should not be more than 40%.

Hence the third constraint is capital percentage ≤ 40 % of total investment budget (the capital percentage should be less than or equal to forty percent of total investment budget). This constraint is same for both entities.

The first parameter is VAT (value added tax) parameter. The VAT is assumed to be 0.

Hence the first parameter is VAT = 0 % (the value added tax is zero percent). This constraint is same for both entities.

The second parameter is depreciation method parameter. The depreciation method is selected as straight line depreciation.

Hence the second parameter is depreciation method parameter and it is straight line depreciation. This constraint is same for both entities.

The third parameter is the economic life span of the shipyard and the PORREP parameter. The economic life span of the shipyard and the PORREP is selected as 49 years.

Hence the third parameter is the economic life span of the shipyard and the PORREP and it is 49 years. This constraint is same for both entities.

The fourth parameter is the capital recovery period parameter. The capital recovery period is selected as 5 years.

Hence the fourth parameter is the capital recovery period and it is 5 years. This constraint is same for both entities.

The fifth parameter is the depreciation period parameter. The depreciation period is selected as 10 years.

Hence the fifth parameter is the depreciation period and it is 10 years. This constraint is same for both entities.

The sixth parameter is the shipyard and the PORREP construction period parameter. The shipyard and the PORREP construction period is selected as 5 years.

Hence the sixth parameter is the shipyard and the PORREP construction period and it is 5 years. This constraint is same for both entities.

The seventh parameter is the first sale income parameter. The first sale income is in the first year of the shipyard construction period. The first sale income for the PORREP is in the second year of the construction.

Hence the seventh parameter is the first sale income parameter and it is 1st year of the shipyard construction period. The first sale income for the PORREP is in 2nd year of the PORREP construction period.

The eight parameter is the grace period and total period parameter. The grace period is in the 2 years and the total period is 10 years.

Hence the eight parameter is the grace period and total period parameter and it is 2 years and 10 years respectively. This constraint is same for both entities.

The ninth parameter is the loan interest rate parameter. The loan interest rate is assumed as LIBOR+1.5 (LIBOR + 150 basis point). The LIBOR rates are presented in Figure 4.13. The LIBOR in June 2008 is 3,16375 %. The LIBOR is accepted as the average of LIBOR rates (4,1291 %) between January, 1998 and June, 2008 as shown in Table 4.4. Moreover it is assumed that the commercial credit loan interest rate and the equipment loan interest rate are same, actually negligible in current study. The repayment conditions for commercial credit loan and the equipment loan is assumed to be the same, actually negligible in current study.

Table 4.4 : 1 Year LIBOR, (Source: Url-12).

Month	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Jan	5,774	5,108	6,659	5,284	2,42	1,477	1,4607	3,271	4,9412	5,4414	4,22375
Feb	5,836	5,405	6,76	4,925	2,496	1,368	1,3645	3,5114	5,1526	5,3328	2,84938
Mar	5,914	5,307	6,97	4,67	3,006	1,34	1,3401	3,842	5,2476	5,2009	2,70875
Apr	6,024	5,303	6,964	4,33	2,613	1,362	1,8082	3,7101	5,4217	5,2967	2,48625
May	5,93	5,503	7,453	4,259	2,634	1,2214	2,0764	3,7789	5,4139	5,3885	3,07875
Jun	5,94	5,803	7,214	4,055	2,251	1,2014	2,4682	3,8632	5,766	5,4048	3,16375
Jul	5,897	5,836	7,047	3,835	2,07	1,2789	2,4632	4,1745	5,591	5,42563	
Aug	5,648	6,023	6,978	3,6	1,943	1,4714	2,3001	4,3123	5,4501	5,245	
Sep	5,186	6,053	6,811	2,65	1,813	1,2857	2,4445	4,4067	5,2985	5,275	
Oct	4,865	6,313	6,725	2,311	1,664	1,4551	2,5289	4,6765	5,3348	4,90125	
Nov	5,244	6,261	6,618	2,492	1,705	1,4867	2,9607	4,7379	5,2439	4,6375	
Dec	5,213	6,508	5,997	2,445	1,447	1,4582	3,1004	4,8226	5,3139	4,4575	

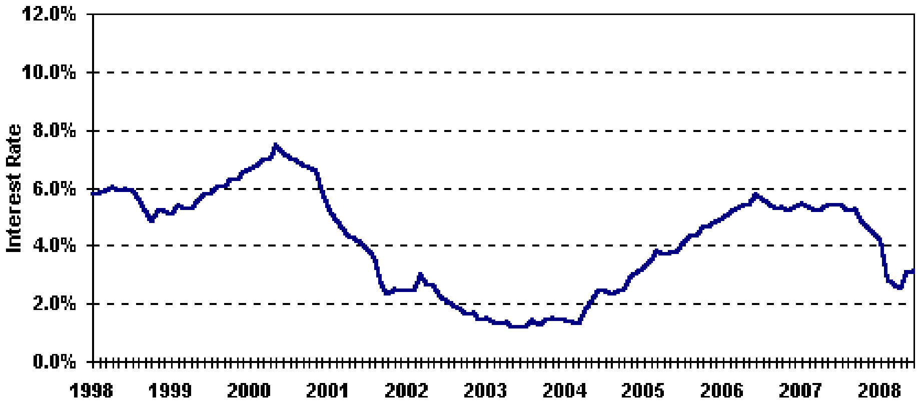


Figure 4.13 : 1 Year LIBOR, (Source: Url-12).

The tenth parameter is taxes during investment and taxes after investment including cooperation taxes parameter. During investment and after construction period the tax rate is assumed to be 20%. This value and application procedure is taken from the corporation tax law. (10 Haziran 1949 Tarihli Resmi Gazete, Sayı: 7229, Kanun No:5422 and following, consecutive, subsequent rules, regulations and so forth)

Hence the tenth parameter is the taxes during investment and taxes after investment including cooperation taxes. During investment period the tax rate is 20% and after investment period the tax rate is 20%. This constraint is same for both entities.

The eleventh parameter is the inflation rate parameter. The inflation rate is assumed to be the global inflation rate bases and it is assumed to be 7%. This value is selected according to the inflation targeting policy of countries and long term inflation expectations. The data was gathered from Kuttner (2004) study as shown in Figure 4.14.

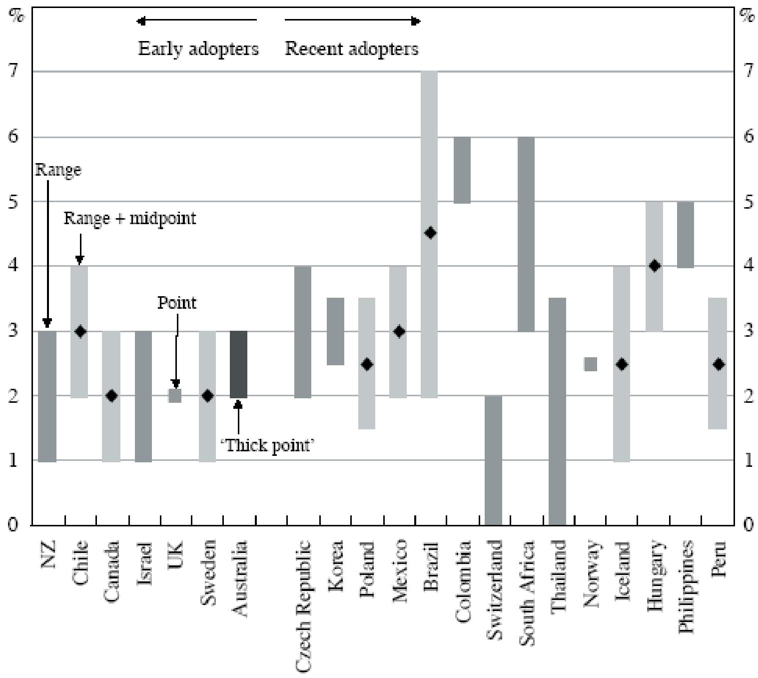


Figure 4.14 : Infliation Targets, (Source: Kuttner, 2004).

Hence the eleventh parameter is the inflation rate parameter and it is 7%. This constraint is same for both entities.

The twelfth parameter is learning curve parameter for the shipyard investment. The manhour cost, duration, quality and other important properties of the first vessel and the sister ships of other vessels are not same according to the effect of the gathered knowledge etc., because Gelibolu Gemi Endustrisi Sanayi ve Ticaret A.S plans to build up sister vessels. According to this product philosophy, it is assumed that the manhour cost of the vessels shall be decreased as shown in Figure 4.15. It is assumed that the manhour learning curve effect is limited only with four vessels.

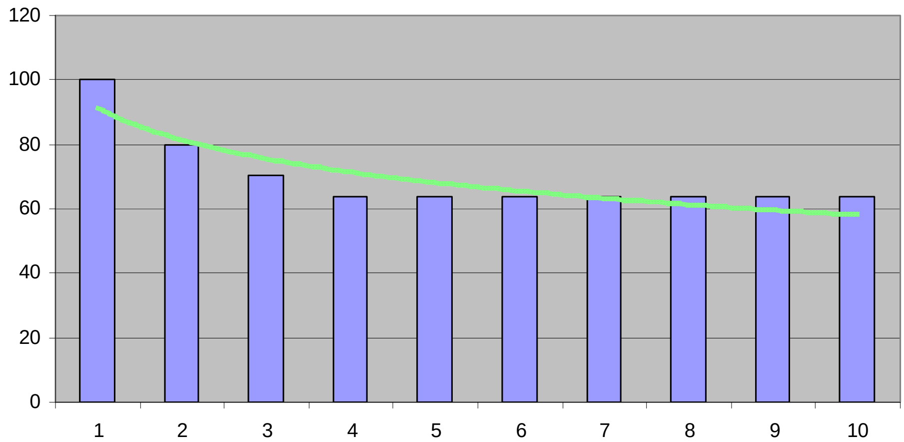


Figure 4.15 : Gelibolu Gemi Endustrisi Sanayi ve Ticaret A.S learning curve for manhour cost.

The delivery duration of the vessels is assumed to be decreased as shown in Figure 4.16. It is assumed that the learning curve effect is limited only with five vessels.

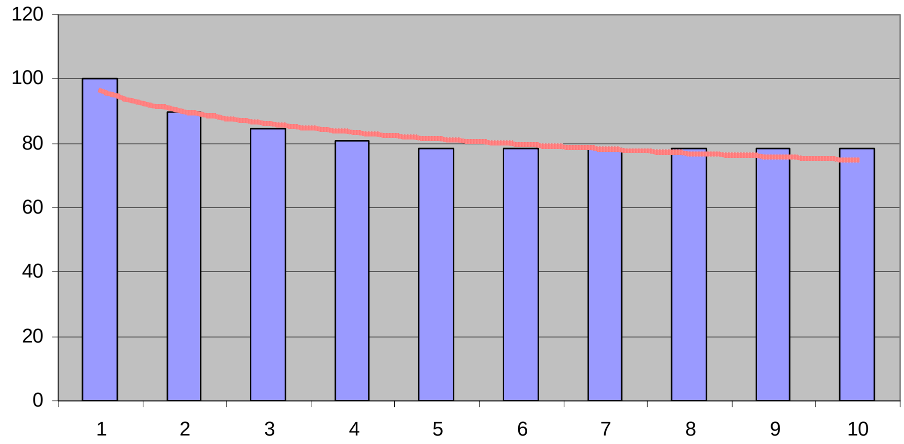


Figure 4.16 : Gelibolu Gemi Endustrisi Sanayi ve Ticaret A.S learning curve for delivery duration.

The learning percent from different industries are given as aerospace 85%, shipbuilding 80%-85%, complex machine tools for new models 75%-85%, repetitive electronics manufacturing 90%-95%, repetitive machining or punch-press operations 90%-95%, repetitive electrical operations 75%-85%, repetitive welding operations 90%, raw materials 93%-96%, purchased parts 85%-88% by Stewart et. al. (1995).

Hence the twelfth parameter is the learning curve parameter and it is assumed to be 80% for direct labour cost and 90% for delivery duration. In the virtual entity this parameter is not taken into consideration.

The thirteenth parameter is minimum attractive rate of return parameter. In general, it is accepted as LIBOR+4% or LIBOR +5%. In Turkey, due to the other investment opportunities especially in financial sector, the investors could easily gather 20% rate of return which makes the minimum attractive rate of return at least 25%. In current study, it is accepted as LIBOR + 4%.

Hence the thirteenth parameter is the MARR parameter and is equal to LIBOR + 4%. This constraint is same for both entities.

The fourteenth parameter is the contract payment terms paramater for the shipyard investment. The standard AWES contract terms as 20% at the contract effectiveness, 15% hull upto framenumber 89 complete, 15% hull complete, 20% the launching, 30% the delivery is assumed to be the contract payment terms for all vessels.

Hence the AWES contract payment terms are the fourteenth parameter. In the virtual entity this parameter is not taken into consideration.

Step 11: Cross check the objectives, parameters, constraints and attributes

The objectives, parameters, constraints and attributes were checked and all of them were appointed and none of them have any confusion effect between each other. These objectives, parameters, constraints and attributes are same for the Gelibolu Gemi Endustrisi Sanayi ve Ticaret A.S and the Virtual PORREP.

Step 12 & Step 13: Generate the expert pool and select the experts

The expert pool was generated and than selected as Retired Admiral Msc. Metin POYRAZLAR and Retired Admiral Msc. Nadir KINAY. This step was directly performed by the investors. Both staff were appointed as the project managers of investment or so called the investment managers, so that all of the steps and stages of the proposed method had been performed by the investment managers.

Step 14: Decide the investors names who shall attend the study

In current study, the investors did not want to attend the study or procedure directly and gave the full power to experts, henceforth the investor related steps had to be skipped. The method is flexible on this kind of occasions and can be run without any problem.

Step 15: Publish the pre-decision report

The pre-decision report was delivered to the experts.

Step 16: Collect Data for Investment Analysis Study

The necesary data had been collected for the shipyard and the Virtual PORREP as such

- The product segment of the shipyard was selected as 30.000 DWT Bulker, 30.000 DWT Tanker - D/Hull, 115.000 DWT Bulker, 180.000 DWT Tanker - D/Hull. The selection was performed by the experts.
- The sales price forecasts for product segment of the shipyard was taken from OSC–Ocean Shipping Consultants LTD., (2000) with a correction value and a cycle in forecast (*a generic forecast modelling, which is out of scope of the current thesis, is performed based on historic data*) was assumed and the data

was generated according to this assumtion as shown in Figure 4.17 and in Figure 4.18 for the base case.

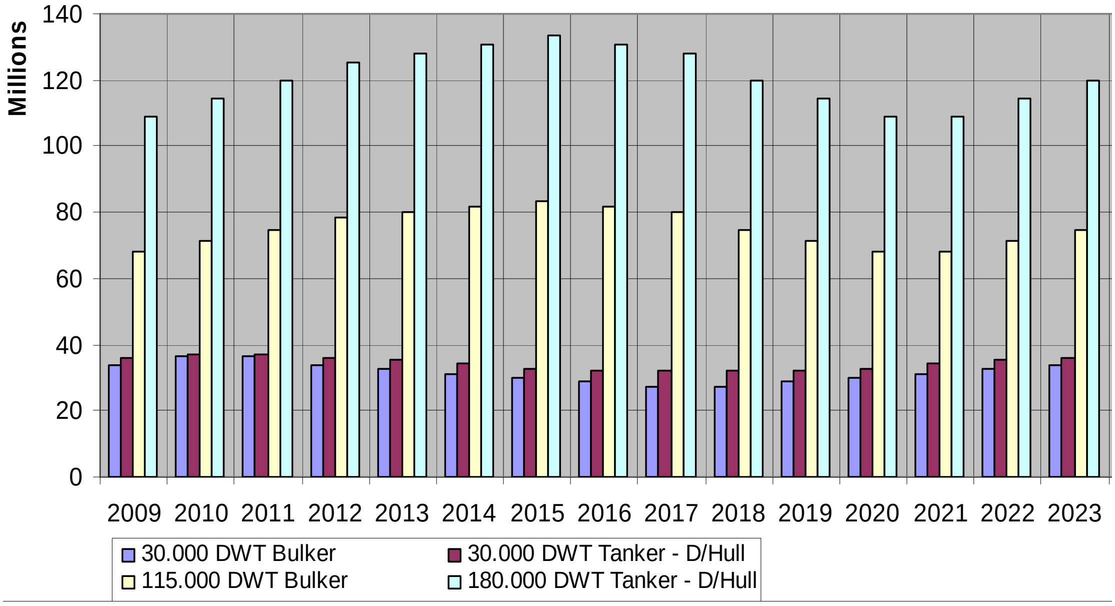


Figure 4.17 : Sales price forecast for the base case between 2009 – 2023.

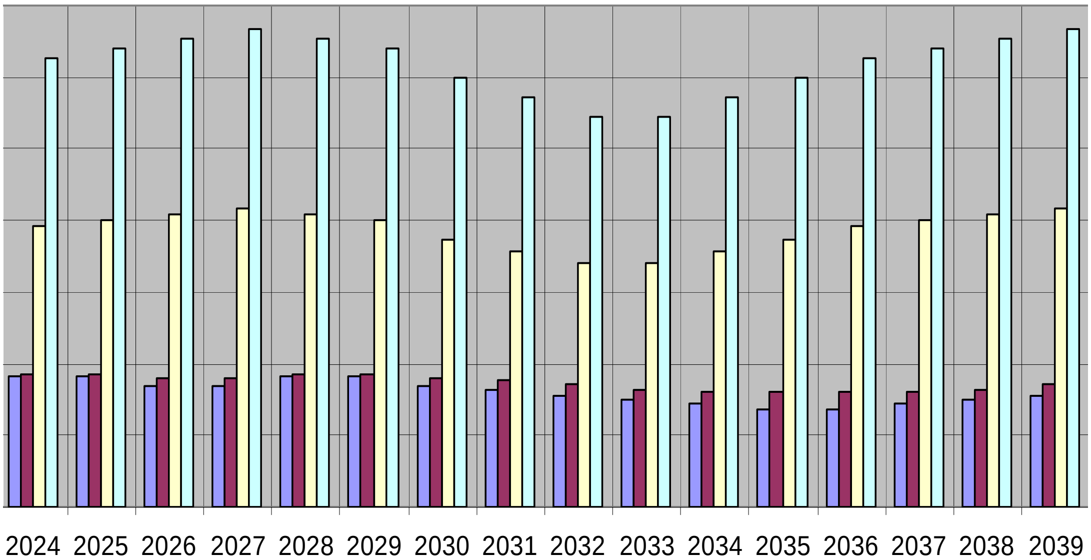


Figure 4.18 : Sales price forecast for the base case between 2024 – 2039.

- The forecast risk should be deduced in a manner that the data estimation risk could be minimized. There are several distribution models which can be easily adopted into this kind of analysis. The most commonly preferred distribution is Gaussian distribution or normal distribution. In current study, three low cases and three high cases were generated. All this information for 30.000 DWT Bulker is shown in Figure 4.19. Each data point in the range between the low case 3 and high case 3 was taken into consideration. This analysis was performed for each of the product in the product segment of the shipyard. These information is presented in Appendix G.

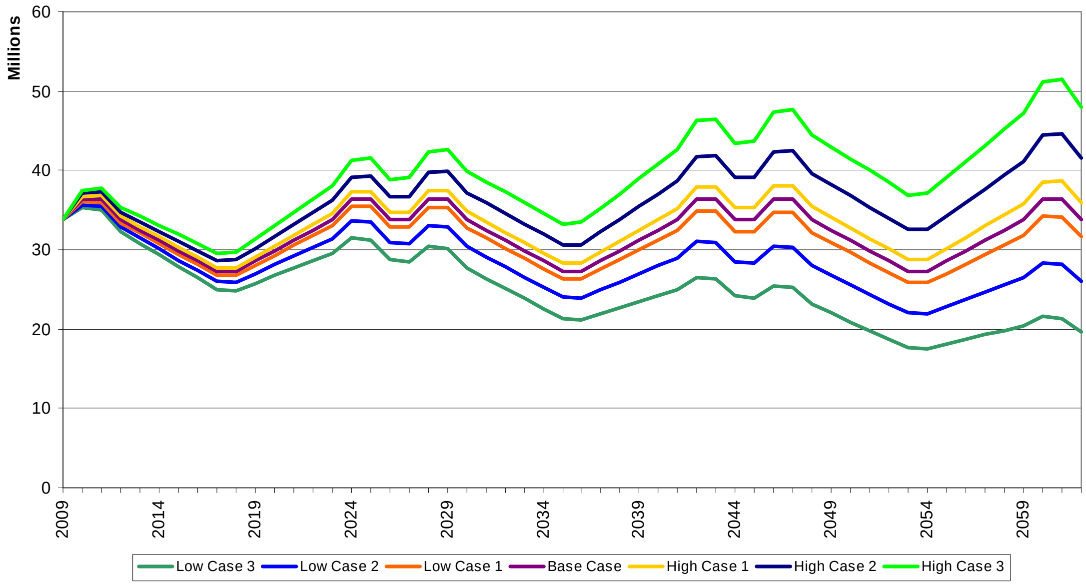


Figure 4.19 : Sales price forecast 30.000 DWT Bulker.

- The schedule for the 30.000 DWT Bulker, 30.000 DWT Tanker - D/Hull, 115.000 DWT Bulker, 180.000 DWT Tanker - D/Hull independent from yearly time table was generated. According to this study, the delivery schedule for the shipyard for each product segment was calculated.

- The contract terms and the delivery schedule based on the income statement and the income cash flow was calculated on yearly basis according to this data. The income cash flow for the 30.000 DWT Bulker is presented as shown in Figure 4.18. The income cash flow for the 30.000 DWT Bulker, 30.000 DWT Tanker - D/Hull, 115.000 DWT Bulker, 180.000 DWT Tanker - D/Hull was also tabulated.

- The sales price forecasts for port and repair yard was taken from OSC – The European and Mediterranean Containerport Markets to 2015, OSC – Containerport Markets in the Middle East and South Asia to 2020 and OSC – The World Ship Repair Market to 2015 with a summation of the forecasts and correction value and an incremental trend in forecast (*a generic forecast modelling, which is out of scope of the current thesis, is performed based on* historic data) was assumed and the data was generated according to this assumtion.

- The forecast risk should be deduced in a manner that the data estimation risk could be minimized. There are several distribution models which can be easily adopted into this kind of analysis. The most commonly preferred distribution is Gaussian distribution or normal distribution. In current study, three low cases and three high cases were generated. All this information for PORREP Container Terminal is shown in Figure 4.20. Each data point in the range between the low case 3 and high case 3 was taken into consideration. This analysis was performed for each of the service in the service segment of the PORREP. These information is presented in Appendix G.

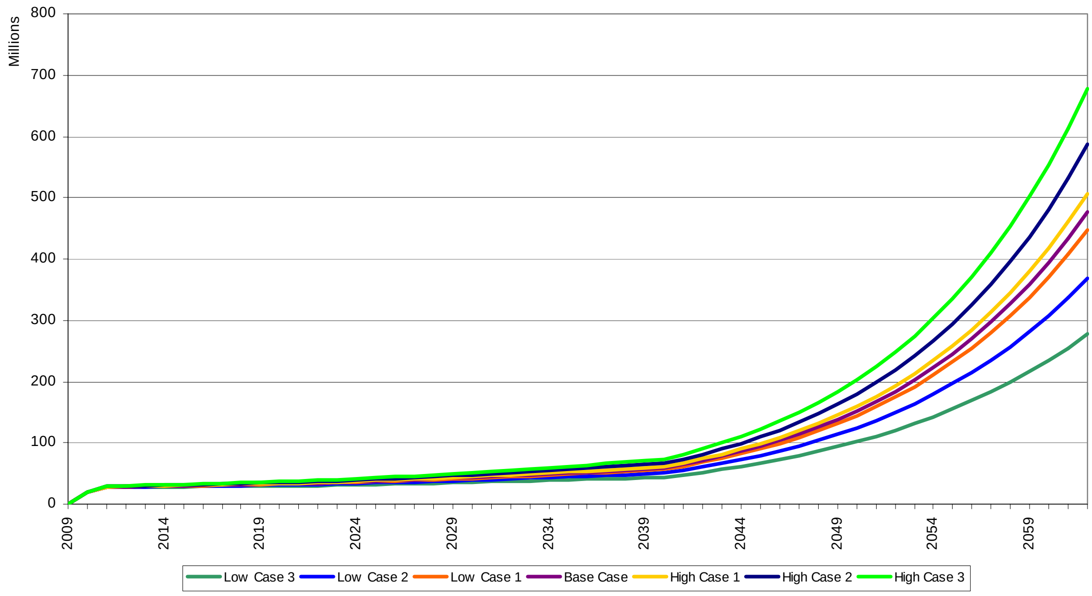


Figure 4.20 : Sales price forecast PORREP Container Terminal.

Step 17: Fill the data into the Model and Investment Calculations

The data was filled into the Model for the shipyard and for the PORREP. The model can be built up in any optimization software or any spreedsheet calculation software with special formulations and macros.

Step 18: Generate Pareto Optimal Design Alternatives

According to the data that was filled in and the other parameters etc. the Pareto optimal design alternatives were generated. In the current model, 50 generations were selected and executed. In the last run, the directional crossover probability was 0.5, the selection probability was 0.05 and the mutation probability was 0.1. The last run took more than 2 days in a PC (Pentium IV, 1.4 GHz) environment. This step totally took more than 3 months in current study because of being the first execution.

Step 19: Select / Filter / Set Pareto Optimal Design Alternatives

1514 different designs were obtained in design space with 517 error designs, 79 feasible designs and 918 unfeasible designs. 28 good designs and 14 PODAs were filtered and marked for all cases. The scatter plot diagrams of the optimisation parameters are presented in Figure 4.21. The history charts are presented in Appendix G.

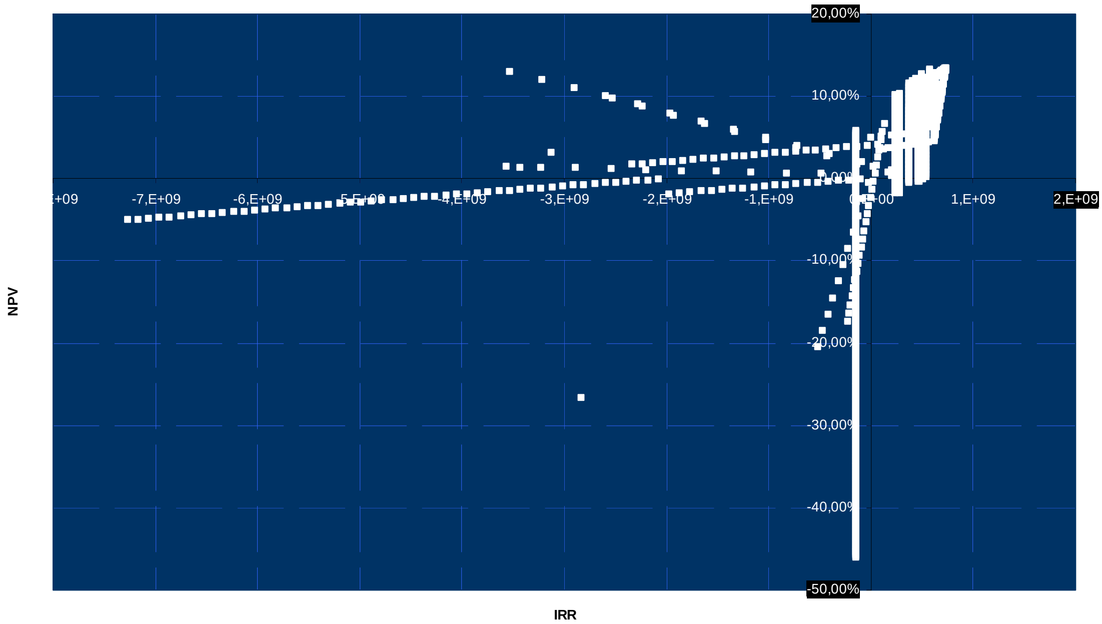


Figure 4.21 : Scatter chart IRR vs. NPV on design table.

Step 20: Assign Each Investor the Weights by the Share Rate

The shareholders and the share rates are as following:

- Recep Sami YAZICI (16,66%)
- Sadan KALKAVAN (20,32%)
- Aynur KALKAVAN (13%)
- Fuat MIRAS (16,68%)
- Servet YARDIMCI (16,66%)
- Saban YARDIMCI (16,68%)

Although the investors and their weights were given, as mentioned in Step 14 (decide the investors names who shall attend the study), the investors would not be involved to the process, hence this step and all other steps related to investors would be skipped.

Step 21: Normalize the Weight of Investors

This step was skipped according to Step 14 and Step 20.

Step 22: Collect each Investor Opinion for each Expert

This step was skipped according to Step 14 and Step 20.

Step 23: Assign Expert Weight according to Investors point of view

This step was skipped according to Step 14 and Step 20.

Step 24: Collect each Expert Opinion for each Expert

When comparing expert i with expert j a score of 1 represents indifference between the two, a score of 3 represents weakly preferred, 5 depicts a strong preference, 7 depicts a very strong preference and 9 represents the absolute preference of i over j. The following questionnaires form was sent to experts for their judgments as shown in Table 4.5.

Table 4.5 : Expert opinion collection table – evaluation matrix

1	2	3	4	5	6	7	8	9
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
EXPERT 1								
Expert 1								Expert 2
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
EXPERT 2								
Expert 1								Expert 2
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme

Step 25: Transform Fuzzy Data into Fuzzy Membership Function for each Weight Assignment of each Expert

The weight assignments of each expert was transformed into fuzzy triangle function and presented as shown in Figure 4.22 and in Table 4.6.

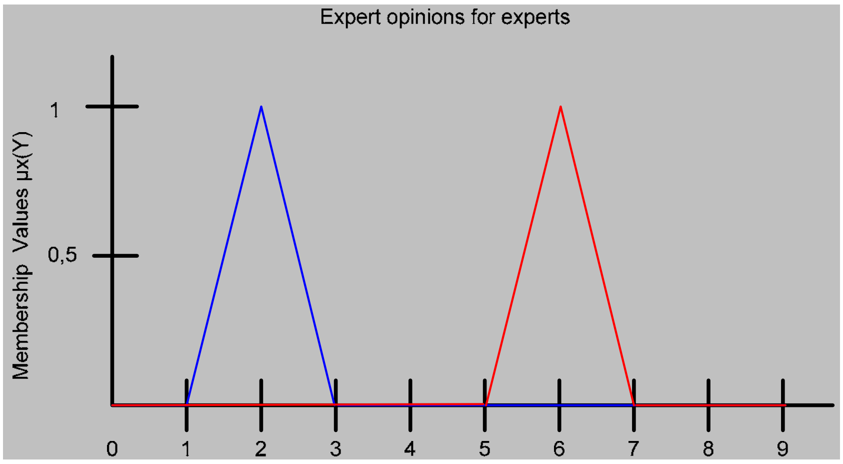


Figure 4.22 : Fuzzy membership functions of experts

The weight assignment of each expert was converted into the fuzzy evaluation matrix as presented in Table 4.6.

Table 4.6 : Fuzzy evaluation matrix of experts

Expert	Expert 1	Expert 2
Expert 1	(1, 1, 1)	(5, 6, 7)
Expert 2	(1, 2, 3)	(1, 1, 1)

Step 26: Synthesize Fuzzy Membership Function and Find the Value of the Fuzzy Synthetic Degree

The value of the fuzzy synthetic degree was calculated as by Formula 4.1 and Formula 4.2.

$$S_{Expert.1} = (6,7,8) \otimes (0.13, 0.1, 0.83) = (0.78, 0.7, 6.64) \quad \textbf{(4.1)}$$

$$S_{Expert2} = (2,3,4) \otimes (0.13, 0.1, 0.83) = (0.26, 0.3, 3.32) \quad \textbf{(4.2)}$$

Step 27: Defuzzify the Synthetic Degrees to Calculate Each Weight Assignment of Each Expert

The synthetic degrees was defuzzified by the Equation 3.2.3. According to this calculation the weight of expert 1 is $w_{Expert.1}$=2.21 and the weight of expert 2 is $w_{Expert.2}$=1.05.

Step 28: Compare the Expert Weight of Investors and Experts - Adjust the Expert Weights

In step 14 the decision of the investors were given, henceforth in current study the α values should not been taken into consideration.

Step 29: Normalize the Weight of Experts to Calculate the Weight Assignment of each Expert

The weight of expert 1 was calculated as $w_{Expert.1}$=0.68 and the weight of expert 2 was calculated as $w_{Expert.2}$=0.32.

Step 30: Collect each Expert Opinion for each Attribute to Assign the Relative Importance of Attributes

At this step, the expert opinion for each attribute was collected as shown in Table 4.7 and in Table 4.8.

Table 4.7 : Expert 1 Opinion collection table for assigment of relative importance of attributes – evaluation matrix

1	2	3	4	5	6	7	8	9
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Total EBITDA								Average Net Income
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Total EBITDA								Payback period
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Total EBITDA								Rantability
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Total EBITDA								Ease of Credit Funding
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Average Net Income								Payback period
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Average Net Income								Rantability
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Average Net Income								Ease of Credit Funding
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Payback period								Rantability
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Payback period								Ease of Credit Funding
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Rantability								Ease of Credit Funding
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme

Table 4.8 : Expert 2 Opinion collection table for assigment of relative importance of attributes – evaluation matrix

1	2	3	4	5	6	7	8	9
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Total EBITDA								Average Net Income
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Total EBITDA								Payback period
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Total EBITDA								Rantability
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Total EBITDA								Ease of Credit Funding
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Average Net Income								Payback period
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Average Net Income								Rantability
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Average Net Income								Ease of Credit Funding
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Payback period								Rantability
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Payback period								Ease of Credit Funding
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
Rantability								Ease of Credit Funding
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme

Step 31: Transform Fuzzy Data into Fuzzy Membership Function for each Weight Assignment of each Attribute

The weight assignments of each expert was transformed into fuzzy triangle function and was converted into the fuzzy evaluation matrix as presented in Table 4.9.

Table 4.9 : Fuzzy evaluation matrix of attributes

Expert 1	Total EBITDA	Average Net Income	Payback period	Rantability	Ease of Credit Funding
Total EBITDA	(1, 1, 1)	(1, 2, 3)	(7, 8, 9)	(6, 7, 8)	(8, 9, 9)
Average Net Income	(1, 2, 3)	(1, 1, 1)	(7, 8, 9)	(7, 8, 9)	(8, 9, 9)
Payback period	(7, 8, 9)	(7, 8, 9)	(1, 1, 1)	(3, 4, 5)	(5, 6, 7)
Rantability	(6, 7, 8)	(7, 8, 9)	(3, 4, 5)	(1, 1, 1)	(5, 6, 7)
Ease of Credit Funding	(8, 9, 9)	(8, 9, 9)	(5, 6, 7)	(5, 6, 7)	(1, 1, 1)
Expert 2	Total EBITDA	Average Net Income	Payback period	Rantability	Ease of Credit Funding
Total EBITDA	(1, 1, 1)	(2, 3, 4)	(6, 7, 8)	(5, 6, 7)	(7, 8, 9)
Average Net Income	(2, 3, 4)	(1, 1, 1)	(6, 7, 8)	(6, 7, 8)	(7, 8, 9)
Payback period	(6, 7, 8)	(6, 7, 8)	(1, 1, 1)	(4, 5, 6)	(4, 5, 6)
Rantability	(5, 6, 7)	(6, 7, 8)	(4, 5, 6)	(1, 1, 1)	(4, 5, 6)
Ease of Credit Funding	(7, 8, 9)	(7, 8, 9)	(4, 5, 6)	(4, 5, 6)	(1, 1, 1)

Step 32: Synthesize Fuzzy Membership Function and Find the Value of the Fuzzy Synthetic Degree

The value of the fuzzy synthetic degree was calculated as by Formula 4.3 - Formula 4.12.

$$S_{Total.EBITDA.Expert.1} = (23,27,30) \otimes (0.008,0.007,0.007) = (0.18,0.19,0.21) \quad \textbf{(4.3)}$$

$$S_{Average.Net.Income.Expert.1} = (24,27,31) \otimes (0.008,0.007,0.007) = (0.19,0.19,0.22) \quad \textbf{(4.4)}$$

$$S_{Payback.Period.Expert.1} = (23,27,31) \otimes (0.008,0.007,0.007) = (0.18,0.19,0.22) \quad \textbf{(4.5)}$$

$$S_{Rantability.Expert.1} = (22,26,30) \otimes (0.008,0.007,0.007) = (0.18,0.18,0.21) \quad \textbf{(4.6)}$$

$$S_{Ease.of.Credit.Funding.Expert.1} = (27,31,33) \otimes (0.008,0.007,0.007) = (0.22,0.22,0.23) \quad \textbf{(4.7)}$$

$$S_{Total.EBITDA.Expert.2} = (21, 25, 29) \otimes (0.009, 0.008, 0.007) = (0.19, 0.2, 0.2) \quad \textbf{(4.8)}$$

$$S_{Average.Net.Income.Expert.2} = (22, 26, 30) \otimes (0.009, 0.008, 0.007) = (0.2, 0.21, 0.21) \quad \textbf{(4.9)}$$

$$S_{Payback.Period.Expert.2} = (21, 25, 29) \otimes (0.009, 0.008, 0.007) = (0.19, 0.2, 0.2) \quad \textbf{(4.10)}$$

$$S_{Rantability.Expert.2} = (20, 24, 28) \otimes (0.009, 0.008, 0.007) = (0.18, 0.19, 0.2) \quad \textbf{(4.11)}$$

$$S_{Ease.of.Credit.Expert.2} = (23, 27, 31) \otimes (0.009, 0.008, 0.007) = (0.21, 0.22, 0.22) \quad \textbf{(4.12)}$$

Step 33: Defuzzify the Synthetic Degrees to Calculate Each Weight Assignment of Each Attribute

The synthetic degrees was defuzzified by the Equation 3.2.3. According to this calculation for expert 1 the weight of total EBITDA is $w_{total\ EBITDA}$=0.19, the weight of average net income is $w_{average\ net\ income}$=0.20, the weight of payback period is $w_{payback\ period}$=0.2, the weight of rantability is $w_{rantability}$=0.19, the weight of ease of credit funding is $w_{ease\ of\ credit\ funding}$=0.23. According to this calculation for expert 2 the weight of total EBITDA is $w_{total\ EBITDA}$=0.2, the weight of average net income is $w_{average\ net\ income}$=0.21, the weight of payback period is $w_{payback\ period}$=0.2, the weight of rantability is $w_{rantability}$=0.19, the weight of ease of credit funding is $w_{ease\ of\ credit\ funding}$=0.22.

Step 34: Normalize the Weight of Attributes to Calculate the Weight Assignment of each Attribute

The weight of total EBITDA was calculated as $w_{total\ EBITDA}$ =0.2, the weight of average net income was calculated as $w_{average\ net\ income}$ =0.2, the weight of payback period was calculated as $w_{payback\ period}$ =0.2, the weight of rantability income was calculated as $w_{rantability}$ =0.19, the weight of ease of credit funding was calculated as $w_{ease\ of\ credit\ funding}$=0.21.

Step 35: Collect each Expert Opinion for each PODA with respect to each Objective Attribute

At this step, the expert opinion for each PODAs with respect to each objective attribute was collected as shown in Table 4.10.

"S" stands for the shipyard and "P" stands for the PORREP. Three low cases, one base case and three high cases were generated and the evaluation matrix is presented in Table 4.10. S_{LC3} stands for low case 3 for shipyard, S_{LC2} stands for low case 2 for shipyard, S_{LC1} stands for low case 1 for shipyard, S_{BC} stands for base case for shipyard, S_{HC1} stands for high case 1 for shipyard, S_{HC2} stands for high case 2 for shipyard, S_{HC3} stands for high case 3 for shipyard. P_{LC3} stands for low case 3 for virtual PORREP, P_{LC2} stands for low case 2 for virtual PORREP, P_{LC1} stands for low case 1 for virtual PORREP, P_{BC} stands for base case for virtual PORREP, P_{HC1} stands for high case 1 for virtual PORREP, P_{HC2} stands for high case 2 for virtual PORREP, P_{HC3} stands for high case 3 for virtual PORREP.

Table 4.10 : Expert 1 & Expert 2 Opinion collection table for each PODA with respect to each objective attribute – evaluation matrix

	PODAs			
	Total EBITDA	Average Net Income	Payback period	Rantability
S_{LC3}	5.375.348.091	72.129.670	18	1,17
S_{LC2}	6.813.297.937	93.441.996	17	1,18
S_{LC1}	6.850.847.210	94.001.818	17	1,23
S_{BC}	7.129.626.856	98.136.146	17	1,23
S_{HC1}	7.408.406.501	102.270.473	17	1,23
S_{HC2}	8.095.159.403	112.450.798	16	1,23
S_{HC3}	8.934.617.291	124.894.809	16	1,24
P_{LC3}	8.775.379.340	122.765.313	19	1,42
P_{LC2}	11.958.004.867	169.915.779	18	1,56
P_{LC1}	12.219.411.120	173.788.922	18	1,66
P_{BC}	12.838.542.736	182.961.701	18	1,67
P_{HC1}	13.457.674.352	192.134.479	18	1,67
P_{HC2}	15.057.147.545	215.830.837	17	1,67
P_{HC3}	16.929.098.804	243.563.915	17	1,67

Step 36: Collect each Expert Opinion for each PODA with respect to each Subjective Attribute

At this step, the expert opinion for each PODA with respect to each subjective attribute was collected as shown in Table 4.11 and in Table 4.12. "S" stands for the shipyard and "P" stands for the PORREP in Table 4.11 and in Table 4.12.

Table 4.11 : Expert 1 opinion collection table for each PODA with respect to each objective attribute – evaluation matrix

PODAs								
1	2	3	4	5	6	7	8	9
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{LC3}								P_{LC3}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{LC2}								P_{LC2}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{LC1}								P_{LC1}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{BC}								P_{BC}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{HC1}								P_{HC1}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{HC2}								P_{HC2}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{HC3}								P_{HC3}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme

Table 4.12 : Expert 2 Opinion collection table for each PODA with respect to each objective attribute – evaluation matrix

PODAs								
1	2	3	4	5	6	7	8	9
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{LC3}								P_{LC3}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{LC2}								P_{LC2}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{LC1}								P_{LC1}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{BC}								P_{BC}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{HC1}								P_{HC1}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{HC2}								P_{HC2}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme
S_{HC3}								P_{HC3}
extreme	very strong	strong	moderate	equal	moderate	strong	very strong	extreme

Step 37: Transform Fuzzy Data into Fuzzy Membership Function for each PODA with Respect to each Subjective Attribute

The weight assignments of each expert was transformed into fuzzy triangle function and was converted into the fuzzy evaluation matrix as presented in Table 4.13.

Table 4.13 : Fuzzy evaluation matrix of PODAs * Ease of Credit Funding*

Expert 1	P_{LC3}	P_{LC2}	P_{LC1}	P_{BC}	P_{HC1}	P_{HC2}	P_{HC3}
S_{LC3}	(5, 6, 7)	*	*	*	*	*	*
S_{LC2}	*	(5, 6, 7)	*	*	*	*	*
S_{LC1}	*	*	(5, 6, 7)	*	*	*	*
S_{BC}	*	*	*	(5, 6, 7)	*	*	*
S_{HC1}	*	*	*	*	(5, 6, 7)	*	*
S_{HC2}	*	*	*	*	*	(5, 6, 7)	*
S_{HC3}	*	*	*	*	*	*	(5, 6, 7)
Expert 2	P_{LC3}	P_{LC2}	P_{LC1}	P_{BC}	P_{HC1}	P_{HC2}	P_{HC3}
S_{LC3}	(6, 7, 8)	*	*	*	*	*	*
S_{LC2}	*	(6, 7, 8)	*	*	*	*	*
S_{LC1}	*	*	(6, 7, 8)	*	*	*	*
S_{BC}	*	*	*	(6, 7, 8)	*	*	*
S_{HC1}	*	*	*	*	(6, 7, 8)	*	*
S_{HC2}	*	*	*	*	*	(6, 7, 8)	*
S_{HC3}	*	*	*	*	*	*	(6, 7, 8)

Step 38: Synthesize Fuzzy Membership Function and Find the Value of the Fuzzy Synthetic Degree

The value of the fuzzy synthetic degree was calculated as by Formula 4.13 - Formula 4.40.

$$S_{Slc3.Expert.1} = (6,7,8) \otimes (0.083, 0.071, 0.063) = (0.498, 0.497, 0.504) \quad \textbf{(4.13)}$$

$$S_{Plc3.Expert.1} = (7,8,9) \otimes (0.083, 0.071, 0.063) = (0.581, 0.568, 0.567) \quad \textbf{(4.14)}$$

$$S_{Slc2.Expert.1} = (6,7,8) \otimes (0.083, 0.071, 0.063) = (0.498, 0.497, 0.504) \quad \textbf{(4.15)}$$

$$S_{Plc2.Expert.1} = (7,8,9) \otimes (0.083, 0.071, 0.063) = (0.581, 0.568, 0.567) \quad \textbf{(4.16)}$$

$$S_{Slc1.Expert.1} = (6,7,8) \otimes (0.083, 0.071, 0.063) = (0.498, 0.497, 0.504) \quad \textbf{(4.17)}$$

$$S_{Plc1.Expert.1} = (7,8,9) \otimes (0.083, 0.071, 0.063) = (0.581, 0.568, 0.567) \quad \textbf{(4.18)}$$

$$S_{Sbsc.Expert.1} = (6,7,8) \otimes (0.083, 0.071, 0.063) = (0.498, 0.497, 0.504) \quad \textbf{(4.19)}$$

$$S_{Pbsc.Expert.1} = (7,8,9) \otimes (0.083, 0.071, 0.063) = (0.581, 0.568, 0.567) \quad \textbf{(4.20)}$$

$$S_{Shc3.Expert.1} = (6,7,8) \otimes (0.083, 0.071, 0.063) = (0.498, 0.497, 0.504) \quad \textbf{(4.21)}$$

$$S_{Phc3.Expert.1} = (7,8,9) \otimes (0.083, 0.071, 0.063) = (0.581, 0.568, 0.567) \quad \textbf{(4.22)}$$

$$S_{Shc2.Expert.1} = (6,7,8) \otimes (0.083, 0.071, 0.063) = (0.498, 0.497, 0.504) \quad \textbf{(4.23)}$$

$$S_{Phc2.Expert.1} = (7,8,9) \otimes (0.083, 0.071, 0.063) = (0.581, 0.568, 0.567) \quad \textbf{(4.24)}$$

$$S_{Shc1.Expert.1} = (6,7,8) \otimes (0.083, 0.071, 0.063) = (0.498, 0.497, 0.504) \quad \textbf{(4.25)}$$

$$S_{Phc1.Expert.1} = (7,8,9) \otimes (0.083, 0.071, 0.063) = (0.581, 0.568, 0.567) \quad \textbf{(4.26)}$$

$$S_{Slc3.Expert.2} = (7,8,9) \otimes (0.066, 0.059, 0.053) = (0.462, 0.472, 0.477) \quad \textbf{(4.27)}$$

$$S_{Plc3.Expert.2} = (8,9,10) \otimes (0.066, 0.059, 0.053) = (0.528, 0.531, 0.53) \quad \textbf{(4.28)}$$

$$S_{Slc2.Expert.2} = (7,8,9) \otimes (0.066, 0.059, 0.053) = (0.462, 0.472, 0.477) \quad \textbf{(4.29)}$$

$$S_{Plc2.Expert.2} = (8,9,10) \otimes (0.066, 0.059, 0.053) = (0.528, 0.531, 0.53) \quad \textbf{(4.30)}$$

$$S_{Slc1.Expert.2} = (7,8,9) \otimes (0.066, 0.059, 0.053) = (0.462, 0.472, 0.477) \quad \textbf{(4.31)}$$

$$S_{Plc1.Expert.2} = (8,9,10) \otimes (0.066, 0.059, 0.053) = (0.528, 0.531, 0.53) \quad \textbf{(4.32)}$$

$$S_{Sbsc.Expert.2} = (7,8,9) \otimes (0.066, 0.059, 0.053) = (0.462, 0.472, 0.477) \quad \textbf{(4.33)}$$

$$S_{Pbsc.Expert.2} = (8,9,10) \otimes (0.066, 0.059, 0.053) = (0.528, 0.531, 0.53) \quad \textbf{(4.34)}$$

$$S_{Shc3.Expert.2} = (7,8,9) \otimes (0.066, 0.059, 0.053) = (0.462, 0.472, 0.477) \quad \textbf{(4.35)}$$

$$S_{Phc3.Expert.2} = (8,9,10) \otimes (0.066, 0.059, 0.053) = (0.528, 0.531, 0.53) \quad \textbf{(4.36)}$$

$$S_{Shc2.Expert.1} = (7,8,9) \otimes (0.066, 0.059, 0.053) = (0.462, 0.472, 0.477) \quad \textbf{(4.37)}$$

$$S_{Phc2.Expert.1} = (8,9,10) \otimes (0.066, 0.059, 0.053) = (0.528, 0.531, 0.53) \quad \textbf{(4.38)}$$

$$S_{Shc1.Expert.1} = (7,8,9) \otimes (0.066, 0.059, 0.053) = (0.462, 0.472, 0.477) \quad \textbf{(4.39)}$$

$$S_{Phc1.Expert.1} = (8,9,10) \otimes (0.066, 0.059, 0.053) = (0.528, 0.531, 0.53) \quad \textbf{(4.40)}$$

Step 39: Defuzzifying the synthetic Degrees to Calculate each Weight Assignment of each PODA with Respect to each Subjective Attribute

The synthetic degrees was defuzzified by the Equation 3.2.3.

According to this calculation for expert 1 the weight of S_{LC3} is w_{SLC3}=0.499, the weight of S_{LC2} is w_{SLC2}=0.499, the weight of S_{LC1} is w_{SLC1}=0.499, the weight of S_{BC} is w_{SBC}=0.499, the weight of S_{HC1} is w_{SHC1}=0.499, the weight of S_{HC2} is w_{SHC2}=0.499, the weight of S_{HC3} is w_{SHC3}=0.499, the weight of P_{LC3} is w_{PLC3}=0.571, the weight of P_{LC2} is w_{PLC2}=0.571, the weight of P_{LC1} is w_{PLC1}=0.571, the weight of P_{BC} is w_{PBC}=0.571, the weight of P_{HC1} is w_{PHC1}=0.571, the weight of P_{HC2} is w_{PHC2}=0.571, the weight of P_{HC3} is w_{PHC3}=0.571. According to this calculation for expert 2 the weight of S_{LC3} is w_{SLC3}=0.471, the weight of S_{LC2} is w_{SLC2}=0.471, the weight of S_{LC1} is w_{SLC1}=0.471, the weight of S_{BC} is w_{SBC}=0.471, the weight of S_{HC1} is

w_{SHC1}=0.471, the weight of S_{HC2} is w_{SHC2}=0.471, the weight of S_{HC3} is w_{SHC3}=0.471, the weight of P_{LC3} is w_{PLC3}=0.53, the weight of P_{LC2} is w_{PLC2}=0.53, the weight of P_{LC1} is w_{PLC1}=0.53, the weight of P_{BC} is w_{PBC}=0.53, the weight of P_{HC1} is w_{PHC1}=0.53, the weight of P_{HC2} is w_{PHC2}=0.53, the weight of P_{HC3} is w_{PHC3}=0.53.

Step 40: Normalize the Weight of Attributes to Calculate the Weight Assignment of each PODA with Respect to each Subjective Attribute

The weight of S_{LC3} is w_{SLC3}=0.485, the weight of S_{LC2} is w_{SLC2}=0. 485, the weight of S_{LC1} is w_{SLC1}=0.485, the weight of S_{BC} is w_{SBC}=0.485, the weight of S_{HC1} is w_{SHC1}=0.499, the weight of S_{HC2} is w_{SHC2}=0.499, the weight of S_{HC3} is w_{SHC3}=0.499, the weight of P_{LC3} is w_{PLC3}=0.571, the weight of P_{LC2} is w_{PLC2}=0.571, the weight of P_{LC1} is w_{PLC1}=0.571, the weight of P_{BC} is w_{PBC}=0.571, the weight of P_{HC1} is w_{PHC1}=0.571, the weight of P_{HC2} is w_{PHC2}=0.571, the weight of P_{HC3} is w_{PHC3}=0.571.

Step 41: Check whether all Data are collected for the ANP Model

All data was collected for the ANP Model. The model could now be built up.

Step 42: Check whether all Data are transformed into to crips number or not

All data was transformed into to crips numbers. The model could now be built up.

Step 43: Build up ANP Model with crips numbers converted fuzzy numbers

ANP model was build up by free version of Super Decisions software package as a screenview is shown in Figure 4.23.

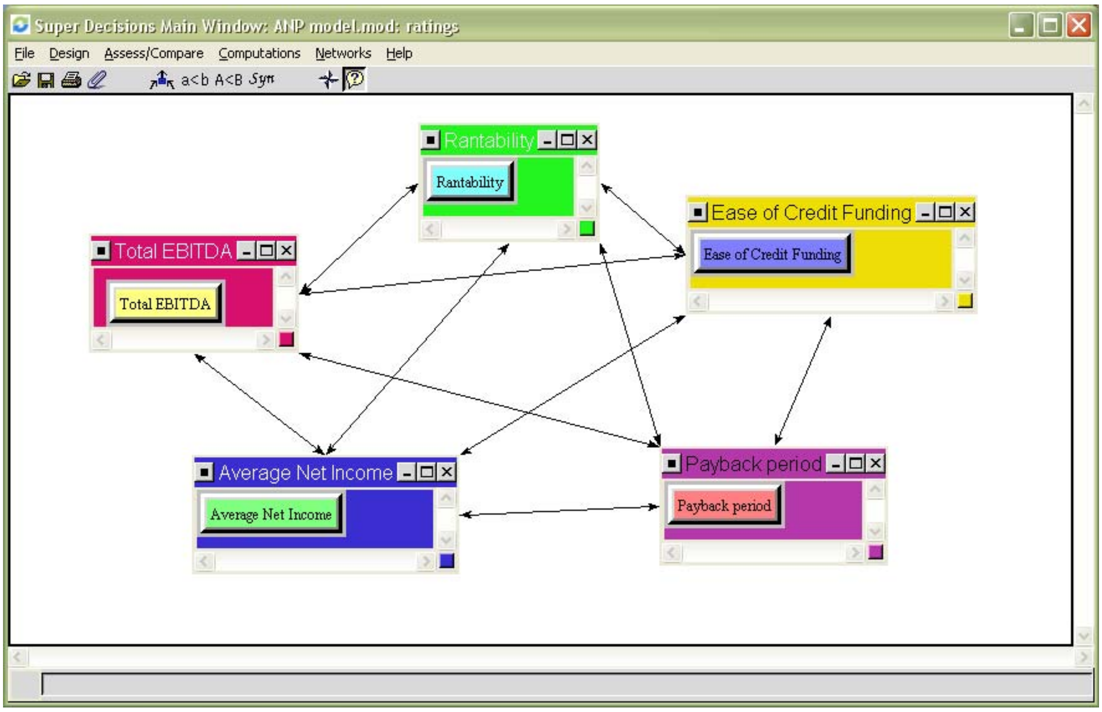


Figure 4.23 : Screenview of ANP model.

Step 44: Find Overall Alternative Ranking values for PODAs

ANP model was run and the OARs were gathered as presented in Table 4.14.

The overall alternative ranking values for Pareto optimal design alternatives of Gelibolu Gemi Endustrisi Sanayi ve Ticaret A.S. that is the name of a legal entity of a shipyard in Turkey and a virtual feasibility evaluation of a virtual entity of port and shiprepair yard named as Virtual Gelibolu PORREP is one by one presented. The OAR of S_{LC3} is 0,43 while the OAR of P_{LC3} is 0,57, the OAR of S_{LC2} is 0,42 while the OAR of P_{LC2} is 0,58, the OAR of S_{LC1} is 0,42 while the OAR of P_{LC1} is 0,58, the OAR of S_{BC} is 0,42 while the OAR of P_{BC} is 0,58, the OAR of S_{HC1} is 0,42 while the OAR of P_{HC1} is 0,58, the OAR of S_{HC2} is 0,42 while the OAR of P_{HC2} is 0,58, the OAR of S_{HC3} is 0,42 while the OAR of P_{HC3} is 0,58.

Table 4.14 : OARs matrix of PODAs

PODAs	OARs	PODAs	OARs	PODAs	OARs	PODAs	OARs
S_{LC3}	0,43	S_{LC2}	0,42	S_{LC1}	0,42	S_{BC}	0,42
S_{HC1}	0,42	S_{HC2}	0,42	S_{HC3}	0,42	P_{LC3}	0,57
P_{LC2}	0,58	P_{LC1}	0,58	P_{BC}	0,58	P_{HC1}	0,58
P_{HC2}	0,58	P_{HC3}	0,58				

Step 45: Order or Rank PODAs according to OARs

The OARs of PODAs which had been presented in step 44 were ranked.

These are presented in Table 4.15.

Table 4.15 : OARs Matrix of PODAs (final ranking)

Order	PODAs	OARs	Order	PODAs	OARs
1	P_{LC3}	0,57	2	S_{LC3}	0,43
1	P_{LC2}	0,58	2	S_{LC2}	0,42
1	P_{LC1}	0,58	2	S_{LC1}	0,42
1	P_{BC}	0,58	2	S_{BC}	0,42
1	P_{HC1}	0,58	2	S_{HC1}	0,42
1	P_{HC2}	0,58	2	S_{HC2}	0,42
1	P_{HC3}	0,58	2	S_{HC3}	0,42

Step 46: Publish the Decision Report

The decision report was published according to business development plan report bases. In this report, final ranks of Pareto optimal design alternatives were given according to the forecasting method based as one rank of three low cases and three high cases.

Henceforth the overall alternative ranking value for Pareto optimal design alternatives of Gelibolu Gemi Endustrisi Sanayi ve Ticaret A.S., that is the name of a legal entity of a shipyard in Turkey is *0,44* and the overall alternative ranking value for Pareto optimal design alternatives of a virtual feasibility evaluation of a virtual entity of port and shiprepair yard named as Virtual PORREP is *0,56*.

Both results were calculated by Equation 3.2.7. The overall OAR of each industry was calculated by weight of each case for each industry which was appointed by decision makers, the OAR of each PODA for each industry which was calculated as presented in current study and by the simple additive method mentality as formulated by Equation 3.2.7.

Moreover in this report sensitivity analysis should be performed to see the effects of variables on the OAR values.

In current case sensitivity analysis was performed to see the effect of ease of credit attribute evaluation change as shown in Figure 4.24.

This kind of sensitivity analysis should be performed for all variables and attributes.

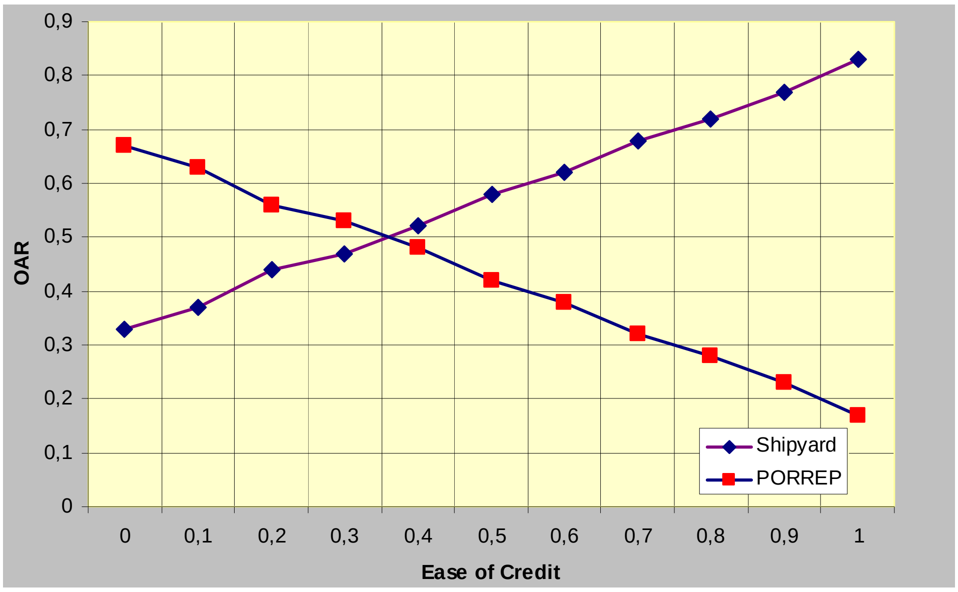


Figure 4.24 : Sensitivity analysis of ease of credit

Step 47: Send the Decision Report to Experts and Investors

The decision report in this case study was not sent to investors, however it was sent to experts.

This decision report normally should cover whole steps of this stage in the proposed method.

Step 48: The Final Decision

The final decision should be given after video conferencing or e-mail circulation of the decision report.

This step was not in the scope of this thesis.

The investors or the decision makers signature should be taken in this step. This could be done by digital signature or hard copy signature. A cover letter or a contract paper should be in detail prepared and signed by the decision makers.

Step 49: The Consensus Achieved

This step was not in the scope of this thesis.

In normal conditions while performing the Step 48, this step is also performed. Whenever any recommendation, rejection or hold, this should be given under written terms. If the consensus achived there will not be any recommendation, rejection or hold in the cover letter or in the contract paper. In the step, the most crusial action is to taking the cover letters or contract papers in written terms, to reduce the future problems the oral acceptance of oral holds, recommendations or rejections should not be accepted or prefered.

Step 50: Publish the Post-Decision Report

This step was not in the scope of this thesis.

This post-decision report normally should cover whole stages of the proposed method. All steps and stages should be described in detail including references. The material which is used for the analysis should be given as an enclosed file. In this report cover page, foreword, contents, acronyms, figures, tables, appendices and chapters sections should be presented. This report should be similar to MIL-STD-881B.

Step 51: INVESTMENT

This step was not in the scope of this thesis.

By finalizing Step 51 the new generic method for large investment analysis is finalized.

5. CONCLUSION AND RECOMMENDATIONS

The main purpose of current study was to achieve and to solve the common problems of investment analysis mentioned in the first section as given under the title of the statement of problem.

This last chapter summarizes the major achievements or step ups of the research. It combines the elements discussed in previous chapters, by discussing the accomplishments and shortcomings of the proposed method. Finally, it underlines and explains the way for the following research in this topic.

The statement of problem, the motivation of research study, the objectives or the goals of research foci, the scope of research study and overview of research study structure and finally thesis organization were given in Chapter 1, a review of relevant literature and the classification study of research topic is summarized in Chapter 2. The conceptual model of proposed method and its methodology is given in Chapter 3. A case study in shipbuilding industry and ship repair and port industry is presented to validate and to verify the proposed methodology and demonstrate its application.

In the real life, tycoons, investors, chief executives, experts in financial holdings, consultants, government agencies etc. who can be named as decision makers or even persons in personal life are constantly faced with the complex problems of selecting an alternative from a given set of finite number of alternatives and should make their own decisions. Hence the study of decision making processes has always one of a kind of research interest field. Investment analysis in any industry is one of the important examples for the decision making process. In investment decisions, depending on the conditions of world political, economical, social, legal etc. status, not only awareness of financial aspects but also other aspects has been taken into consideration.

Common problems of investment analysis in industries such as shipbuilding, shipping, energy, defense industry or logistics are to be;

- Mega-projects and mega-investments,

- Involvement of multiple objectives,
- Imprecise data,
- The mixture of fuzzy and crisp data,
- Involvement of multiple decision makers,
- Expert weighting,

The current research thesis discussed multiple attribute analysis related problems, multiple criteria optimization related problems, Pareto efficiency subjects, Executive Support Systems, financial statements and their usage, risk analysis topics, fuzzy logic problems to solve only one problem which was making correct decision in the investment analysis. One of the detailed classification study was conducted which investigated thirty four conspicuous electronic databases, ten well known online book shopping web sites such as Online books, Amazon were reviewed. The approaches and basic concepts were introduced and explained in detail literature review. A new generic method for large investment analysis in industry based on multi-objective optimization and fuzzy multi attribute decision making was explained and validated by executing a case study.

5.1 Contributions of the Research

The current thesis might be one of the *"cross-industry studies"*, which the main contributions are reached as given below. The most important contribution is undertaken to fill that gap in the field of decision making procedures and models of investment analysis knowledge. In general, the main research contributions are specifically:

I. A compendious and comprehensible framework for exploring, cataloguing, synthesizing and integrating existing literature were proffered by help of special survey analysis method which was built up in current thesis based on special techniques in the literature.

II. The various research foci such as decision making, management systems, investment analysis, industry applications and properties, mathematical and statistical methods, software and coding were identified and categorized.

III. The investment analysis decision or performance factors in several sectors were identified, explained in detail and grouped or re-grouped by help of a detailed classification study.

IV. A pros and cons analysis for the most widely used investment analysis were prepared.

V. A new procedure or technique or "*red tape*" for decision making at investment analysis were proposed based on the classification study which had been conducted in the literature review.

This method has the ability to combine all of the thoughts of all investment involvers and several type of analysis and methods.

VI. The system for building up an ESS based on the new proposed methodology was analyzed in the literature review and several software packages were recommended for this ESS.

A combined software packages can be adopted to built up this ESS, however the best way is to develop a new software which could be coded in windows based languages such as C++. This final stage which is software development is out of scope of the current thesis, however the base knowledge for developing of this software and different tools which should be available in this software were given in current thesis by help of literature review, the proposed method and the case study.

VII. A case study was conducted in shipbuilding and ship repair - port sector to illustrate how well the proposed method fits to real applications.

It has been realized that the method fits mostly the real world applications, however the execution takes more time than expected. This execution duration problem can only be solved by developing a software package which combines communication tools, mathematic tools, logic tools and decision tools inherently.

5.2 Recommendations for Future Research

In current study as explained in Sub-Section 1.3 and re-explained in Sub-Section 4.1, there have been several contributions reached. Moreover this thesis provided a theoretical and practical foundation of a new investment analysis model, which could be carried out as a base for future research and development. This thesis and the proposed approach should be executed in several industries to verify and to validate this new generic method, in addition it is very obvious that some steps of this generic method is very open for improvement. Some improvements that can be enhanced in the proposed methodology and some special important industries for the verification and for the execution are as the following:

- Step 4 should be improved in this new generic method for large investment analysis. In step 4, forecasts of the industry is taken from several resources and directly used in current method, however the most appropriate way is the develop a new forecasting method which takes the standard methods as a base and adopt these forecasting methods to the generic investment method. In current study, the first awkward footsteps of this philosophy was tried to be applied in the case study, however the forecasting method was not in the scope of this study, henceforth the most important "*bigfoot step*" is developing a new forecasting method.
- The special ESS as a software tool should be developed as which is one of the most important improvements of this current study. The software development is out of the scope of current study, henceforth this study did not cover the software development, however for ease of execution of this generic method for large investments, a new software should be developed in another study and should be adopted in different financial holdings, government agencies etc.

- This new generic method for large investment analysis should be executed in agriculture industry in at most 2 years time. Nowadays the most crucial agreements among countries are the land rent contracts (The durations in these contracts are almost 99 years) between developed countries and non-developed countries. This kind of action is named as neocolonialism. “Food and Agriculture Organization of the United Nations” research implies that these activities shall reshaped the world political status, moreover these activities will increase the malnutrition especially by the effect of increasing usage of bio-fuels. The United Nations statistics for undernutrition percentage by country is presented in Figure 5.1. Henceforth a new research study should be prepared and this new generic investment method should be executed in these cases to decide whether these activities are appropriate for the upper most objectives of the world or not.

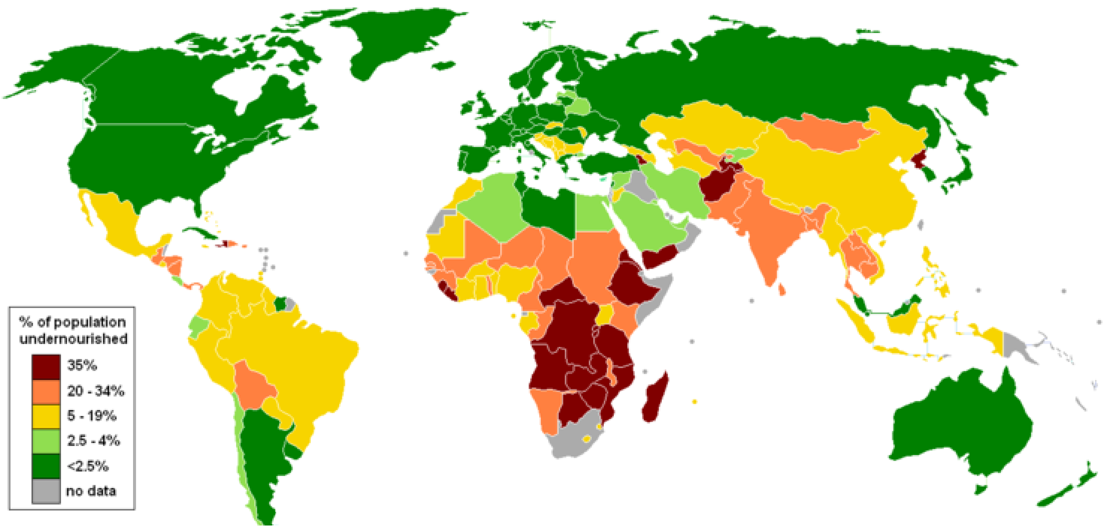


Figure 5.1 : Undernutrition by country -United Nations statistics, (Source: Url-13).

- This new generic method for large investment analysis should be executed in water management and fresh water generation industry in at most 5 years time. It is obvious that the fresh water for irrigation and potable purposes shall be decreased rapidly due to the fact of some climatic and enviromental reasons. The statistical data and related analysis proves that this shall be the most crucial problem of the world in almost 10 years time. This method for irrigation is now in investigation for improvement of water usage efficiency (Url-14). Henceforth a new research study should be prepared and this new generic investment method should be executed in case studies of water management and fresh water generation to decide how the fresh water resources could be improved and in what way fresh water could be generated according to the upper most objectives of the world.

Finally, with different case studies in different sectors and with improvements mentioned above, it shall be seen that the proposed method can efficiently help the investment decision makers to make their decisions as appropriate as possible in real world.

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APPENDICES

APPENDIX A. MANAGEMENT SYSTEMS CLASSIFICATION STUDY

Table A.1 : Management systems classification study information table.

		1st	2nd	3rd
		Name of Study	Authors' surname	Journal-Book Name
	YEAR			
1	1984	DSS Design	Bahl - Hunt	ACM SIGMIS Database
2	1988	Distributed Decision Making	Holsapple - Whinston	ACM SIGOIS Bulletin
3	1993	Computer Based Systems	Wilson et al	Association for Computing Machinery - ACM
4	1987	Reducing Managerial Risk	Hoplin	Association for Computing Machinery - ACM
5	2005	Improving Situation Awareness	Pott et al	ACM International Conference Proceeding
6	1996	Evaluating Ethical Decision	Loch - Conger	COMMUNICATIONS OF THE ACM
7	1996	A Comparative Study	Vlahos - Ferratt	ACM SIGCPR/ SIGMIS '96
8	1997	Effects Of Electronic Communication	Yoo	Association for Information Systems
9	1986	Communications Design for Co-oP	Bui - Jarke	ACM TRANSACTIONS ON OFFICE INFORMATION SYSTEMS
10	2001	System development a la MODDE	Meikle - Yearwood	ACM International Conference on Artificial Intelligence and Law
11	1984	Channel Selection & Effective	Trauth et. al	ACM TRANSACTIONS ON OFFICE INFORMATION SYSTEMS
12	1988	Computer-Based Systems	Kraemer - King	ACM Computing Surveys - ACM
13	1992	Computer Assisted Decision	Gerson et. al	ACM SIGCPR
14	1988	Computer Aided Petri	Kyratzoglou	IEEE Winter Simulation Conference Proceedings
15	2005	Competitive Intelligence Systems	Sauter - Free	Database for Advances in Information Systems
16	1999	Intuitive Decision-Making	Sauter	Communications of the ACM
17	1995	Goal Driven Business	Jacobs - Holten	ACM Conference on Organizational Computing Systems - Proceedings
18	1990	Expert Systems: True	Whitley	Proceedings of the 1990 ACM SIGBDP conference on Trends and directions in expert systems
19	2000	Use and Perceived	Vlahos et al	Proceedings of the 2000 ACM SIGCPR conference on Computer personnel research
20	1978	An Approach For	Carlson	ACM SIGMIS Database
21	2005	A Qualitative Empirical	Zannier - Maurer	Proceedings of the 2005 workshop on Human and social factors of software engineering
22	1999	Exploring the Boundaries	Vreede - Brujin	Database for Advances in Information Systems
23	1969	Management Information System	Weingart	Proceedings of the 1969 24th national conference
24	1984	Group Decision Support	DeSanctis - Gallupe	ACM SIGMIS Database
25	2005	VERN: Facilitating Democratic	Yardi - Hill - Chan	Proceedings of the 2005 international ACM SIGGROUP conference on Supporting group work
26	2002	An Architecture for	Forgionne	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
27	2002	Categorizing Decision Support	Power	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
28	2002	From Human Decision	Pomerol - Adam	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
29	2002	Procedural Cuing Using	Hope	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
30	2002	Innovative Features in	Findler	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
31	2002	Knowledge Warehouse: An	Nemati et. al	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
32	2002	Understanding the process	Mora et al.	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
33	2002	Knowledge Management - Sharing	Yew et. al	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
34	1994	A functional taxonomy	Mentzas	International Journal of Operations & Production Management

Table A.1 (continued) **:** Management systems classification study information table.

	4th	5th	6th	7th		8th		9th	10th	11th	12th
	Journal Origin	Main Group	Sub Group	Research Level		Research Approach		Impact Level	Key Term	Key Term	Key Term
				Macro	Micro	Emprical	Non-Emprical				
	NA	Management Systems	Software and coding	F	G	I		MT	DSS		
1	NA	Management Systems	Software and coding	F	G	I		MT	DSS	OA	
2	NA	Management Systems	Decision Making	S	G		C	LT	CBS	KB-DSS	
3	NA	Management Systems	Decision Making	S	G		C	LT	AI	ES	
4	EU	Management Systems	Software and coding	I	G	I		MT	DSS	SA	OT
5	NA	Management Systems	Decision Making	S	G		M	MT	DSS		
6	NA	Management Systems	Software and coding	S	G		M	MT	DSS	EIS	OIS
7	NA	Management Systems	Decision Making	S	G		M	MT	ECT	GSS	
8	NA	Management Systems	Software and coding	S	G	I		LT	GDSS	MCDM	IDSS
9	NA	Management Systems	Software and coding	I	G	I		LT	DSS	SIS	
10	NA	Management Systems	Decision Making	S	G		M	MT	MIS		
11	NA	Management Systems	Decision Making	S	G	D		LT	GDSS	CSCW	
12	NA	Management Systems	Decision Making	S	G	I		MT	DSS	NPV	
13	NA	Management Systems	Software and coding	S	G		C	MT	DMO	DDMO	
14	NA	Management Systems	Software and coding	F	G		C	MT	DSS	KM	CIS
15	NA	Management Systems	Decision Making	S	G		C	MT	DSS		
16	NA	Management Systems	Software and coding	S	I		C	MT	KM		
17	NA	Management Systems	Software and coding	F	I		M	MT	ES		
18	NA	Management Systems	Software and coding	S	G		M	MT	DSS	EIS	OIS
19	NA	Management Systems	Software and coding	S	I	I		MT	DSS		
20	NA	Management Systems	Software and coding	S	I	I		MT	DSS	IBIS	
21	NA	Management Systems	Software and coding	S	G	I		LT	GSS	outside the box contributers	
22	NA	Management Systems	Software and coding	F	I		C	LT	MIS		
23	NA	Management Systems	Software and coding	F	G		C	MT	GDSS	LDN	
24	NA	Management Systems	Software and coding	F	G		C	ST	GDSS	unconstrained democracy	groupware
25	NA	Management Systems	Decision Making	S	G		C	ST	IDSS	WDSS	DTS
26	NA	Management Systems	Decision Making	S	G		C	ST	DSS	taxonomies	typologies
27	NA	Management Systems	Decision Making	S	G		C	LT	DSS	look ahead reasoning	what-if analysis
28	NA	Management Systems	Software and coding	S	I		C	LT	ESS	DMSS	
29	NA	Management Systems	Software and coding	F	I		C	ST	DSS	DDSS	DAI
30	NA	Management Systems	Decision Making	S	I		C	MT	KW	GSS	KBMS
31	NA	Management Systems	Decision Making	S	I		C	MT	DMSS		
32	NA	Management Systems	Decision Making	S	I		C	MT	KMS	OLAP	TKB - BKB
33	NA	Management Systems	Decision Making	S	G		C	MT	ODSS	IOIS	EMS
34	NA	Management Systems	Software and coding	S	G		C	LT	DSS	MIS	KBS

Table A.1 (continued) **:** Management systems classification study information table.

		1st	2nd	3rd
		Name of Study	Authors' surname	Journal-Book Name
	YEAR			
35	1999	Essentials of management	Laudon - Laudon	Essentials of management information systems - Prentice hall
36	2002	Spatial Decision Support	Keenan	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
37	2002	DSS for Rescheduling	Dfaz et al	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
38	2002	Using Decision Support	Rinaldi - Bain	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
39	2002	On the Ontology	Nykanen	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
40	2002	Knowledge Management Support	Gibson	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
41	2002	Customer Relationship Management	Watson - Volonino	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
42	2002	Ripple Down Rules	Macquarie	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
43	2002	Intelligent Support Framework	Chandra	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
44	2002	How synthetic characters	Pistolesi	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
45	2002	Using Narratives To	Freeman	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
46	2002	Quality Factors for	Webb - Yadav	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
47	2002	Executive Information Systems	Roldan - Leal	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
48	2002	Critical Factors in	Adam - Pomerol	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
49	2002	DMSS Implementation Research	Mora et al.	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
50	2002	Evacuation Planning and	Silva et. al	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
51	2002	Decision Making Support	Forgionne et. al.	Decision-Making Support Systems: Achievements, Trends and Challenges for the New Decade
52	1993	Factors that Affect	Gordon - Gordon	Proceedings of the ACM SIGCPR Conference
53	2000	Information Technology Governance	Peterson et. al.	International Conference on Information Systems - ACM
54	2006	An empirical study	Li et. al.	Proceedings - International Conference on Software Engineering - ACM
55	1990	Development of an	Byrd and Hauser	Proceedings of the 1990 ACM SIGBDP conference on Trends and directions in expert systems - ACM
56	1992	The relationship between	Sambamurthy et al.	Association for Computing Machinery - ACM
57	2004	A sow herd	Pla et. al.	Computers and Electronics in Agriculture - Elsevier
58	2001	Expert versus Novice	Hung	Proceedings of the 34th Hawaii International Conference on System Sciences-IEEE
59	2002	Challenges in COTS	Alves - Finkelstein	Proceedings of the 14th international conference on Software engineering and knowledge engineering - ACM
60	1991	Integrating expert systems	Aiken et. al.	ACM Transactions on Information Systems - ACM
61	1989	DSS: is it	Venkatraman	ACM SIGCPR Computer Personnel - ACM
62	2004	GIS-based decision	Rao et. al.	Current Science -Bangalore- Current Science Assoc / Indian Academy of Sciences
63	1986	The information transfer	Welsch	ACM SIGMIS Database - ACM
64	1999	The equalizing impact	Tan et. al.	ACM Transactions on Information Systems (TOIS) - ACM
65	1982	A GPSS model	Charalambides	Proceedings of the 14th conference on Winter Simulation - Winter Simulation Conference
66	1997	A decision making	Rosca	Proceedings of the Third IEEE International Symposium - IEEE
67	1986	Computer-Based Systems	Kraemer - King	Proceedings of the 1986 ACM conference on Computer-supported cooperative work - ACM
68	1994	Using electronic group	Zack	Conference companion on Human factors in computing systems - ACM
69	1997	Designing management support	Dutta et. al.	Communications of the ACM - ACM
70	1992	Integrating territories: information	Lee - Madnick	Proceedings of the 1992 ACM SIGCPR conference on Computer personnel research - ACM

Table A.1 (continued) **:** Management systems classification study information table.

	4th	5th	6th	7th		8th		9th	10th	11th	12th
	Journal Origin	Main Group	Sub Group	Research Level		Research Approach		Impact Level	Key Term	Key Term	Key Term
				Macro	Micro	Emprical	Non-Emprical				
35	NA	Management Systems	Software and coding	S	G		C	LT	DSS	MIS	KBS
36	NA	Management Systems	Software and coding	S	I		C	ST	SDSS	GIS	
37	NA	Management Systems	Software and coding	F	I		C	ST	DSS	heuristic	
38	NA	Management Systems	Software and coding	F	I		C	LT	DSS	MCDM	MCDA
39	NA	Management Systems	Software and coding	I	I		C	MT	DSS	ISS	KBA
40	NA	Management Systems	Decision Making	I	I		C	MT	KM	DSS	
41	NA	Management Systems	Software and coding	F	G		C	ST	CRM	DSS	B2B & B2C
42	NA	Management Systems	Decision Making	S	I		C	MT	HCI	KBS	DSS
43	NA	Management Systems	Software and coding	I	I		C	MT	IE	DSS	
44	NA	Management Systems	Software and coding	I	I		C	LT	DMSS	DBMS	MBMS
45	NA	Management Systems	Software and coding	I	I		C	MT	NBIS	IT	DSS
46	NA	Management Systems	Decision Making	S	I		C	MT	DSSR	DMSS	
47	NA	Management Systems	Decision Making	S	I	D		MT	EIS	ESS	
48	NA	Management Systems	Software and coding	S	I		C	MT	CSF	GUI	OLAP
49	NA	Management Systems	Decision Making	S	I		C	MT	DMSS	SDP	FBA
50	NA	Management Systems	Decision Making	S	I		C	MT	GIS	GPS	RPD
51	NA	Management Systems	Decision Making	S	I		C	MT	DMSS	EIS	
52	NA	Management Systems	Software and coding	S	G	I		MT	DDBMS	MIS	
53	NA	Management Systems	Software and coding	S	G	I		MT	CIT	DIT	BM
54	NA	Management Systems	Software and coding	I	I		C	MT	CBSD	OSS	COTS
55	NA	Management Systems	Decision Making	S	I	D		MT	DSS	AI	ES
56	NA	Management Systems	Software and coding	S	I	D		MT	MIS	IT	
57	NA	Management Systems	Mathematical and statistical methods	I	I		M	LT	DSS	GUI	
58	NA	Management Systems	Software and coding	S	I	I		MT	ESS		
59	NA	Management Systems	Software and coding	S	I		C	MT	COTS	AHP	WSM
60	NA	Management Systems	Decision Making	S	G		C	LT	GDSS	ES	DBMS
61	NA	Management Systems	Decision Making	S	I		C	LT	GDSS	MIS	PPS
62	AS	Management Systems	Software and coding	S	I		C	MT	DSS	GIS	
63	NA	Management Systems	Decision Making	S	I		C	LT	DSS	MIS	ITS
64	NA	Management Systems	Decision Making	S	I		M	LT	GSS		
65	NA	Management Systems	Software and coding	S	G		M	MT	GPSS	CQS	CSE
66	NA	Management Systems	Decision Making	S	I		C	MT	DSS		
67	NA	Management Systems	Decision Making	S	G	D		LT	GDSS	EIS	
68	NA	Management Systems	Decision Making	S	I		C	MT	DSC	UIDT	
69	NA	Management Systems	Decision Making	S	I		C	MT	DSS	MSS	
70	NA	Management Systems	Decision Making	S	I		C	MT	DBMS	DM	

APPENDIX B. DECISION MAKING CLASSIFICATION STUDY

Table B.1 : Decision making classification study information table.

		1st	2nd	3rd
		Name of Study	Authors' surname	Journal-Book Name
	YEAR			
1	2006	An integrated multi	Olcer et. al	Applied Soft Computing Journal
2	2005	ELECTRE Methods	Figueira et. al.	Multiple Criteria Decision Analysis: State of the Art Surveys
3	2005	PROMETHEE Methods	Brans - Mareschal	Multiple Criteria Decision Analysis: State of the Art Surveys
4	2005	Other Outranking Approaches	Martel - Matarazzo	Multiple Criteria Decision Analysis: State of the Art Surveys
5	1983	On the problem	Vansnick	European Journal of Operational Research
6	1984	Propositions d'extensions	Leclercq	Revue Belge de Recherche Operationnelle de Statistique et d' Informatique
7	1997	A new PCCA	Greco	European Journal of Operational Research
8	1998	Passive and Active	Giarlotta	Journal of Multi-Criteria Decision Analysis
9	1997	Modeling Preferences Using	Martel - Zaras	International Conference on Methods and Applications of Multicriteria Decision Making
10	1982	Assessing a set	Lagrèze - Siskos	European Journal of Operational Research
11	1985	UTASTAR: An ordinal	Siskos - Yannacopoulos	Investigação Operacional
12	1990	A review of	Despotis et. al.	Foundations of Computing and Decision Sciences
13	2001	Comparative analysis of	Beuthe et. al.	European Journal of Operational Research
14	1983	Analyse de systèmes	Siskos	Foundations of Control Engineering
15	1982	Assessing a set	Jacquet-Lagrèze	European Journal of Operational Research
16	2000	Building additive utilities	Zopounidis - Doumpos	Optimization Methods and Software-Taylor & Francis Journals
17	1980	The analytical hierarchial	Saaty	The Analytical Hierarchial Process, New York, Wiley
18	1999	Fundamentals of the	Saaty	ISAHP 1999
19	1995	General overview of	Bana e Costa - Vansnick	Advances in Multicriteria Analysis
20	2006	Decision Making with	Saaty - Vargas	Decision Making with the Analytic Network Process - Springer Science+Business Media, LLC
21	2001	Ordinal multiattribute sorting	Roubens	Aiding Decisions with Multiple Criteria:Essays in Honour of Bernard Roy-Kluwer Academic
22	1995	A method and	Larichev - Moshkovich	European Journal of Operational Research
23	2001	Ranking multicriteria alternatives	Larichev	European Journal of Operational Research
24	2002	Ordinal judgments for	Moshkovich et. al.	European Journal of Operational Research
25	1994	An approach to	Larichev - Moshkovich	International Transactions of Operational Research
26	2002	Multicriteria decision aid	Doumpos - Zopounidis	Multicriteria Decision Aid Classification Methods, Kluwer Academic Publishers. Dordrecht
27	2003	Development of Software	Zavadskas et. al.	Institute of Mathematics and Informatics, INFORMATICA
28	2006	Incorporating multiple criteria	Moffett - Sarkar	Diversity and Distributions
29	2004	Business economics and	Jones	John Wiley & Sons, LTD. New York
30	2002	What every engineer	Wang	Marcel Dekker AG. Basel, Switzerland
31	2002	Guidebook to decision	Baker et. al.	Guidebook to decision-making methods
32	1995	Multiple attribute decision	Yoon and Hwang	Multiple attribute decision making an introduction, Sage university paper
33	1981	Multiple attribute decision	Yoon and Hwang	Multiple attribute decision making: methods and applications
34	2004	Decision analysis for	Goodwin and Wright	Decision analysis for management judgment. John Wiley & Sons Ltd

Table B.1 (continued) **:** Decision making classification study information table.

	4th	5th	6th	7th		8th		9th	10th	11th	12th
	Journal Origin	Main Group	Sub Group	Research Level		Research Approach		Impact Level	Key Term	Key Term	Key Term
				Macro	Micro	Emprical	Non-Emprical				
1	NA	Decision Making	Mathematical and Statistical Methods	I	G	I		ST	MCDM	FMAGDM	MOGA
2	NA	Decision Making	Mathematical and Statistical Methods	S	G	I		ST	MARSAN	ELECTRE	
3	NA	Decision Making	Mathematical and Statistical Methods	S	G	I		ST	PROMETHEE	GAIA	
4	NA	Decision Making	Mathematical and Statistical Methods	S	G	I		ST			
5	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	TACTIC		
6	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	MELCHIOR		
7	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	IDRA		
8	NA	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	PACMAN		
9	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	Martel and Zaras		
10	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	UTA		
11	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	UTASTAR		
12	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	UTA		
13	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	UTA		
14	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	UTA		
15	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	UTADIS		
16	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	MHDIS		
17	NA	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	AHP		
18	AS	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	ANP		
19	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	MACBETH		
20	NA	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	ANP		
21	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	TOMASO		
22	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	ZAPROS		
23	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	ZAPROS III		
24	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	STEP-ZAPROS		
25	NA	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	ORCLASS		
26	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	logit analysis	probit analysis	LDA
27	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	Wald's rule	Hurwicz's rule	Hodges-Lehmann rule
28	NA	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	Modified AHP	CANs	NDS
29	NA	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	Risk and Uncertanity		
30	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	uncertanity	decision tree	
31	NA	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	K-T method	AHP	SMART
32	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	SAW	Maximin	Maximax
33	NA	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	TOPSIS		
34	EU	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	SMART	AHP	

Table B.1 (continued) **:** Decision making classification study information table.

		1st	2nd	3rd
		Name of Study	Authors' surname	Journal-Book Name
	YEAR			
35	2005	The next wave	Golden et. al.	The next wave in computing, optimization, and decision technologies. Springer Science + Business Media, Inc.
36	2005	Paradigms and Challenges	Roy	Multiple Criteria Decision Analysis: State of the Art Surveys
37	2005	Preference Modelling	Ozturk et al	Multiple Criteria Decision Analysis: State of the Art Surveys
38	2005	Conjoint Measurement Tools	Bouyssou - Pirlot	Multiple Criteria Decision Analysis: State of the Art Surveys
39	2006	A methodology to	Sassenburg	International Conference on Software Engineering (ACM)
40	1994	Preference-based decision	Wong	ACM Transactions on Information Systems (TOIS)
41	1997	Decision Making In	Stephanidis et. al.	International Conference on Intelligent User Interfaces, Proceedings IUI (ACM)
42	2001	Decision Making It	Mintzberg - Westley	MT Sloan Management Review (ABI/INFORM Global)
43	1997	A comprehensive model	McLeod	International Conference on Information Systems - ACM
44	2002	Challenges in COTS	Alves-Finkelstein	Proceedings of the 14th international conference on Software engineering and knowledge engineering - ACM
45	1998	A comparative investigation	Cappel-Windsor	ACM SIGMIS Database - ACM
46	2001	Dynamic reorganization	Barber-Martin	International Conference on Autonomous Agents - ACM
47	2005	Strategic decision making	Yim - Choi	ACM International Conference Proceeding Series - ACM
48	1980	New directions in	Sherman	ACM SIGUCCS Newsletter - ACM
49	2002	Statements of core	Harris et. al.	Journal of Computing Sciences in Colleges
50	1973	Simulation of an	Tuggle et. al.	Winter Simulation Conference
51	1996	Decision making: a	Albers	ACM Special Interest Group for Design of Communication - ACM
52	2001	Modelling and improving	Robinson et. al.	IEEE Computer Society
53	2005	Towards a simulation	Chin	Winter Simulation Conference
54	2000	Decision making support	Mason - Moffat	Society for Computer Simulation International
55	1984	Simulation of a	Kimbler - Bennett	IEEE Press
56	2004	On-demand data	Sharaf - Chrysanthis	Kluwer Academic Publishers
57	1985	A decision making	Yaverbaum	ACM SIGCSE Bulletin - ACM
58	1977	Simulation analysis of	Eliashberg - Day	Winter Simulation Conference
59	1993	Simulation for real	Rogers	Association for Computing Machinery - ACM
60	2001	Decision making using	Xianglong et. al.	IEEE Computer Society
61	2002	Sequential cost-sensitive	Pednault et. al.	Association for Computing Machinery - ACM
62	1999	Is the east	Teng et. al.	Association for Information Systems
63	1999	Fuzzy rule extraction	Zheng - Kainz	Association for Computing Machinery - ACM
64	1983	Computer communication system	Murrel	Association for Computing Machinery - ACM
65	1994	Approximate methods for	Chung	Association for Computing Machinery - ACM
66	2006	Moral intensity and	Goles et. al.	Association for Computing Machinery - ACM
67	2006	Managing stakeholder involvement	Edelenbos - Klijn	Journal of Public Administration Research and Theory
68	1997	The effects of	Speier et. al.	Proceedings of the eighteenth international conference on Information systems -Association for Information Systems
69	2002	Qualitative decision theory	Dubois et. al.	Journal of the ACM - ACM
70	2000	Emotion, cognition, and	Schwarz	Cognition and Emotion - Psychology Press - Taylor & Francis Journals

Table B.1 (continued) **:** Decision making classification study information table.

	4th	5th	6th	7th		8th		9th	10th	11th	12th
	Journal Origin	Main Group	Sub Group	Research Level		Research Approach		Impact Level	Key Term	Key Term	Key Term
				Macro	Micro	Emprical	Non-Emprical				
35	NA	Decision Making	Mathematical and Statistical Methods	S	G	I		LT	integer programing	mixed integer	
36	NA	Decision Making	Mathematical and Statistical Methods	S	I	D		ST	DA	MCDA	MCAP
37	NA	Decision Making	Mathematical and Statistical Methods	S	I	D		ST	DM		
38	NA	Decision Making	Mathematical and Statistical Methods	S	I	D		ST	DM		
39	NA	Decision Making	Management Systems	S	I		C	ST	SM		
40	NA	Decision Making	Management Systems	S	G		C	ST	AI		
41	NA	Decision Making	Management Systems	S	I	I		LT	ADS	PARs	
42	NA	Decision Making	Management Systems	S	I	D		ST	DM		
43	NA	Decision Making	Management Systems	S	G		C	MT	GDM		
44	NA	Decision Making	Management Systems	I	I		C	MT	COTS	OTSO	WSM
45	NA	Decision Making	Management Systems	S	G	I		LT	IS		
46	NA	Decision Making	Management Systems	I	G		C	LT	DMF		
47	NA	Decision Making	Management Systems	S	G		C	MT	BI	KM	RTE
48	NA	Decision Making	Management Systems	S	G		C	MT	DM		
49	NA	Decision Making	Management Systems	F	G	D		MT	IT		
50	NA	Decision Making	Software and Coding	S	I	D		MT	SIDIP	PBG	
51	NA	Decision Making	Management Systems	S	I		C	MT	Mental Models	Heuristic Choices	
52	NA	Decision Making	Management Systems	F	I	I		MT	AI		
53	NA	Decision Making	Management Systems	I	G	D		MT	DM		
54	NA	Decision Making	Management Systems	I	G	D		MT	C2		
55	NA	Decision Making	Management Systems	F	I		M	ST	DM		
56	NA	Decision Making	Management Systems	I	I		M	MT	OLAP		
57	NA	Decision Making	Management Systems	I	I	D		MT	MIS		
58	NA	Decision Making	Management Systems	S	G		C	MT	expert power	group bayesian	
59	NA	Decision Making	Management Systems	I	I		C	MT	AI	DM	
60	NA	Decision Making	Mathematical and Statistical Methods	F	I		M	LT	MDP	SMDP	DP
61	NA	Decision Making	Mathematical and Statistical Methods	F	I		M	LT	MDP		
62	NA	Decision Making	Management Systems	S	I	I		MT	OC	GSS	
63	NA	Decision Making	Mathematical and Statistical Methods	S	I		M	MT	NFN	GIS	
64	NA	Decision Making	Management Systems	S	G	I		LT	Teleconferencing		
65	NA	Decision Making	Mathematical and Statistical Methods	S	I		M	LT	expert advice		
66	NA	Decision Making	Management Systems	S	I	I		LT	IS		
67	NA	Decision Making	Management Systems	S	I		C	LT	DM		
68	NA	Decision Making	Management Systems	S	I	I		MT	DM	DSS	
69	NA	Decision Making	Mathematical and Statistical Methods	S	I		M	MT	AI	DMU	
70	NA	Decision Making		S	I		C	MT	post decision		

APPENDIX C. INVESTMENT ANALYSIS CLASSIFICATION STUDY

Table C.1 : Investment analysis classification study information table.

		1st	2nd	3rd	4th
		Name of Study	Authors' surname	Journal-Book Name	Journal Origin
	YEAR				
1	2002	Investment Valuation: Tools	Damodaran	Investment Valuation: Tools and Techniques for Determining the Value of Any Asset	NA
2	2001	Quantitative Business Valuation	Abrams	Quantitative business valuation: a mathematical approach for today's professionals	NA
3	1996	A comparison of	Penman and Sougiannis	A comparison of dividend, cash flow, and earnings approaches to equity valuation	NA
4	2003	Accounting for managers	Collier	Accounting for managers:interpreting accounting information for decision-making	NA
5	2001	Fundamentals of corporate	Brealey et.al.	Fundamentals of corporate finance	NA
6	2005	Cash flow sensitivity	Hovakimian and Hovakimian	SSRN	NA
7	1994	Damodaran on valuation	Damodaran	Damodaran on valuation: security analysis for investment and corporate finance, study guide	NA
8	2003	Investment philosophies: successful	Damodaran	Investment philosophies: successful strategies and the investors who made them work	NA
9	2000	Economic and financial	Ardalan	Economic and financial analysis for engineering and project management	NA
10	1996	Engineering economics and	Park and Tippett	Engineering economics and project management	NA
11	1997	The agile manager's	Straub	The agile manager's guide to understanding financial statements	NA
12	1988	The financial analyst's	Levine	The financial analyst's handbook	NA
13	2001	Financial analysis: tools	Helbert	Financial analysis: tools and techniques a guide for managers	NA
14	2003	Foundations of risk	Aven	Foundations of risk analysis a knowledge and decision-oriented perspective	NA
15	1998	Handbook of modern	Logue	Handbook of modern finance	NA
16	1999	How to read	Tracy	How to read a financial report wringing vital signs out of the numbers	NA
17	1995	Modern portfolio theory	Elton and Gruber	Modern portfolio theory and investment analysis	NA
18	2006	Investors in your	Advani	Investors in your backyard how to raise business capital from the people you know	NA
19	1998	Investment science	Luenberger	Investment science	NA
20	2003	Process engineering	Couper	Process engineering economics	NA
21	2004	The Mathematics of	Focardi and Fabozzi	The Mathematics of Financial Modeling and Investment Management	NA
22	2002	Charting in Excel	Gubta	Charting in Excel	NA
23	1998	Optimisation of hybrid	Hochmuth	Optimisation of hybrid energy systems sizing and operation control	NA
24	1996	Principles of corporate	Brealey and Stewart	Principles of corporate finance	NA
25	2006	Introduction to management	Taylor	Introduction to management science	NA
26	2001	Technical analysis: power	Appel	Technical analysis: power tools for active investors	NA
27	2003	Trade, investment, and	The World Bank Report	Trade, investment, and development in the Middle East and North Africa engaging with the World	NA
28	2003	Essentials of financial	Friedlob and Schleifer	Essentials of financial analysis	NA
29	2006	Investment analysis and	Reilly and Brown	Investment analysis and portfolio management	NA
30	2007	A real option	Kjaerland	Energy Policy	NA
31	2006	An investment analysis	Manalo	Management of Innovation and Technology	NA
32	2006	Analysis of currency	Shetty and Manley	Managerial Finance	NA
33	2007	Cost/Benefit analysis	Limbu et.al.	Power Engineering Society General Meeting	NA
34	2006	Cost-effectiveness analysis	Qi et. al.	Management of Innovation and Technology	NA

Table C.1 (continued) **:** Investment analysis classification study information table.

	4th	5th	6th	7th		8th		9th	10th	11th	12th
	Journal Origin	Main Group	Sub Group	Research Level		Research Approach		Impact Level	Key Term	Key Term	Key Term
				Macro	Micro	Emprical	Non-Emprical				
1	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	ROA	ROE	EBIT
2	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	EBIBAT	CARs	CAPM
3	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	DCF	DDM	
4	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	ROCE	PBIT	EBITDA
5	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	DOL	ROE	EBITDA
6	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	IRR		
7	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	EBIT	EBITDA	IRR
8	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	EBIT	EBITDA	PBV
9	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	payback period	NPW	IRR
10	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	NPV	IRR	PV
11	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	income tax	acid-test ratio	ratio of net income to net sales
12	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	ROR		
13	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	EBIT	EBITDA	EBIAT
14	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	NPV	IRR	
15	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	FV	PV	AW
16	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	EBIT	ROE	ROA
17	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	FV	PV	AW
18	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	income tax	payback period	
19	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	IRR	NPV	AW
20	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	POP	NPW	ROA
21	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	CAPM		
22	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	PV	NPW	IRR
23	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	LCC	NPW	
24	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	NPV	IRR	EBIT
25	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	NPV	IRR	EBIT
26	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	EBIT		
27	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	GDP		
28	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	ROA	EPS	P/E
29	NA	Investment Analysis	Mathematical and Statistical Methods	S	I	D	M	LT	P/E	EBIT	EBT
30	NA	Investment Analysis	Industry Applications and Properties	S	I	D	M	LT	NPV		
31	NA	Investment Analysis	Industry Applications and Properties	S	I	D	M	LT	CAPEX	IRR	NPV
32	NA	Investment Analysis	Industry Applications and Properties	S	I	D	M	LT	SMI Index		
33	NA	Investment Analysis	Industry Applications and Properties	S	I	D	M	LT	NPV	IRR	
34	NA	Investment Analysis	Industry Applications and Properties	S	I	D	M	LT	NPV		

Table C.1 (continued) **:** Investment analysis classification study information table.

		1st	2nd	3rd	4th
		Name of Study	Authors' surname	Journal-Book Name	Journal Origin
	YEAR				
35	2006	Probabilistic cost benefit	Limbu et.al.	Power Engineering Society General Meeting	NA
36	2004	Evaluation of investments	Botterud	Probabilistic Methods Applied to Power Systems	NA
37	2002	Financial decisions and	Alonso et. al.	Applied Financial Economics	NA
38	2002	High risk and	Bruss and Ferguson	Department of Statistics	NA
39	2007	Strategic investment decision	Alkaraan and Northcott	Qualitative Research in Accounting & Management	NA
40	2000	Software economics: a	Boehm and Sullivan	Software economics: a roadmap	NA

Table C.1 (continued) **:** Investment analysis classification study information table.

	4th	5th	6th	7th		8th		9th	10th	11th	12th
	Journal Origin	Main Group	Sub Group	Research Level		Research Approach		Impact Level	Key Term	Key Term	Key Term
				Macro	Micro	Emprical	Non-Emprical				
35	NA	Investment Analysis	Industry Applications and Properties	S	I	D	M	LT	PPC	NPV	
36	NA	Investment Analysis	Industry Applications and Properties	S	I	D	M	LT	NPV	SDP	EVPI
37	NA	Investment Analysis	Industry Applications and Properties	S	I	D	M	LT	NPV	PER	
38	NA	Investment Analysis	Industry Applications and Properties	S	I	D	M	LT	NPV		
39	NA	Investment Analysis	Industry Applications and Properties	S	I	D	M	LT	NPV	ROI	EVA
40	NA	Investment Analysis	Industry Applications and Properties	S	I	D	M	LT	NPV		

APPENDIX D. MATHEMATICAL AND STATISTICAL METHODS CLASSIFICATION STUDY

Table D.1 : Mathematical and statistical methods classification study information table.

		1st	2nd	3rd	4th
		Name of Study	Authors' surname	Journal-Book Name	Journal Origin
	YEAR				
1	1996	Measuring manufacturing competence	Azzone - Rangone	International Journal of Production Research	NA
2	1977	Rating and ranking of	Baas - Kwakernaak	Automatica	NA
3	1979	Comparison of fuzzy	Baldwin - Guild	Fuzzy Sets and Systems	NA
4	1993	Combination of fuzzy	Bardossy et. al.	Fuzzy Sets and Systems	NA
5	1997	Implementation of a	Bellehumeur et. al.	Journal of Environmental Management	NA
6	1970	Decision-making in	Bellman - Zadeh	Management Science	NA
7	1982	A fuzzy sets	Bonissone	Approximate Reasoning in Decision Analysis	NA
8	1984	Promethee : a new	Brans et. al.	Proc. of the 10th IFORS International Conference on Operational Research	EU
9	1985	Fuzzy hierarchical analysis	Buckley	Fuzzy Sets and Systems	NA
10	1996	Application of the	Chang	European Journal of Operational Research	EU
11	1994	A fuzzy multi-criteria	Chang - Chen	Fuzzy Sets and Systems	NA
12	1992	Fuzzy multiple attribute	Chen - Hwang	Fuzzy multiple attribute decision making methods and applications	NA
13	1994	A new method	Chen	Cybernetics and Systems	NA
14	1997	A new method	Chen	Fuzzy Sets and Systems	NA
15	1989	Techniques for handling	Chen et. al.	Proc.of the 4th international symposium on computer and information sciences	EU
16	1995	A new method	Chen - Lin	Proc. Of 1995 artificial intelligence workshop	AS
17	1980	An algorithm for	Cheng - McInnis	IEEE Transactions on Systems, Man and Cybernetics	NA
18	1983	Ranking of fuzzy	Dubois - Prade	Information Sciences	NA
19	1984	Fuzzy logics and	Dubois - Prade	Cybernic Systems	NA
20	1988	Weighted fuzzy pattern	Dubois et al.	Fuzzy Sets and Systems	NA
21	1979	A practical development	Efstathiou	PhD Thesis	NA
22	1979	Multiattribute decision making	Efstathiou - Rajkovic	IEEE Transactions on Systems, Man and Cybernetics	NA
23	1999	Approach to decision	Ekel	Computers and mathematics with applications	NA
24	1990	Uncertainties are better	Fang - Chen	AAPG Bulletin	NA
25	2000	A fuzzy outranking	Güngör - Arikan	Fuzzy Sets and Systems	NA
26	1996	Aggregation of fuzzy	Hsu - Chen	Fuzzy Sets and Systems	NA
27	1993	The max-min delphi	Ishikawa et. al.	Fuzzy Sets and Systems	NA
28	1988	A soft measure	Kacprzyk - Fedrizzi	European Journal of Operational Research	NA
29	1992	Group decision making	Kacprzyk et. al.	Fuzzy Sets and Systems	NA
30	1998	A two-phase	Karsak	Production Planning & Control	NA
31	1982	A case history	Kirkwood	Journal of the Operational Research Society	NA
32	1979	An algorithm for	Kwakernaak	Automatica	NA
33	1983	A fuzzy extension	Laarhoven - Pedrycz	Fuzzy Sets and Systems	NA
34	1990	Fuzzy logic in	Lee	IEEE Transactions on Systems, Man and Cybernetics	NA
35	1988	Comparison of fuzzy	Lee - Li	Computers and mathematics with applications	NA

Table D.1 (continued) **:** Mathematical and statistical methods classification study information table.

	5th	6th	7th		8th		9th	10th	11th	12th
	Main Group	Sub Group	Research Level		Research Approach		Impact Level	Key Term	Key Term	Key Term
			Macro	Micro	Emprical	Non-Emprical				
1	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
2	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
3	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
4	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
5	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
6	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
7	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
8	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
9	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
10	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
11	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
12	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
13	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
14	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
15	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
16	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
17	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
18	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
19	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
20	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
21	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
22	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
23	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
24	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
25	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
26	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
27	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
28	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
29	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
30	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
31	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
32	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
33	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
34	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
35	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		

Table D.1 (continued) **:** Mathematical and statistical methods classification study information table.

		1st	2nd	3rd	4th
		Name of Study	Authors' surname	Journal-Book Name	Journal Origin
	YEAR				
35	1988	Comparison of fuzzy	Lee - Li	Computers and mathematics with applications	NA
36	1996	Group decision making	Lee	Fuzzy Sets and Systems	NA
37	1991	A fuzzy multi	Liang - Wang	International Journal of Production Research	NA
38	2000	A fuzzy-logic	Machacha - Bhattacharya	IEEE Transactions on Engineering Management	NA
39	1988	A fuzzy decision	Maeda - Murakami	Information Sciences	NA
40	1989	Fuzzy analysis and	Negi	PhD Thesis	NA
41	1981	Approaches to collective	Nurmi	Fuzzy Sets and Systems	NA
42	1998	A reference framework	Perego - Rangone	International Journal of Production Research	NA
43	1999	Ranking of Indian	Ravi - Reddy	Fuzzy Sets and Systems	NA
44	1993	Application of support	Ribeiro	PhD Thesis	NA
45	1996	Fuzzy multiple attribute	Ribeiro	Fuzzy Sets and Systems	NA
46	1995	A multiple attribute	Ribeiro - Baldwin	Fuzzy Logic and Soft Computing	NA
47	1977	Partial preference analysis	Roy	Conflicting Objectives in Decisions	NA
48	1999	Using artificial intelligence	Siskos et. al.	European Journal of Operational Research	EU
49	1982	Interactive identification of	Takeda	Fuzzy Information and Decision Processes	NA
50	1984	Fuzzy preference orderings	Tanino	Fuzzy Sets and Systems	NA
51	1996	A group decision	Tavana et. al.	Omega	NA
52	1982	A critical assessment	Tong - Efstathiou	Fuzzy Sets and Systems	NA
53	1992	On the problem	Vansnick	European Journal of Operational Research	NA
54	1997	A fuzzy outranking	Wang	International Journal of Production Research	NA
55	1999	Fuzzy outranking approach	Wang	International Journal of Production Research	NA
56	1978	Fuzzy decision making	Yager	Fuzzy Sets and Systems	NA
57	1985	Manufacturing plant location	Yoon - Hwang	International Journal of Production Research	NA
58	1994	Fuzzy logic, neural	Zadeh	Communication of ACM	NA
59	1987	Fuzzy sets, decision	Zimmermann	Kluwer Academic Publishers	EU
60	2008	A Pareto model	Saralees	Mathematical Methods In The Applied Sciences	NA
61	1995	Fuzzy Sets and	Klir and Yuan	Fuzzy Sets And Fuzzy Logic Theory and Applications	NA
62	1975	Fuzzy sets and	Zadeh et. al.	Fuzzy sets and their applications to cognitive and decision processes	NA
63	2007	Introduction to fuzzy	Sivanandam et. al.	Introduction to fuzzy logic using MATLAB	EU
64	2004	Introduction to the Mathematical	Bierens	Introduction to the Mathematical and Statistical Foundations of Econometrics	NA
65	1997	The Econometrics of	Campbell et. al.	The Econometrics of Financial Markets	NA
66	1998	Forecasting Financial Markets	Kutsurelis	Forecasting Financial Markets Using Neural Networks: An Analysis of Methods and Accuracy	NA
67	2007	Econometrics	Hansen	Econometrics	NA
68	1999	The econometric modelling	Mills	The Econometric Modelling of Financial Time Series	NA
69	2007	Nonlinear time series	Gao	Nonlinear Time Series Semiparametric and Nonparametric Methods	NA
70	2004	The economics of	Mishkin	The Economics of Money, Banking and Financial Markets	NA

Table D.1 (continued) **:** Mathematical and statistical methods classification study information table.

	5th	6th	7th		8th		9th	10th	11th	12th
	Main Group	Sub Group	Research Level		Research Approach		Impact Level	Key Term	Key Term	Key Term
			Macro	Micro	Emprical	Non-Emprical				
35	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
36	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
37	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
38	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
39	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
40	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
41	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
42	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
43	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
44	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
45	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
46	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
47	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
48	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
49	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
50	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
51	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
52	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
53	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
54	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
55	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
56	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
57	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
58	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
59	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
60	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	Pareto		
61	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
62	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
63	Mathematical and Statistical Methods	Decision Making	S	G	I		LT	FL		
64	Mathematical and Statistical Methods	Forecasting Methods	S	G		M	LT	the Wald test		
65	Mathematical and Statistical Methods	Forecasting Methods	S	G		M	LT	Learning Networks		
66	Mathematical and Statistical Methods	Forecasting Methods	S	G		M	LT	Neural Networks		
67	Mathematical and Statistical Methods	Forecasting Methods	S	G		M	LT	Univariate Time Series		
68	Mathematical and Statistical Methods	Forecasting Methods	S	G		M	LT	ARCH		
69	Mathematical and Statistical Methods	Forecasting Methods	S	G		M	LT	LRD stochastic volatility models		
70	Mathematical and Statistical Methods	Forecasting Methods	S	G		M	LT	The ISLM Model		

APPENDIX E. SOFTWARE AND CODING METHODS CLASSIFICATION STUDY

Table E.1 : Software and coding methods classification study information table.

		1st	2nd	3rd	4th
		Name of Study	Authors' surname	Journal-Book Name	Journal Origin
	YEAR				
1	2006	An integrated multi	Olcer et. al	Applied Soft Computing Journal	NA
2	2005	ELECTRE Methods	Figueira et. al.	Multiple Criteria Decision Analysis: State of the Art Surveys	NA
3	2005	PROMETHEE Methods	Brans and Mareschal	Multiple Criteria Decision Analysis: State of the Art Surveys	NA
4	1998	Micro-QUALIFLEX: An interactive	Ancot	Micro-QUALIFLEX: An interactive software package for the determination and analysis of the optimal solution to decision problems software plus manual	EU
5	1992	Multiobjective Decision Support	Janssen	Multiobjective Decision Support for Environmental Management	EU
6	1999	Software review: Decision	White and Palocsay	OR/MS Today	NA
7	2000	Software review: Criterium	Haerer	OR/MS Today	NA
8	1996	Software review: Expert	Fernandez	OR/MS Today	NA
9	2004	A career choice	Costa and Chagas	European Journal of Operational Research	EU
10	1999	A review of	Tavares	European Journal of Operational Research	EU
11	1999	Using artificial intelligence	Siskos et. al.	European Journal of Operational Research	EU
12	1996	NAIADE Manual & Tutorial	JRC of EU	NAIADE Manual & Tutorial	EU
13	2007	OnBalance User's Guide	Krysalis	OnBalance User's Guide	EU
14	2001	Feasible goals method	Lotov et. al.	Feasible goals method – search for smart decisions	AS
15	2003	A new visualization	Papadrakakis et. al.	Proceedings of Second MIT Conference on Computational Fluid and Solid Mechanics	NA
16	1994	SOLVEX-System for	Potapov and Kabanov	Proceedings of 3rd IFIP WG-7.6 Working Conference on Optimization-Based Computer-Aided Modelling and Design	EU
17	1998	Developing a multicriteria	Zopounidis and Doumpos	Optimization Methods and Software	EU
18	1988	A visual reference	Korhonen	European Journal of Operational Research	EU
19	2001	Software for visualization	Lotov et. al.	Newsletter of the European Working Group	EU
20	1991	Decision support software	Weber and Lippiatt	Technical report nistir 4543, National Institute of Standards and Technology	NA
21	2005	PARADIGMS AND CHALLENGES	Roy	Multiple Criteria Decision Analysis: State of the Art Surveys	NA
22	2005	Preference Modelling	Ozturk et al	Multiple Criteria Decision Analysis: State of the Art Surveys	NA
23	2005	CONJOINT MEASUREMENT TOOLS	Bouyssou and Pirlot	Multiple Criteria Decision Analysis: State of the Art Surveys	NA
24	1986	Multicriterion analysis of	Matarazzo	Applied Mathematics and Computation	NA
25	1988	Preference ranking global	Matarazzo	European Journal of Operational Research	EU
26	1993	MINORA: A multicriteria	Siskos et. al.	Journal of Information Science and Technology	NA
27	1999	MUSTARD User's Guide	Beuthe and Scannella	MUSTARD User's Guide. Facultés Universitaires Catholiques de Mons	EU
28	1986	PRIAM, an interactive	Levine and Pomerol	European Journal of Operational Research	EU
29	2001	PRIME Decisions: an	Gustafsson et. al.	, Multiple Criteria Decision Making in the New Millennium, volume 507 of Lecture Notes in Economics and Mathematical Systems	EU
30	1999	Multiple criteria trade-off	Jankowski et. al.	Spatial Multicriteria Decision Making and Analysis: A Geographical Information Sciences Approach	NA
31	2001	Multicriteria evaluation of	Jablonsky	Multicriteria evaluation of	EU
32	2000	Web-HIPRE: Global	Mustajoki and Hämäläinen	INFOR	NA
33	2003	MultiGen: An integrated	Mirrazavi et. al.	Decision Support Systems	NA
34	1989	Implementation of a	Clímaco and Antunes	Mathematical and Computer Modelling	NA
35	2000	Additive aggregation with	Dias and Clímaco	Journal of the Operational Research Society	NA

Table E.1 (continued) **:** Software and coding methods classification study information table.

	5th	6th	7th		8th		9th	10th	11th	12th
	Main Group	Sub Group	Research Level		Research Approach		Impact Level	Key Term	Key Term	Key Term
			Macro	Micro	Emprical	Non-Emprical				
1	Software and Coding	Decision Making	S	G	I		LT	FRONTIER		
2	Software and Coding	Decision Making	S	G	I		LT	Electre IS	Electre III-IV	IRIS
3	Software and Coding	Decision Making	S	G	I		LT	DECISION LAB	PROMCALC	
4	Software and Coding	Decision Making	S	G	I		LT	Micro-QUALIFLEX		
5	Software and Coding	Decision Making	S	G	I		LT	DEFINITE		
6	Software and Coding	Decision Making	S	G	I		LT	Decision Explorer		
7	Software and Coding	Decision Making	S	G	I		LT	Criterium Decision Plus 3.0		
8	Software and Coding	Decision Making	S	G	I		LT	Expert choice		
9	Software and Coding	Decision Making	S	G	I		LT	MACBETH		
10	Software and Coding	Decision Making	S	G	I		LT	MacModel		
11	Software and Coding	Decision Making	S	G	I		LT	MIIDAS		
12	Software and Coding	Decision Making	S	G	I		LT	NAIADE		
13	Software and Coding	Decision Making	S	G	I		LT	OnBalance		
14	Software and Coding	Decision Making	S	G	I		LT	FGM		
15	Software and Coding	Decision Making	S	G	I		LT	Multistat		
16	Software and Coding	Decision Making	S	G	I		LT	SOLVEX		
17	Software and Coding	Decision Making	S	G	I		LT	FINCLAS		
18	Software and Coding	Decision Making	S	G	I		LT	VIMDA		
19	Software and Coding	Decision Making	S	G	I		LT	FSCS		
20	Software and Coding	Decision Making	S	G	I		LT	AutoMan 2.0		
21	Software and Coding	Decision Making	S	G	I		LT	DA	MCDA	MCAP
22	Software and Coding	Decision Making	S	G	I		LT			
23	Software and Coding	Decision Making	S	G	I		LT			
24	Software and Coding	Decision Making	S	G	I		LT	MAPPAC		
25	Software and Coding	Decision Making	S	G	I		LT	PRAGMA		
26	Software and Coding	Decision Making	S	G	I		LT	MINORA	UTA	
27	Software and Coding	Decision Making	S	G	I		LT	MUSTARD		
28	Software and Coding	Decision Making	S	G	I		LT	PRIAM		
29	Software and Coding	Decision Making	S	G	I		LT	PRIME Decisions		
30	Software and Coding	Decision Making	S	G	I		LT	RGDB		
31	Software and Coding	Decision Making	S	G	I		LT	SANNA		
32	Software and Coding	Decision Making	S	G	I		LT	Web-HIPRE		
33	Software and Coding	Decision Making	S	G	I		LT	MultiGen		
34	Software and Coding	Decision Making	S	G	I		LT	TRIMAP		
35	Software and Coding	Decision Making	S	G	I		LT	VIP Analysis		

Table E.1 (continued) **:** Software and coding methods classification study information table.

		1st	2nd	3rd	4th
		Name of Study	Authors' surname	Journal-Book Name	Journal Origin
	YEAR				
35	2000	Additive aggregation with	Dias and Clímaco	Journal of the Operational Research Society	NA
36	1992	An integrated MOLP	Antunes et. al.	Computers & Operations Research	NA
37	2000	Interactive multiobjective optimization	Miettinen and Mäkelä	Computers & Operations Research	NA
38	2000	PREFDIS: A multicriteria	Zopounidis and Doumpos	Computers & Operations Research	NA
39	2000	Multicriteria assignment method	Belacel	European Journal of Operational Research	EU
40	2003	The AGAP system	Costa	European Journal of Operational Research	EU

Table E.1 (continued) **:** Software and coding methods classification study information table.

	5th	6th	7th		8th		9th	10th	11th	12th
	Main Group	Sub Group	Research Level		Research Approach		Impact Level	Key Term	Key Term	Key Term
			Macro	Micro	Emprical	Non-Emprical				
35	Software and Coding	Decision Making	S	G	I		LT	VIP Analysis		
36	Software and Coding	Decision Making	S	G	I		LT	TOMMIX		
37	Software and Coding	Decision Making	S	G	I		LT	WWWNIMBUS		
38	Software and Coding	Decision Making	S	G	I		LT	PREFDIS		
39	Software and Coding	Decision Making	S	G	I		LT	PROAFTN		
40	Software and Coding	Decision Making	S	G	I		LT	AGAP		

APPENDIX F. CASE STUDY DATA AND FIGURES

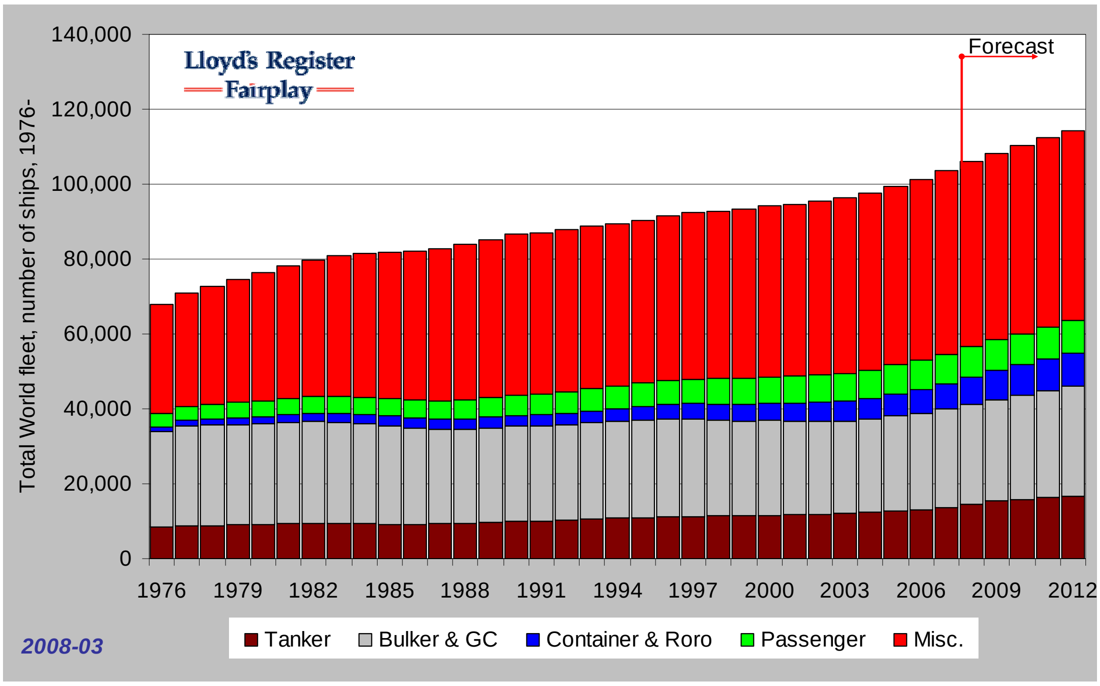

Figure F.1 : All ships fleet no., (Source: Shipbuilding Market Forecast April 2008).

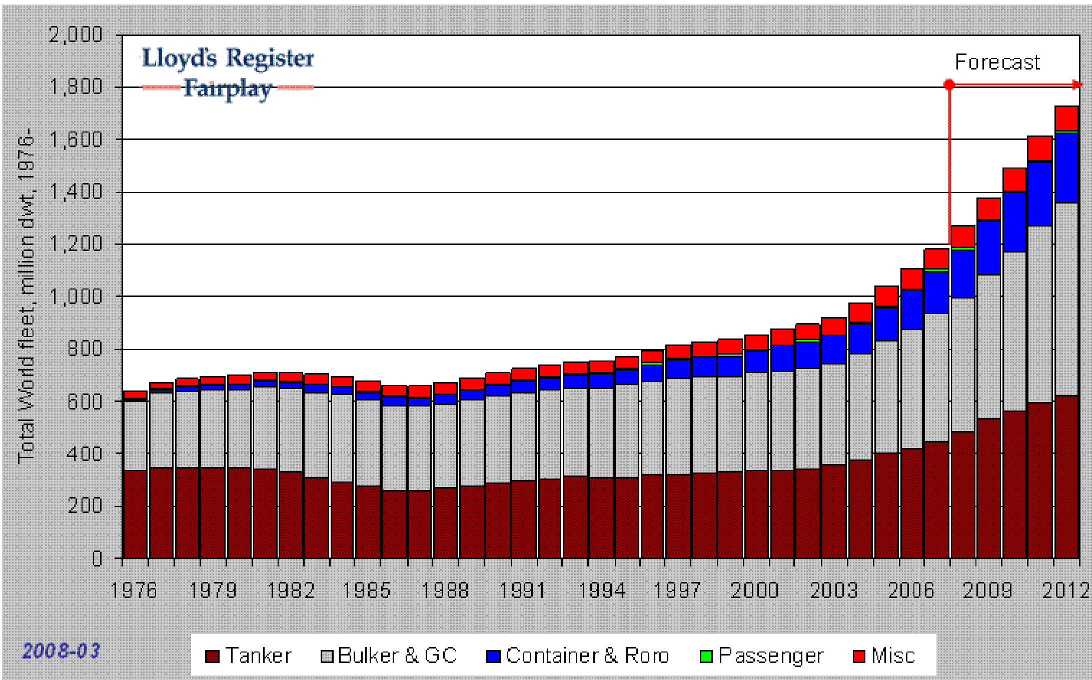

Figure F.2 : All ships fleet DWT., (Source: Shipbuilding Market Forecast April 2008).

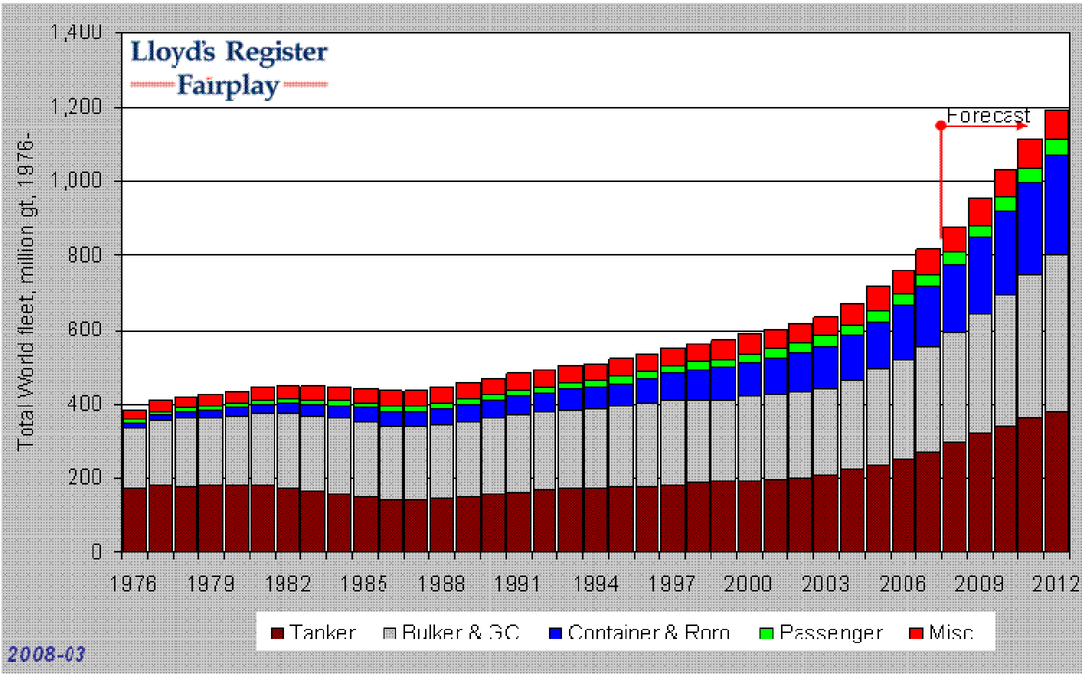

Figure F.3 : All ships fleet GT., (Source: Shipbuilding Market Forecast April 2008).

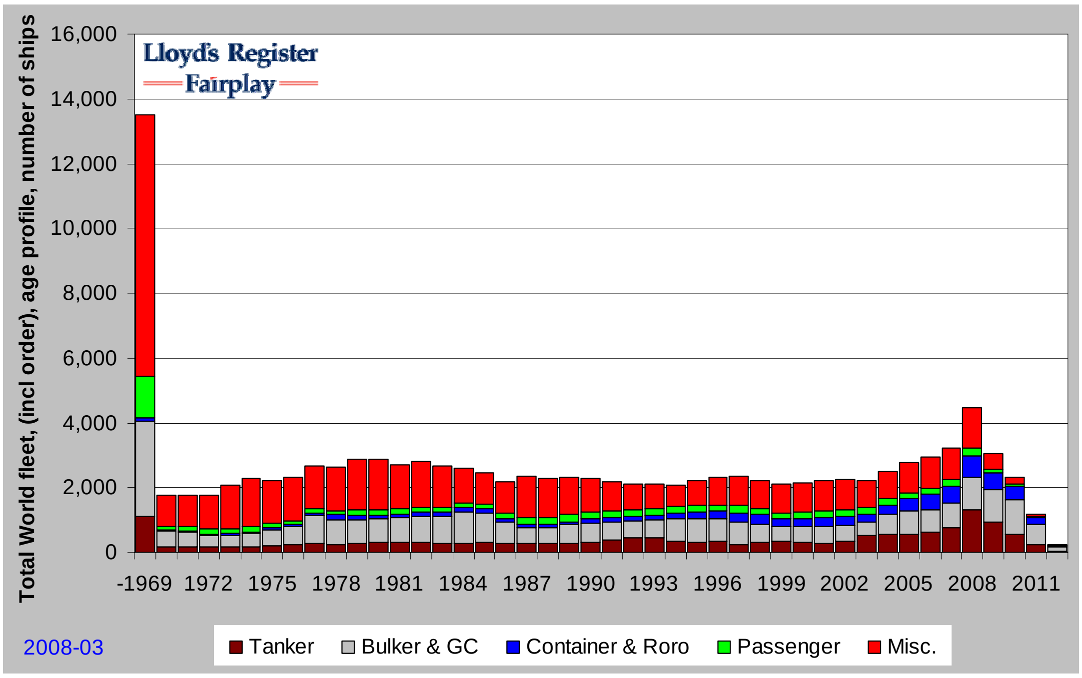

Figure F.4 : All ships age profile incl. orderbook no., (Source: Shipbuilding Market Forecast April 2008).

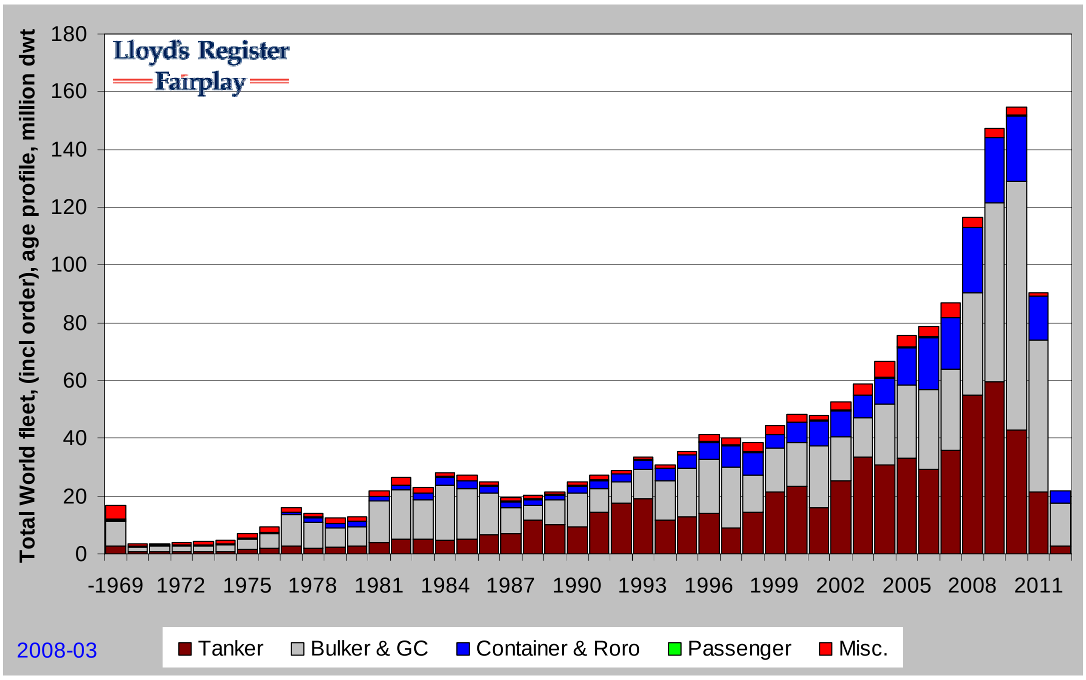

Figure F.5 : All Ships age profile incl. orderbook DWT., (Source: Shipbuilding Market Forecast April 2008).

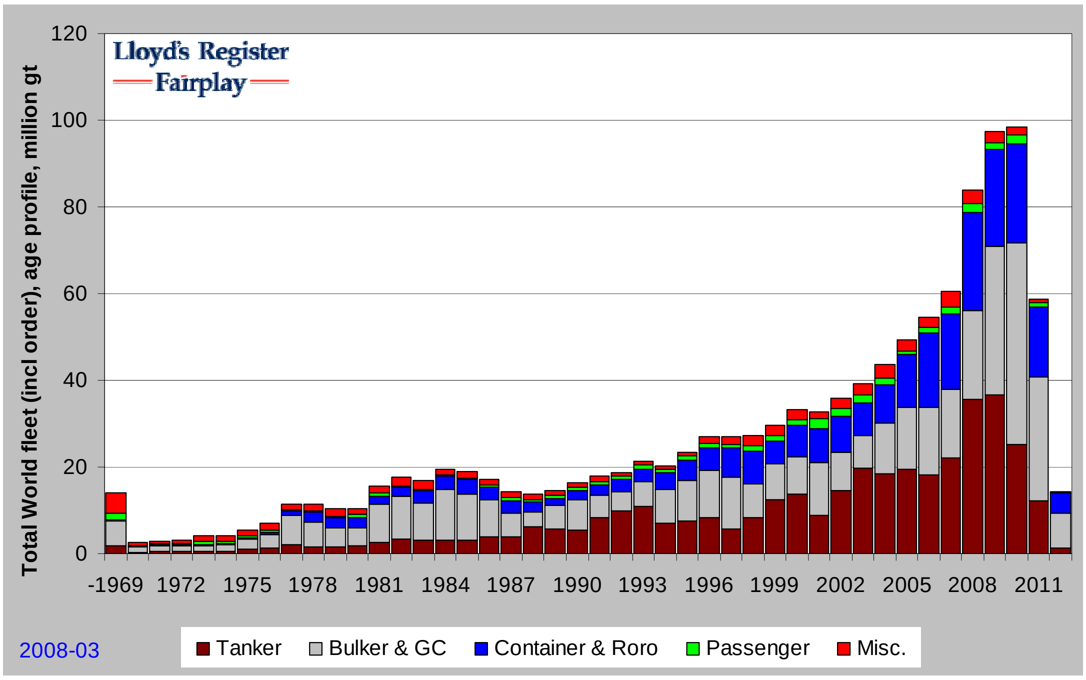

Figure F.6 : All ships age profile incl. orderbook GT., (Source: Shipbuilding Market Forecast April 2008).

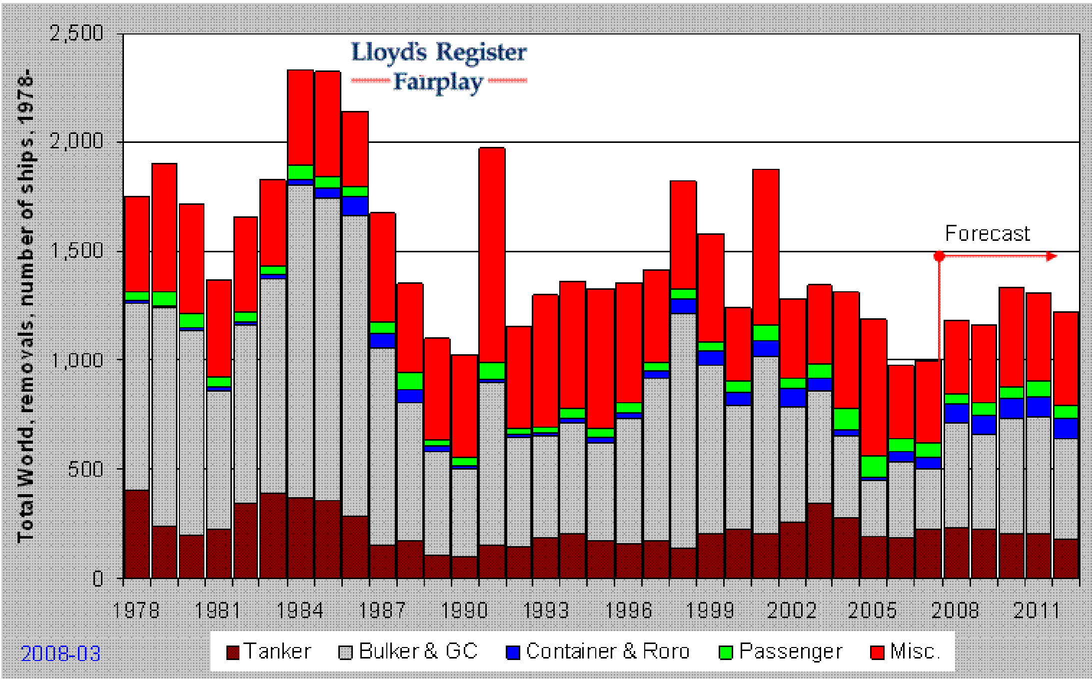

Figure F.7 : All ships removals no., (Source: Shipbuilding Market Forecast April 2008).

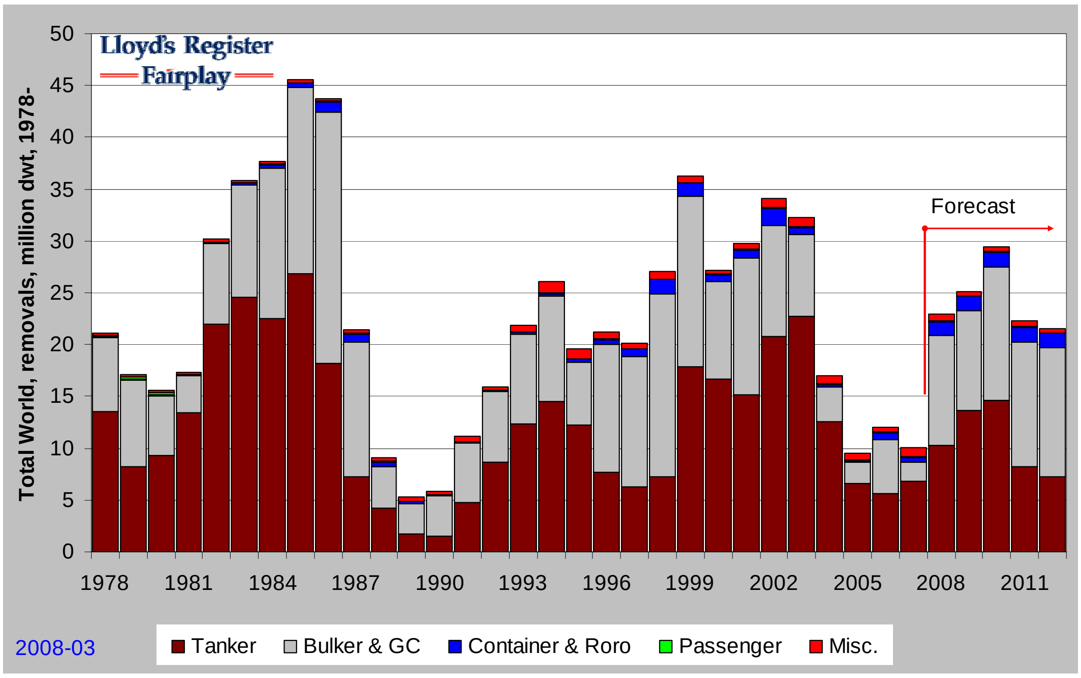

Figure F.8 : All ships removals DWT., (Source: Shipbuilding Market Forecast April 2008).

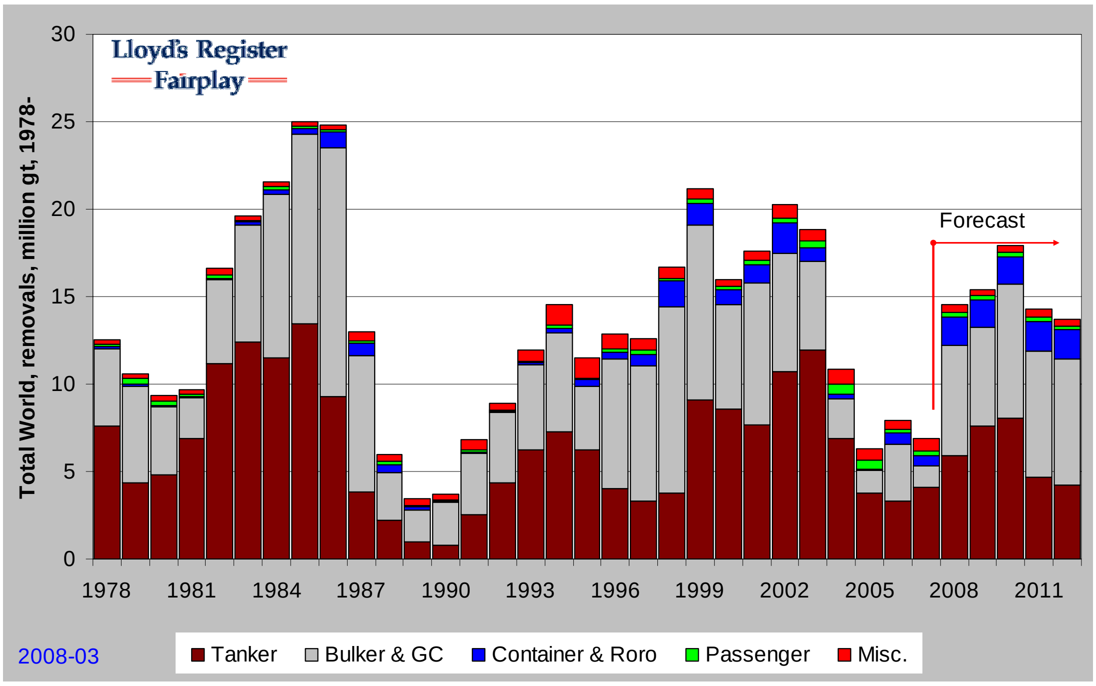

Figure F.9 : All ships removals GT., (Source: Shipbuilding Market Forecast April 2008).

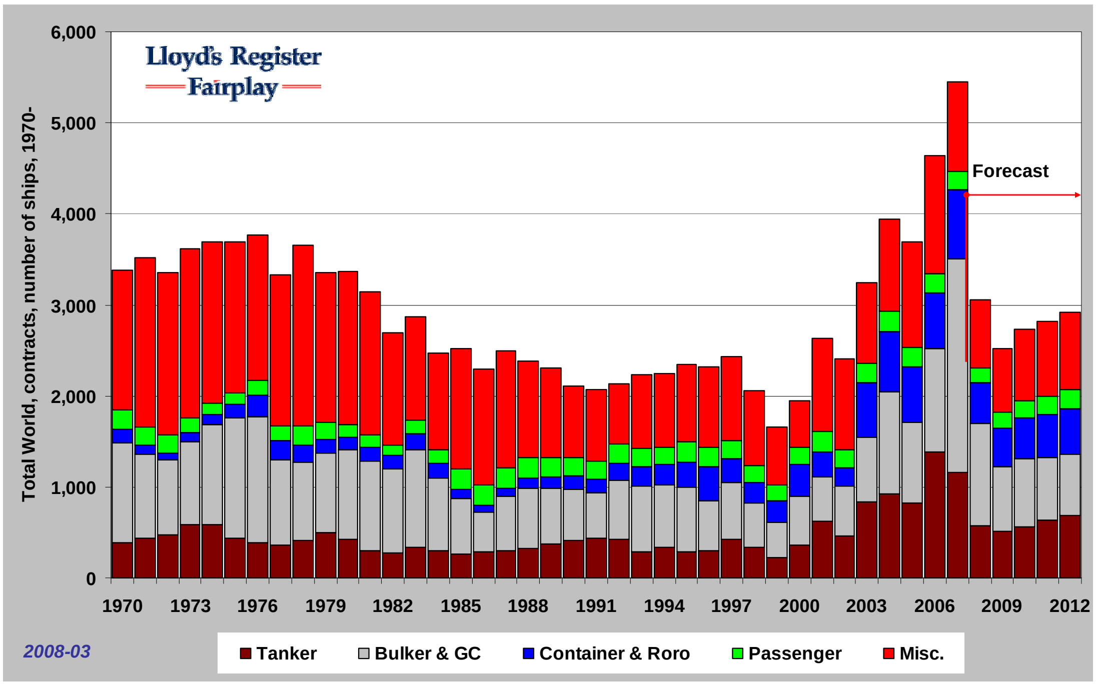

Figure F.10 : All ships contracts no., (Source: Shipbuilding Market Forecast April 2008).

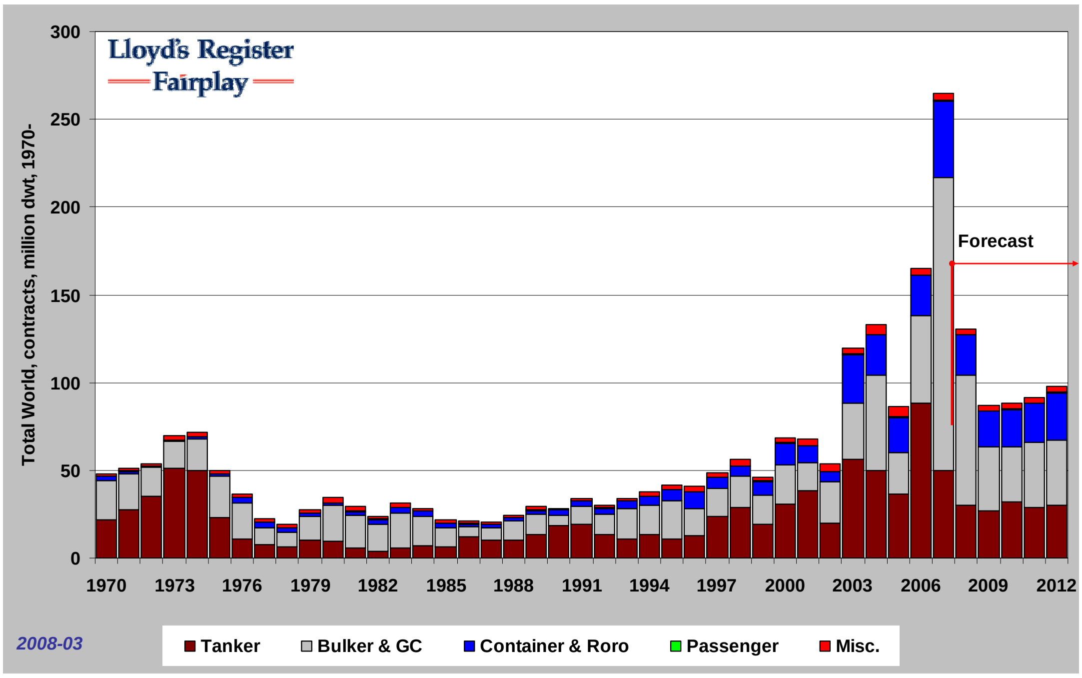

Figure F.11 : All ships contracts DWT., (Source: Shipbuilding Market Forecast April 2008).

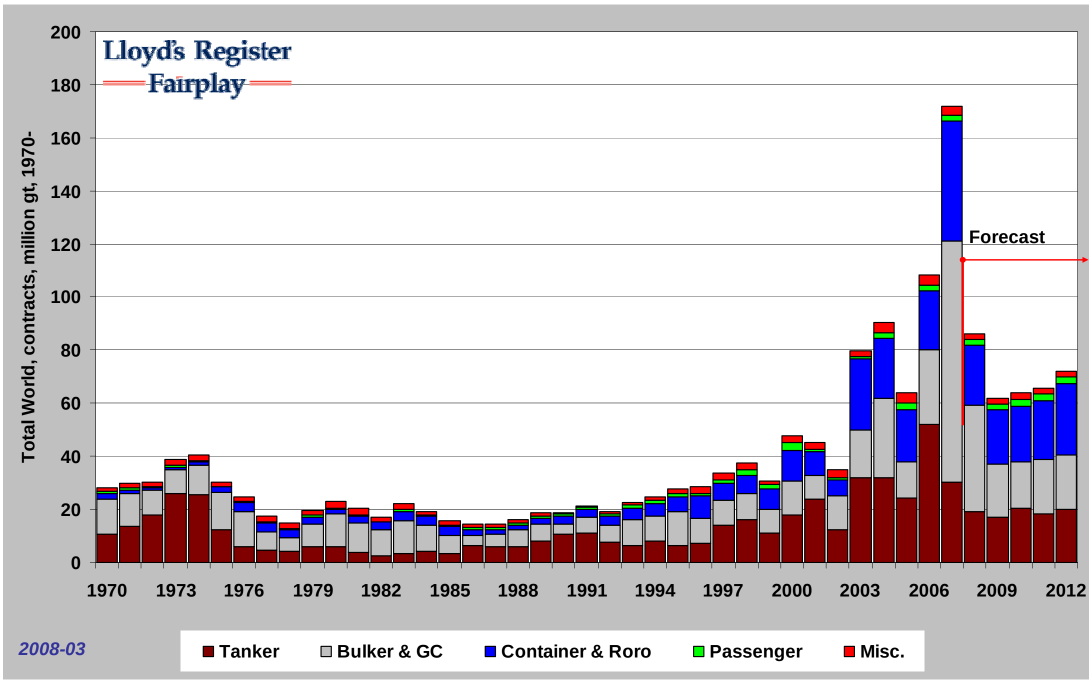

Figure F.12 : All ships contracts GT., (Source: Shipbuilding Market Forecast April 2008).

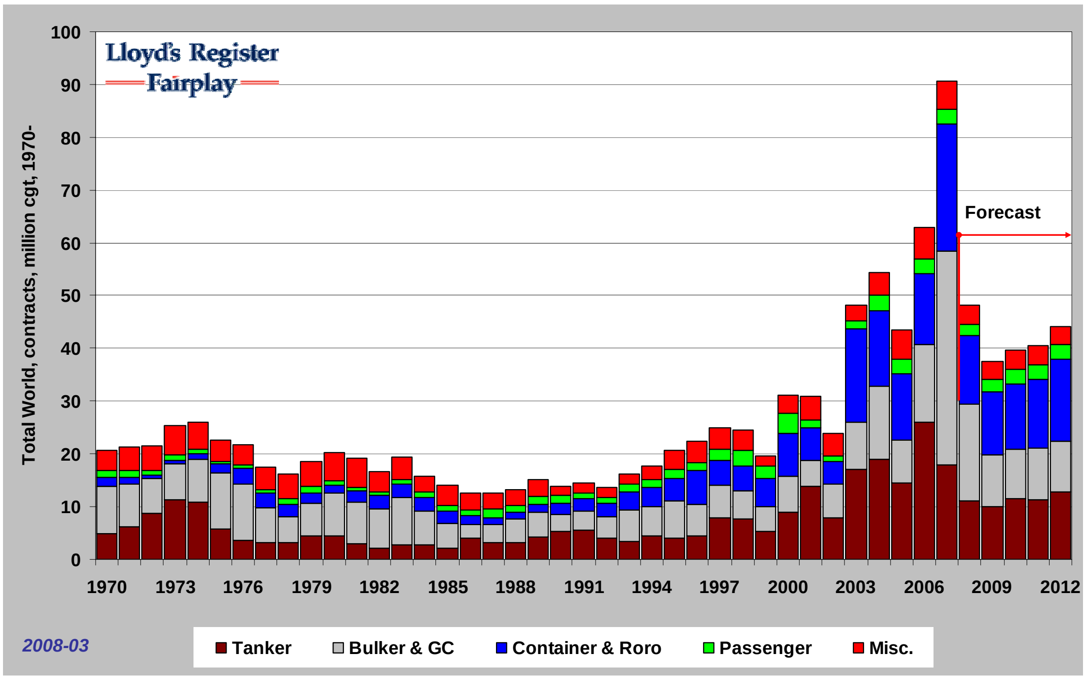

Figure F.13 : All ships contracts CGT., (Source: Shipbuilding Market Forecast April 2008).

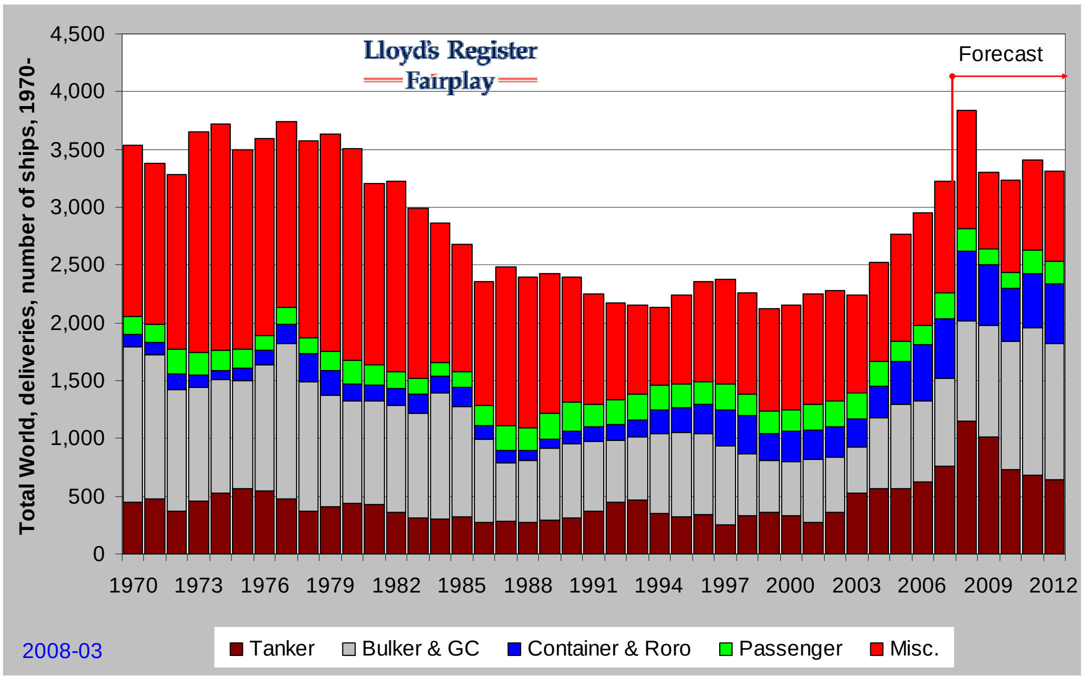

Figure F.14 : All ships deliveries no., (Source: Shipbuilding Market Forecast April 2008).

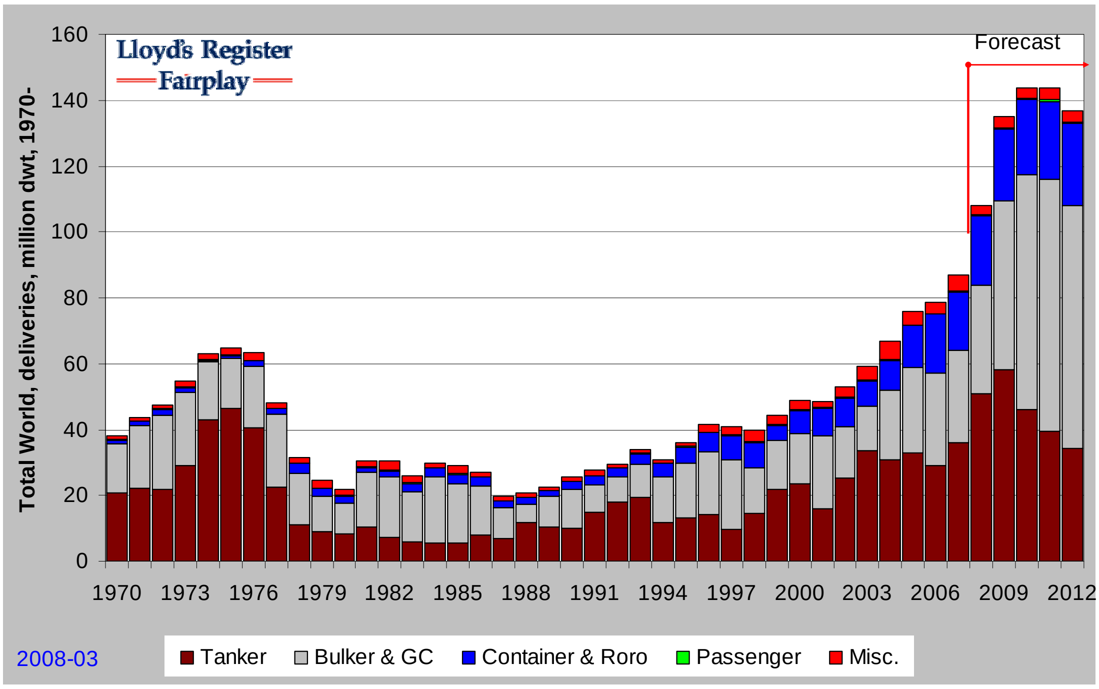

Figure F.15 : All ships deliveries DWT., (Source: Shipbuilding Market Forecast April 2008).

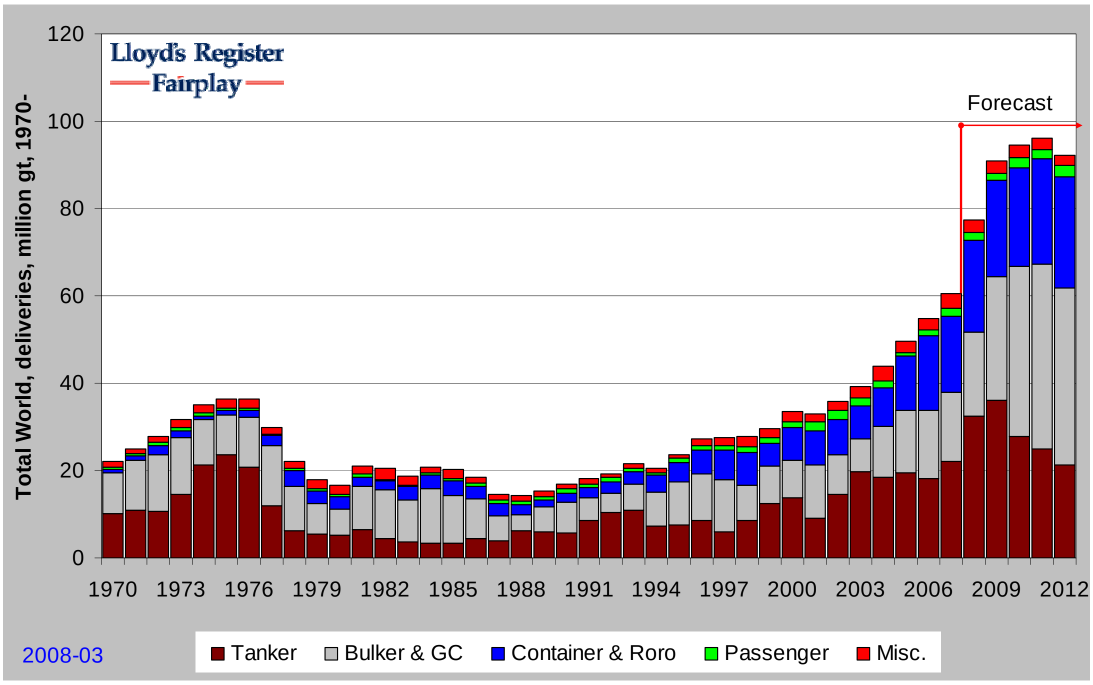

Figure F.16 : All ships deliveries GT., (Source: Shipbuilding Market Forecast April 2008).

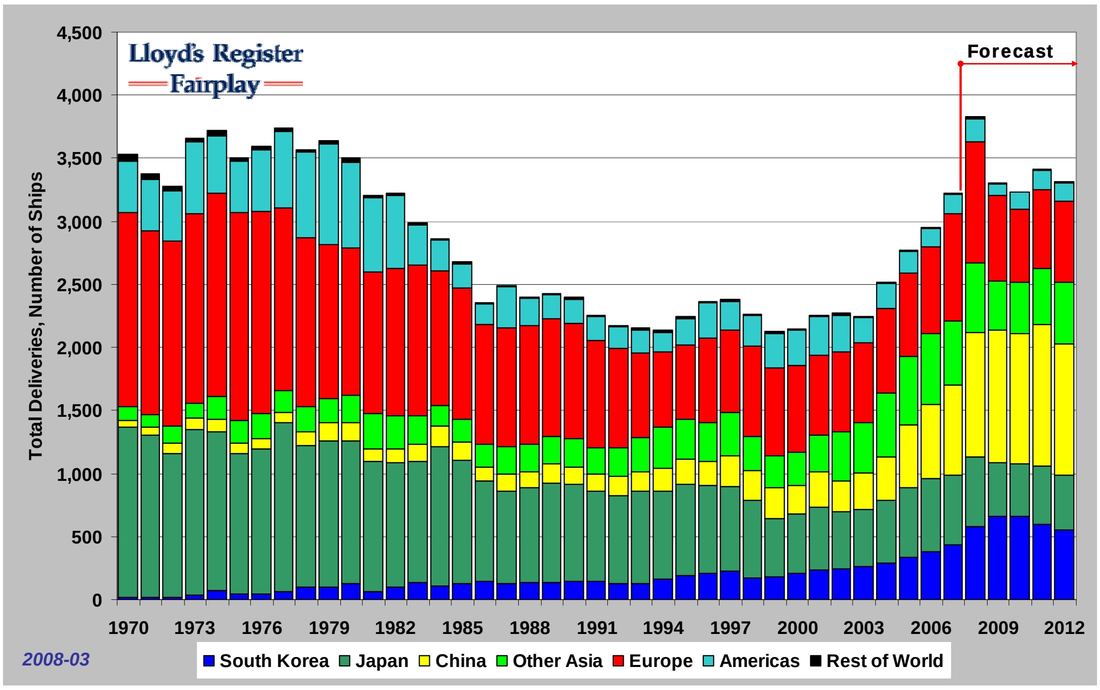

Figure F.17 : All ships deliveries builders region no., (Source: Shipbuilding Market Forecast April 2008).

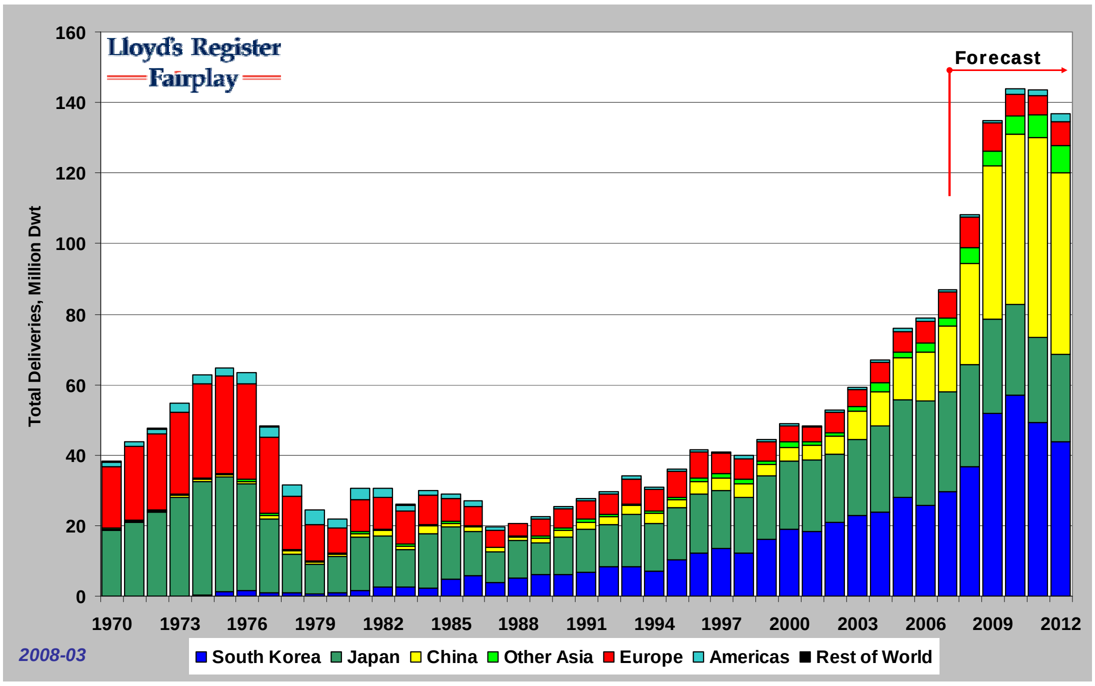

Figure F.18 : All ships deliveries builders region DWT., (Source: Shipbuilding Market Forecast April 2008).

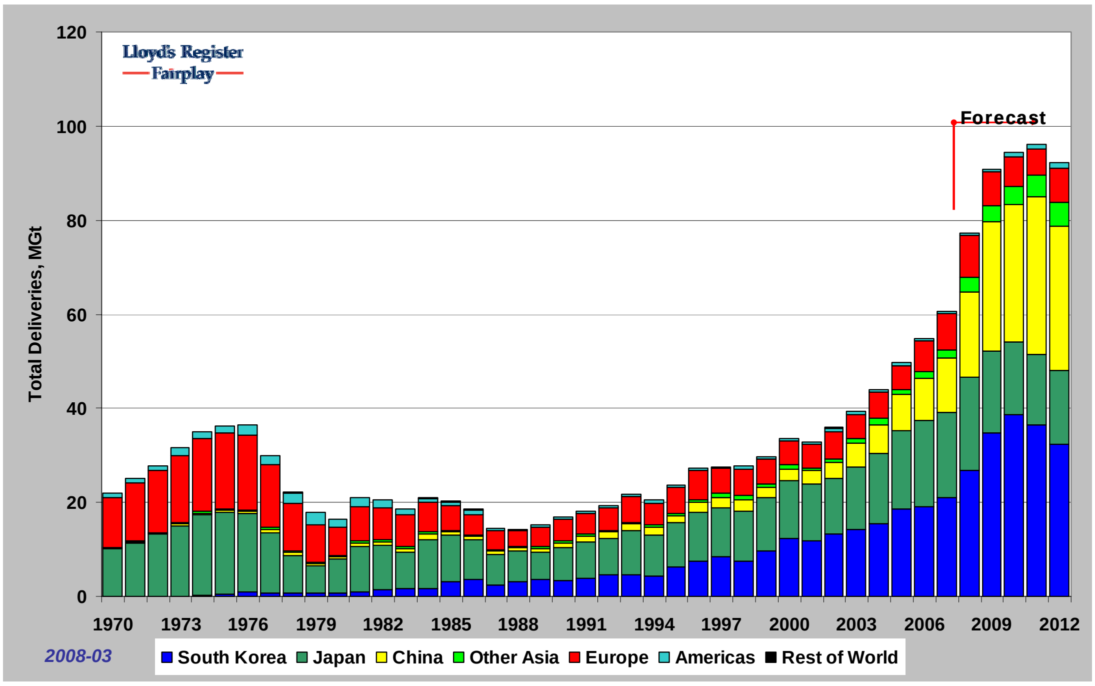

Figure F.19 : All ships deliveries builders region GT., (Source: Shipbuilding Market Forecast April 2008).

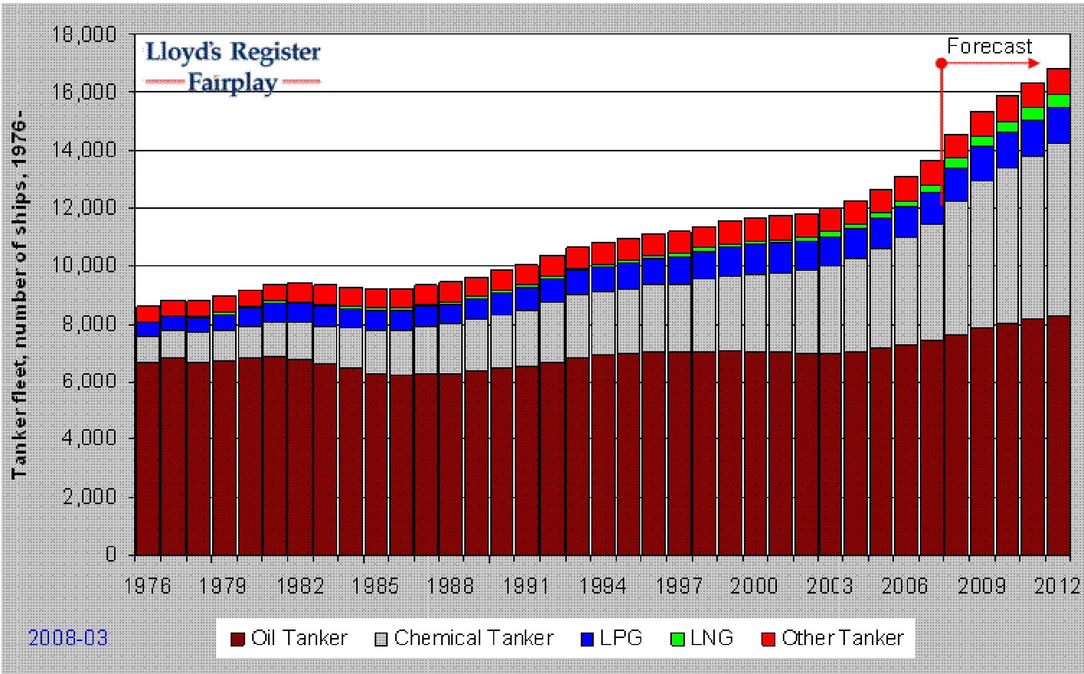

Figure F.20 : Tanker fleet no., (Source: Shipbuilding Market Forecast April 2008).

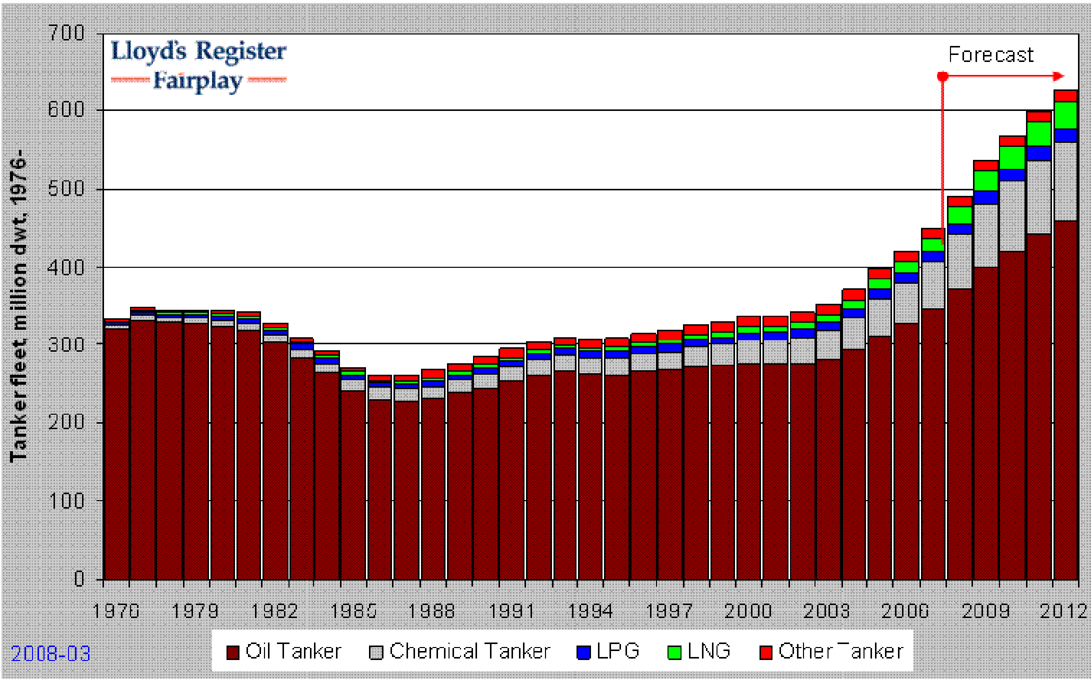

Figure F.21 : Tanker fleet DWT., (Source: Shipbuilding Market Forecast April 2008).

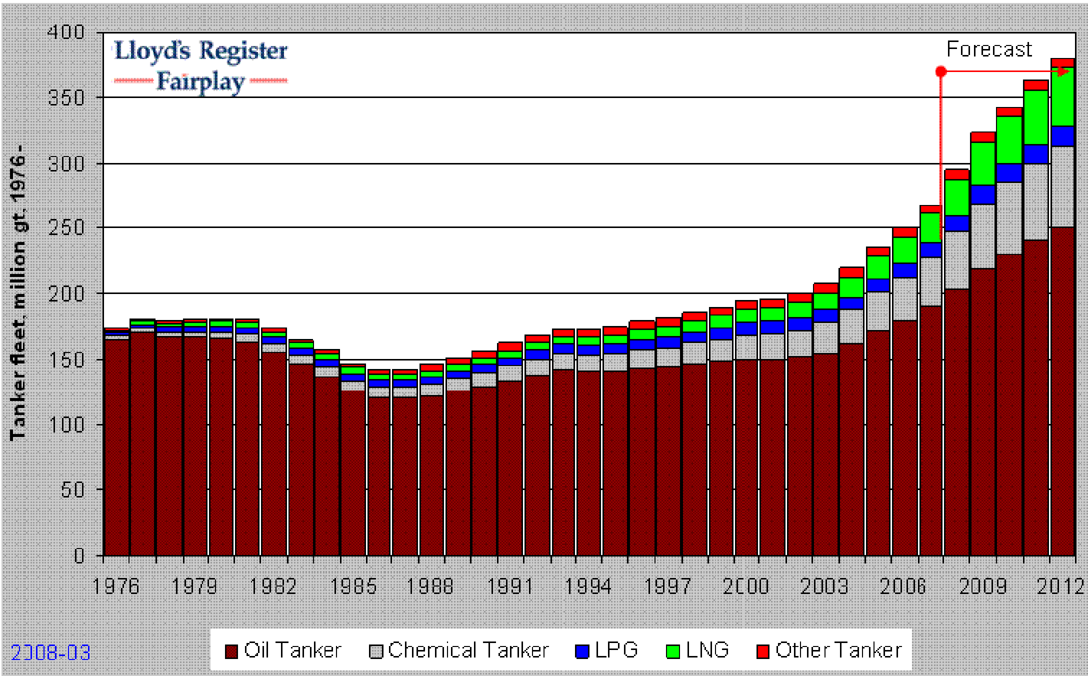

Figure F.22 : Tanker fleet GT., (Source: Shipbuilding Market Forecast April 2008).

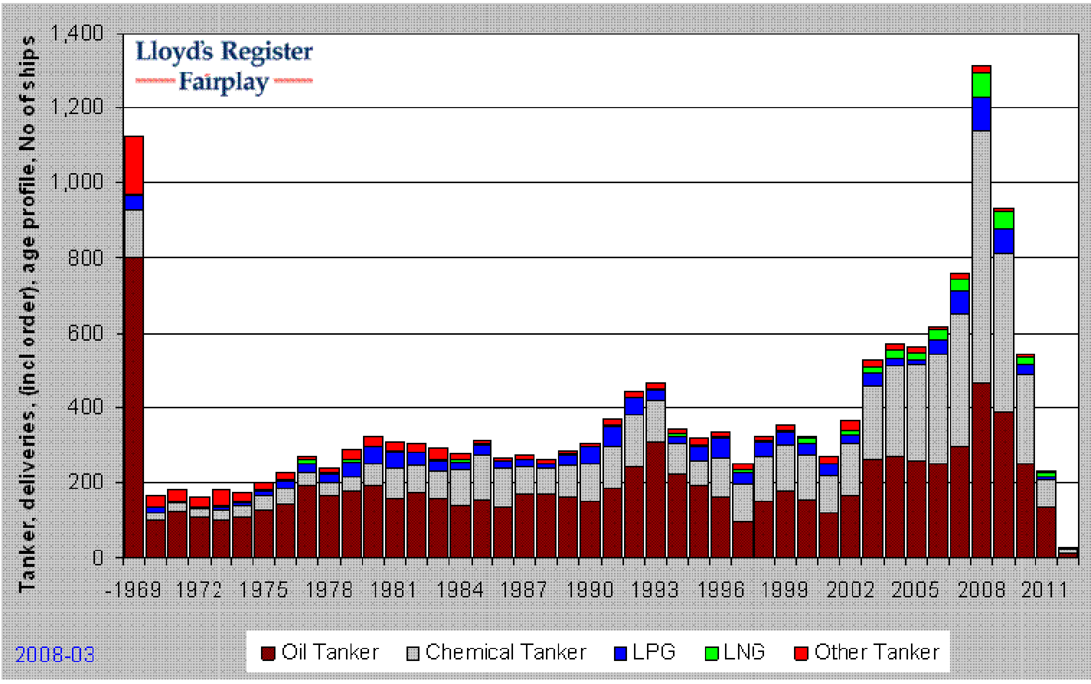

Figure F.23 : Tanker age profile incl. orderbook no., (Source: Shipbuilding Market Forecast April 2008).

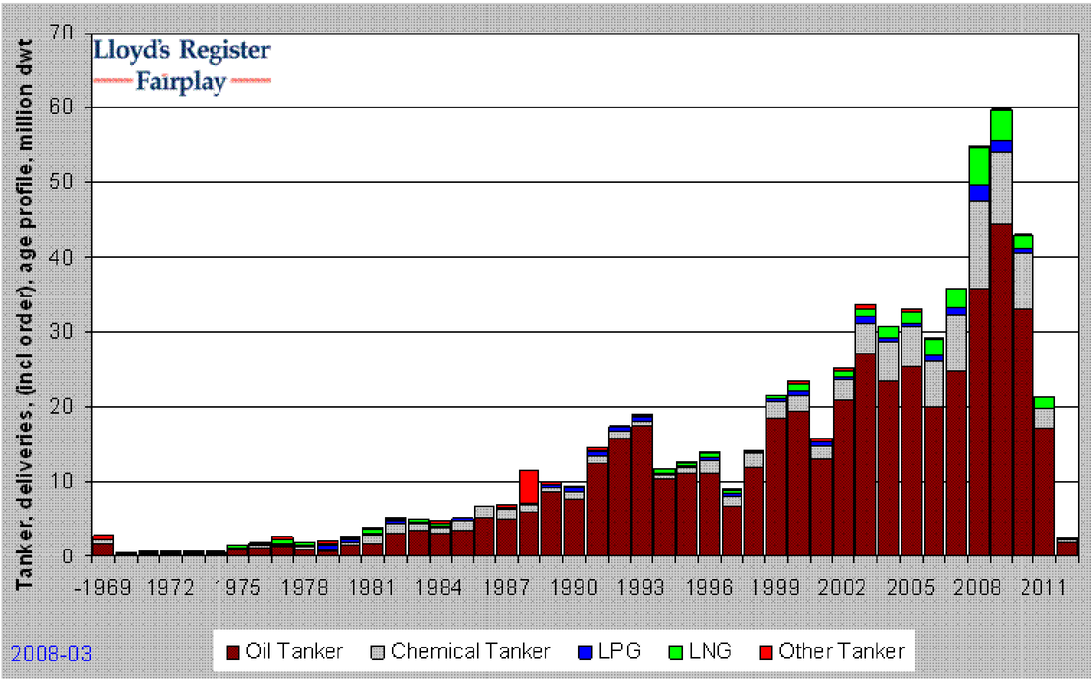

Figure F.24 : Tanker age profile incl. order DWT., (Source: Shipbuilding Market Forecast April 2008).

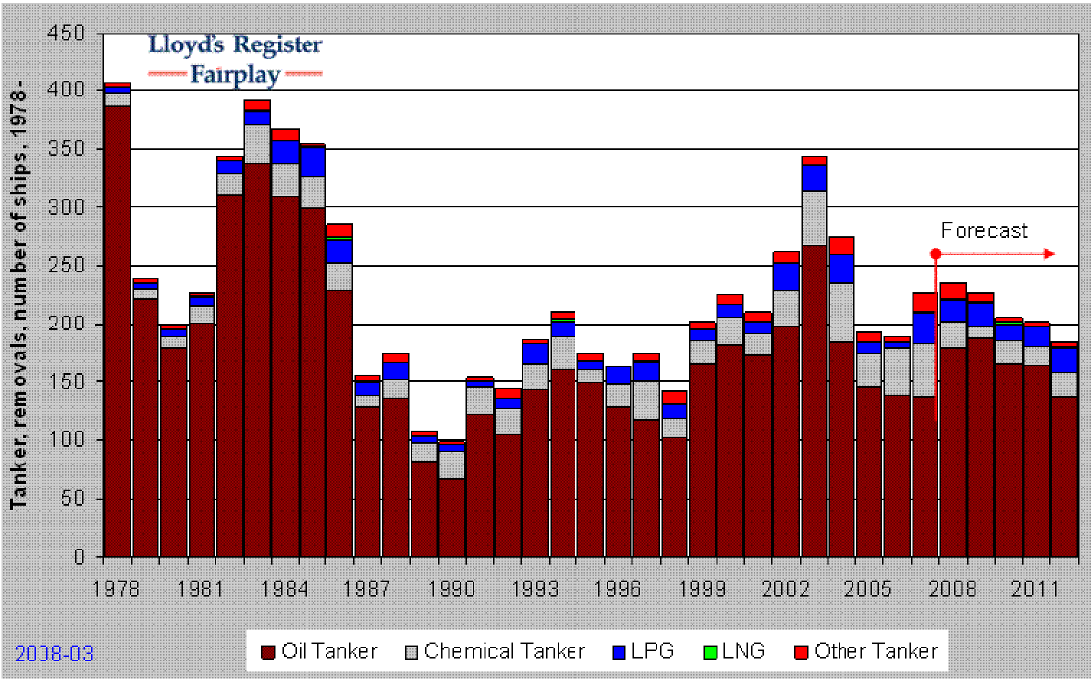

Figure F.25 : Tanker removals no., (Source: Shipbuilding Market Forecast April 2008).

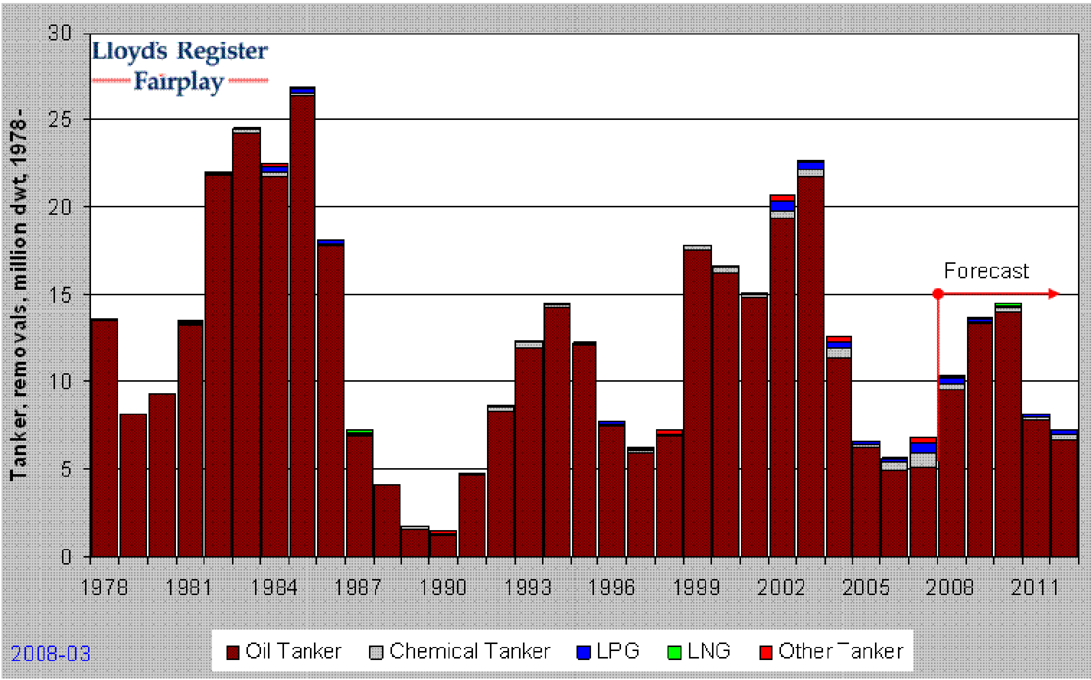

Figure F.26 : Tanker removals DWT., (Source: Shipbuilding Market Forecast April 2008).

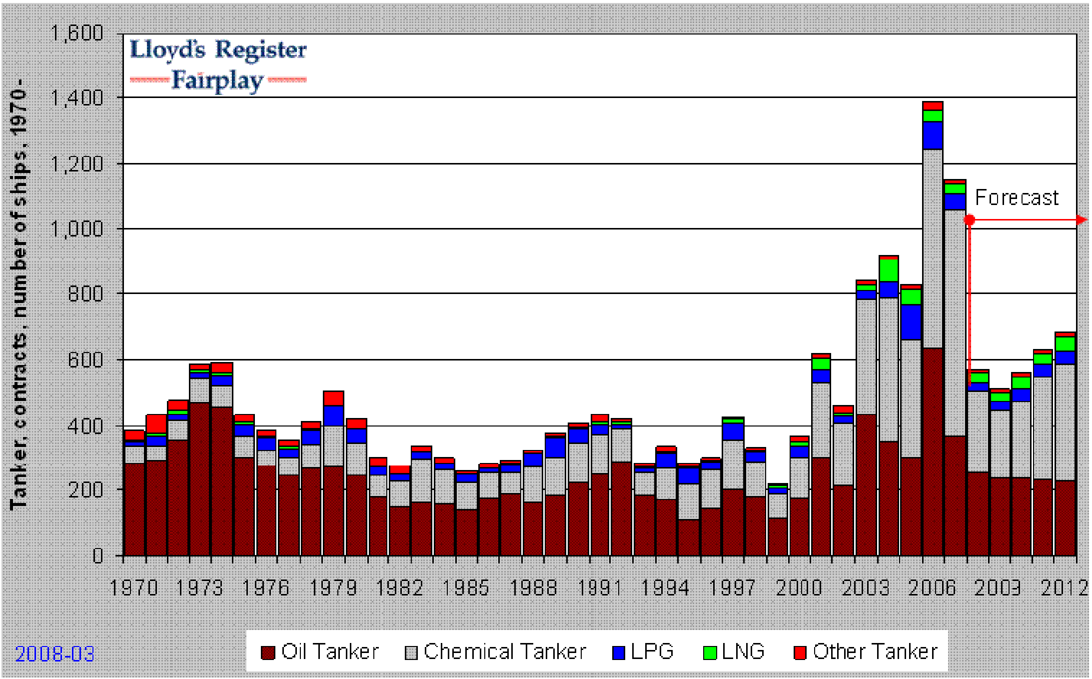

Figure F.27 : Tanker contracts no. (Source: Shipbuilding Market Forecast April 2008).

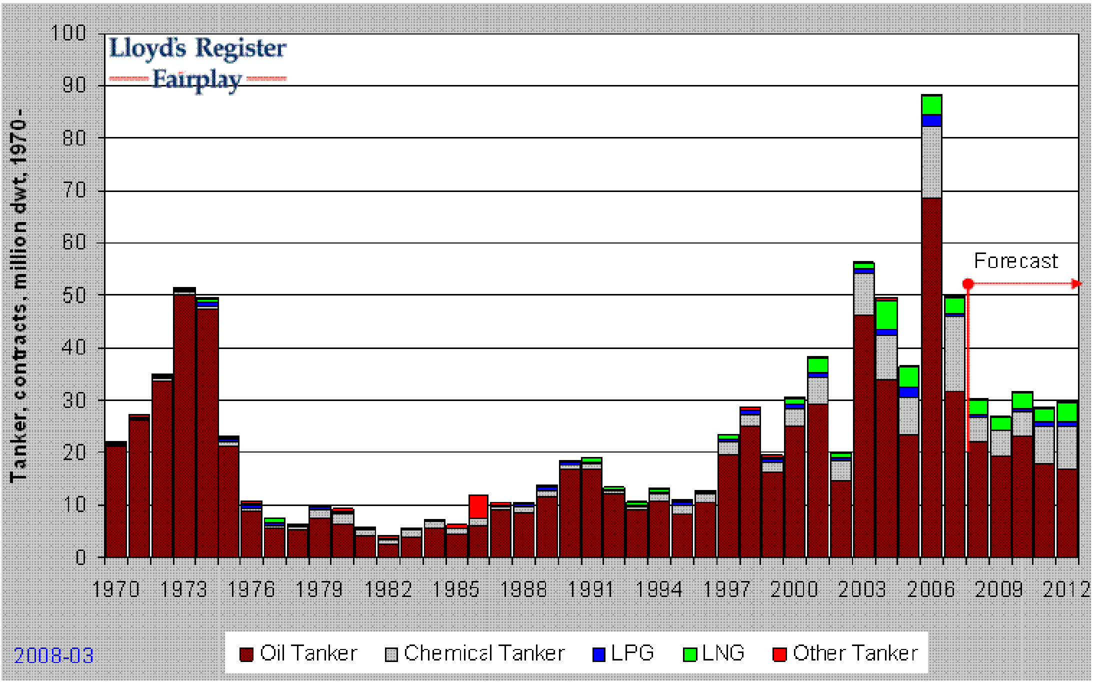

Figure F.28 : Tanker contracts DWT., (Source: Shipbuilding Market Forecast April 2008).

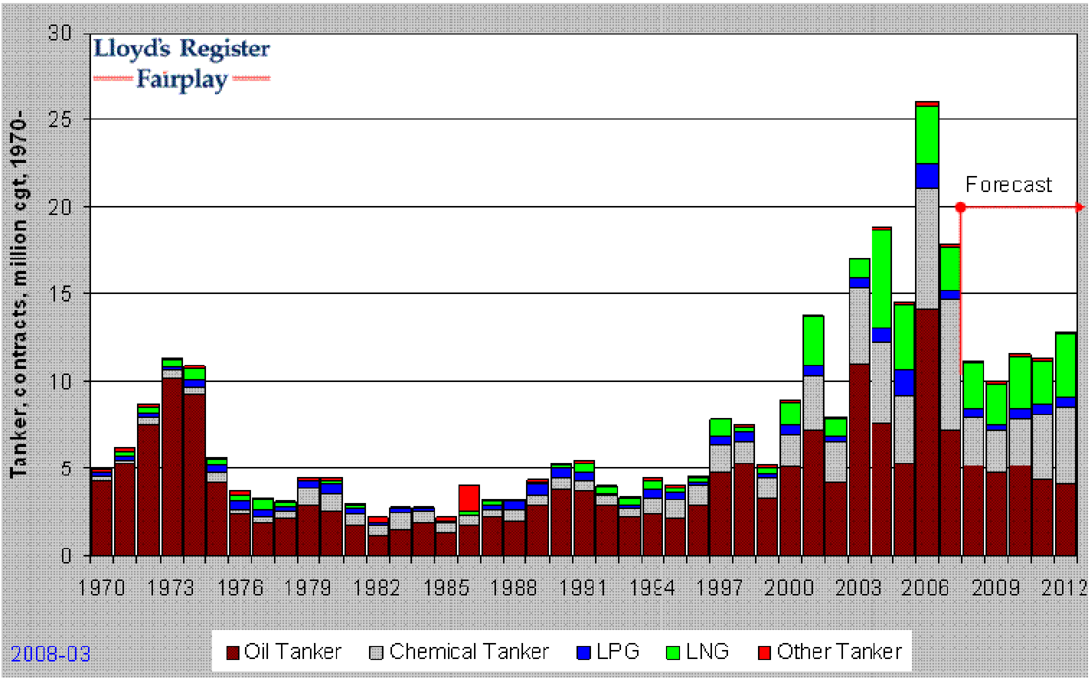

Figure F.29 : Tanker contracts CGT., (Source: Shipbuilding Market Forecast April 2008).

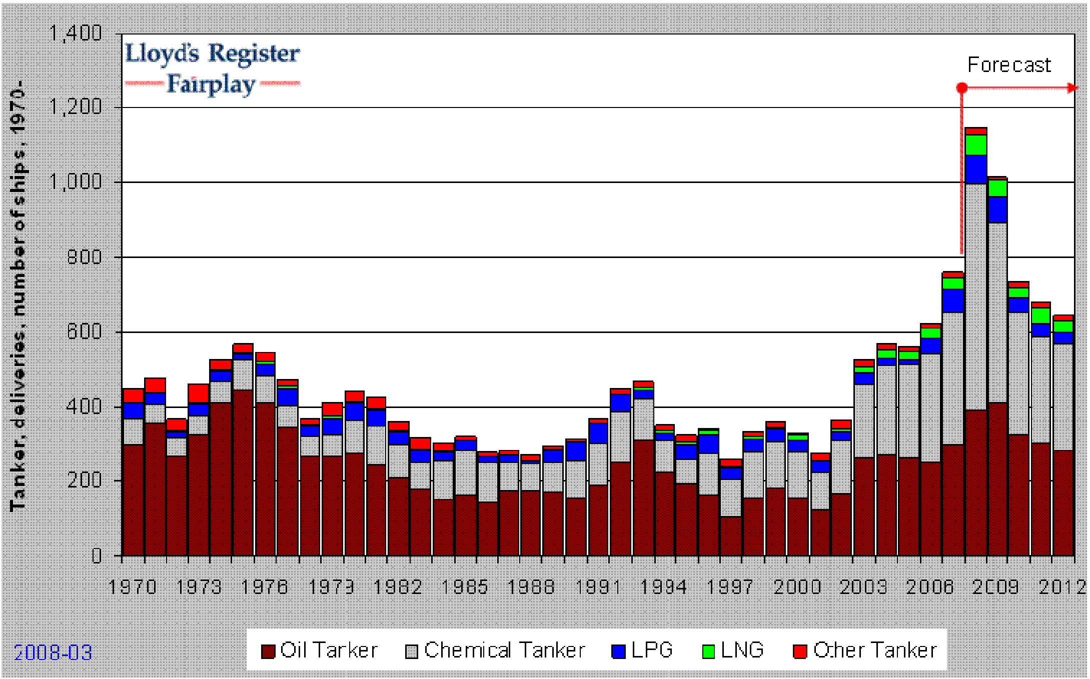

Figure F.30 : Tanker deliveries no., (Source: Shipbuilding Market Forecast April 2008).

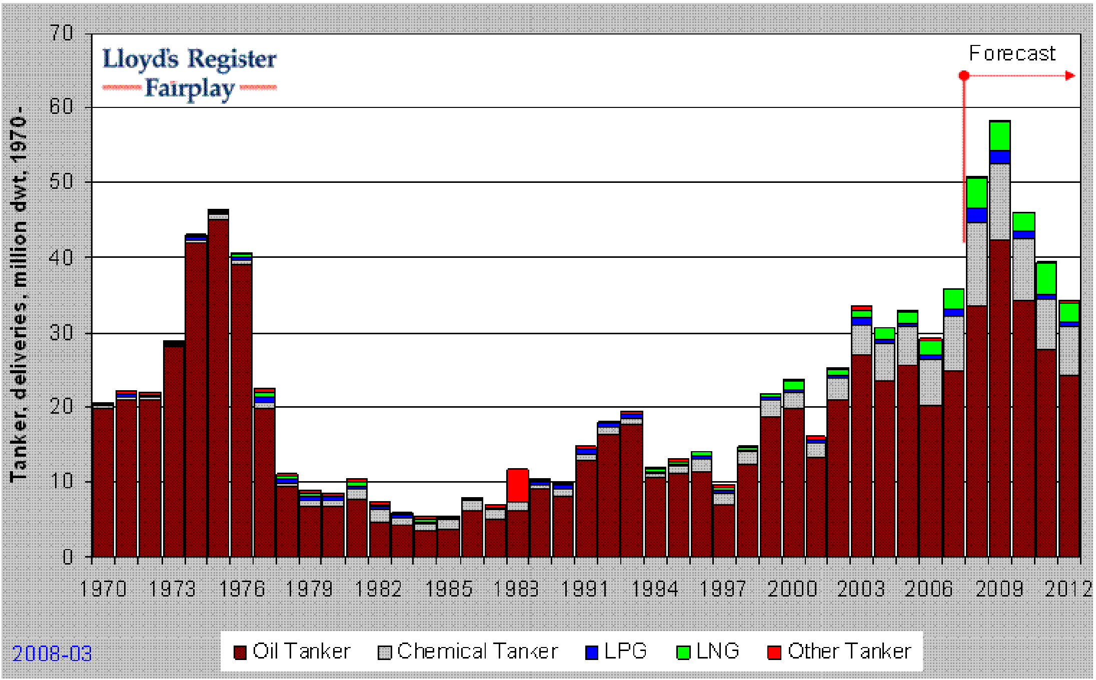

Figure F.31 : Tanker deliveries DWT., (Source: Shipbuilding Market Forecast April 2008).

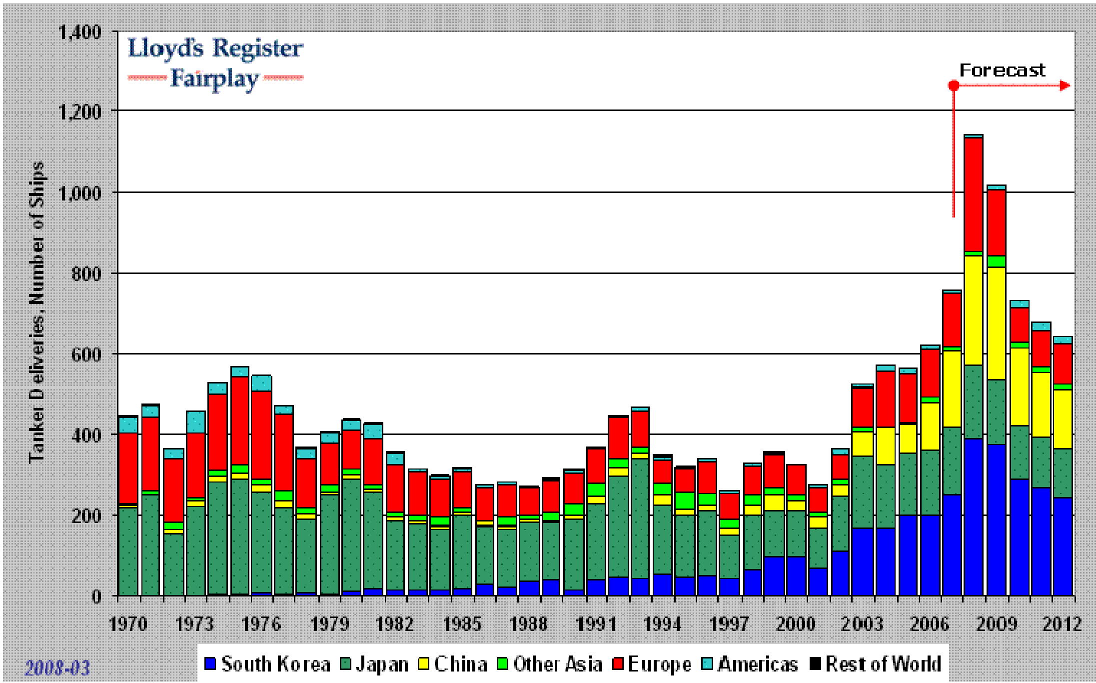

Figure F.32 : Tanker deliveries, builders region no., (Source: Shipbuilding Market Forecast April 2008).

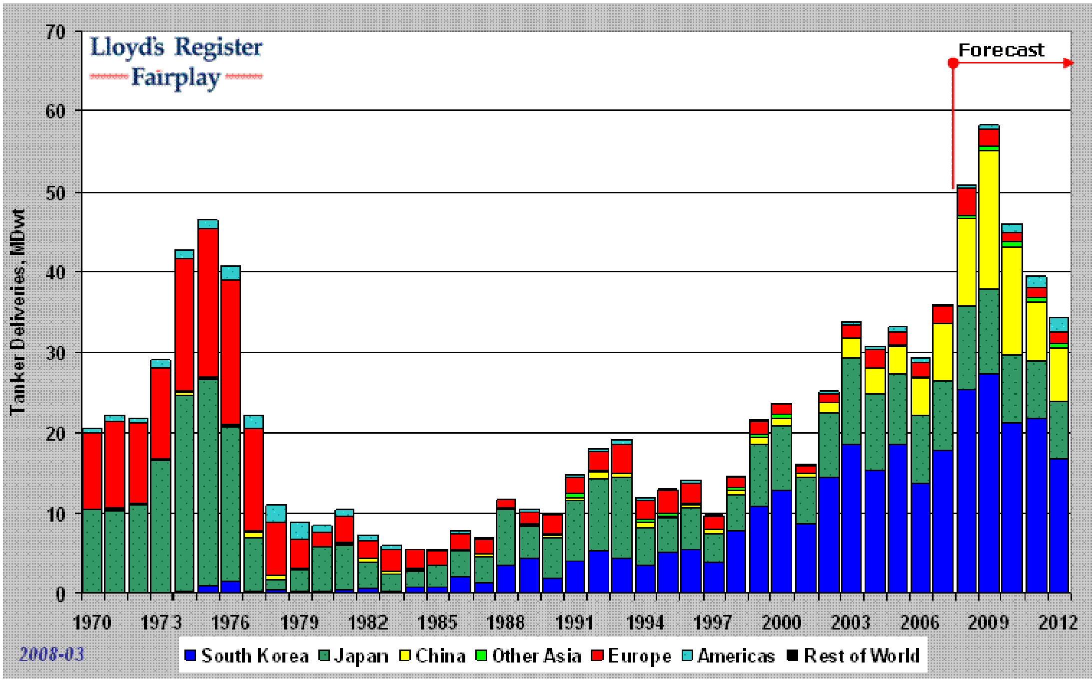

Figure F.33 : Tanker deliveries, builders region DWT., (Source: Shipbuilding Market Forecast April 2008).

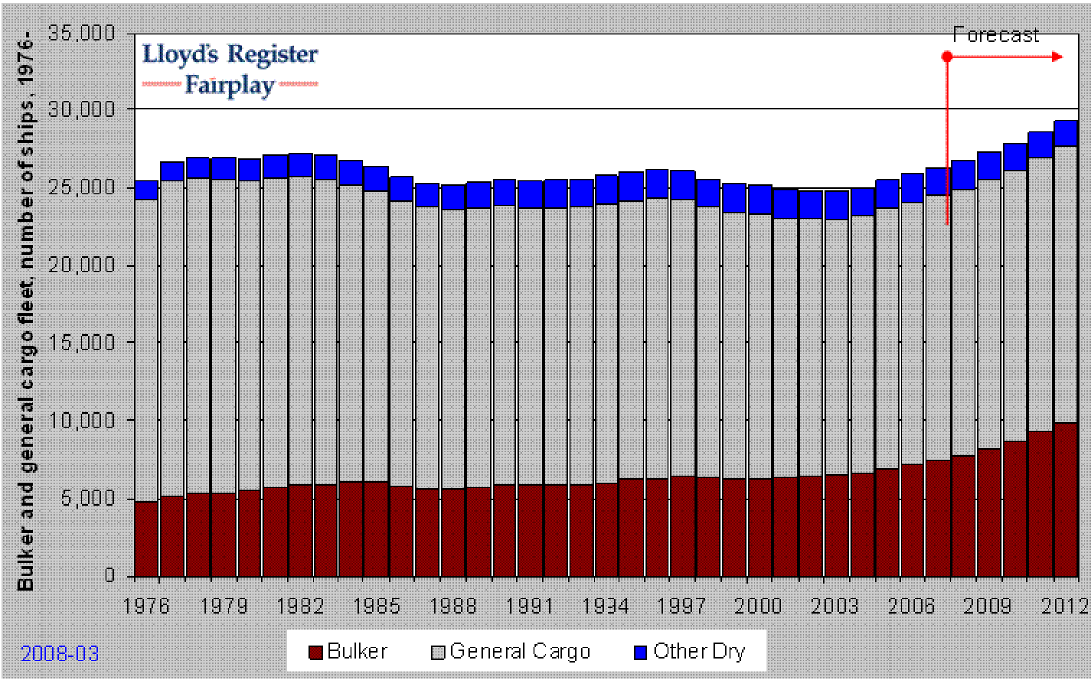

Figure F.34 : General cargo & Bulker fleet no., (Source: Shipbuilding Market Forecast April 2008).

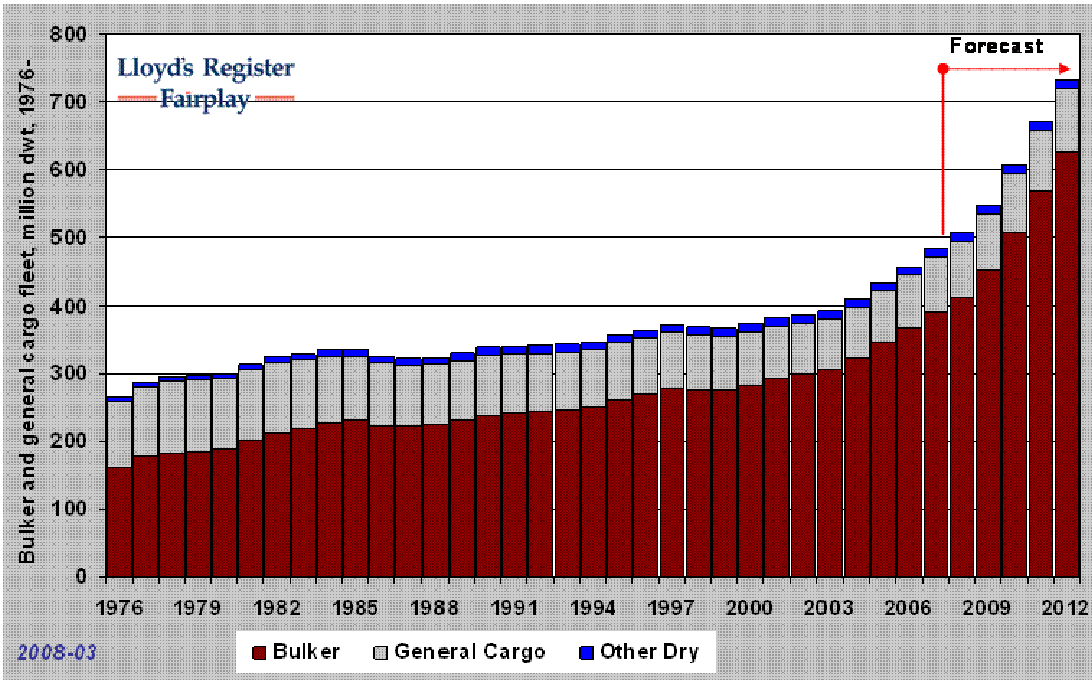

Figure F.35 : General cargo & Bulker fleet DWT., (Source: Shipbuilding Market Forecast April 2008).

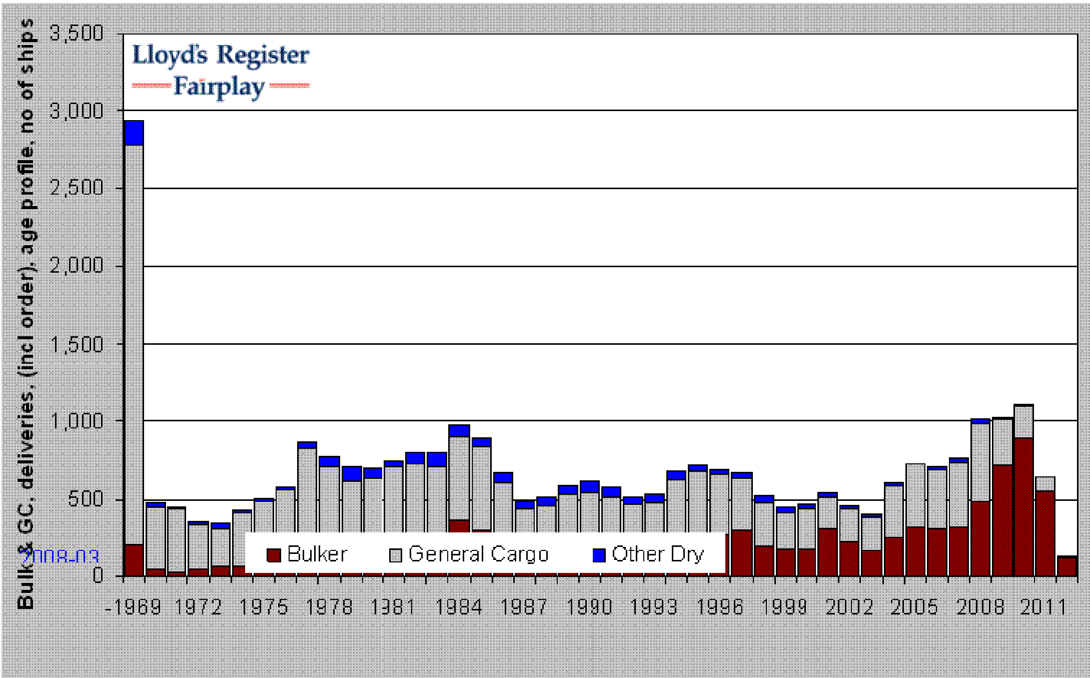

Figure F.36 : General cargo & Bulker age profile incl. orderbook no., (Source: Shipbuilding Market Forecast April 2008).

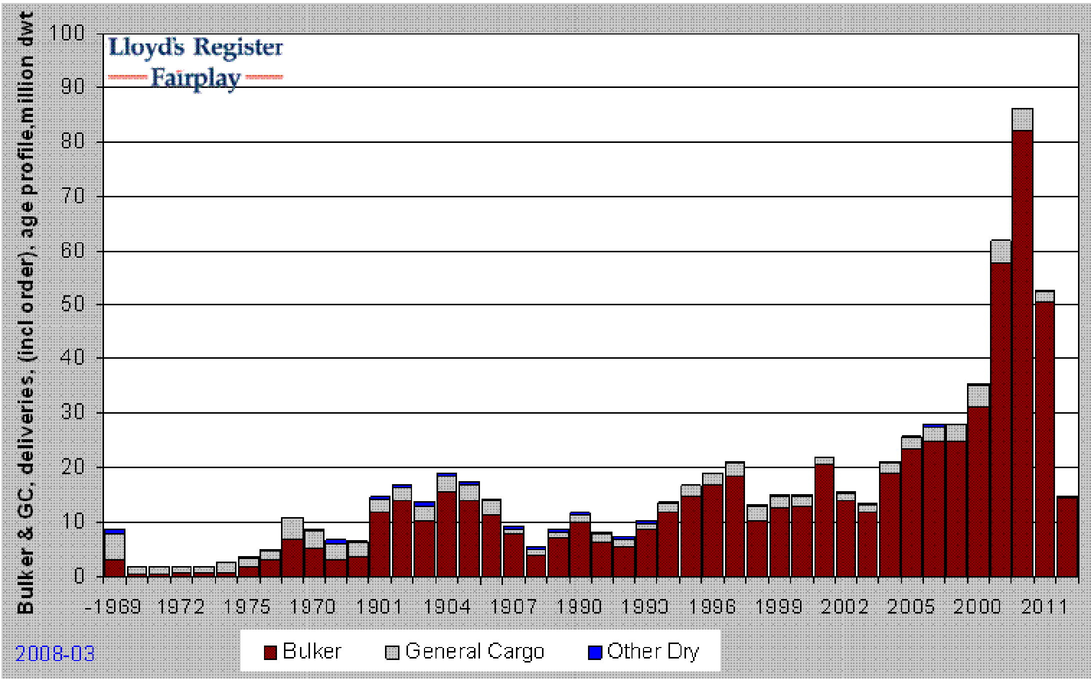

Figure F.37 : General cargo & Bulker age profile incl. orderb. DWT., (Source: Shipbuilding Market Forecast April 2008).

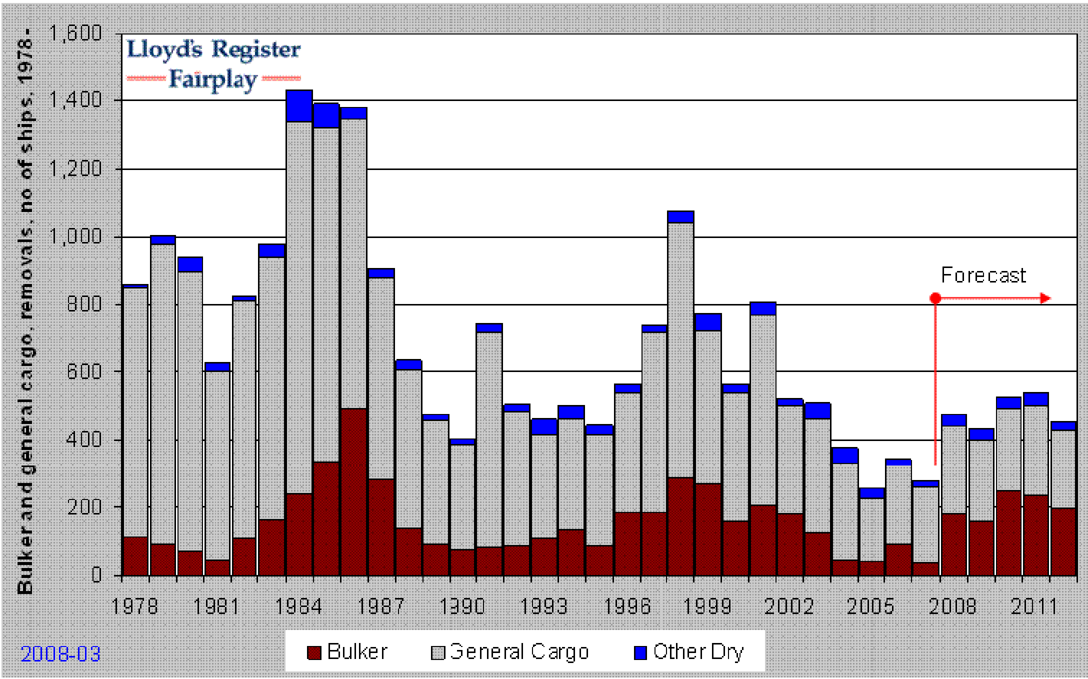

Figure F.38 : General cargo & Bulker removals no., (Source: Shipbuilding Market Forecast April 2008).

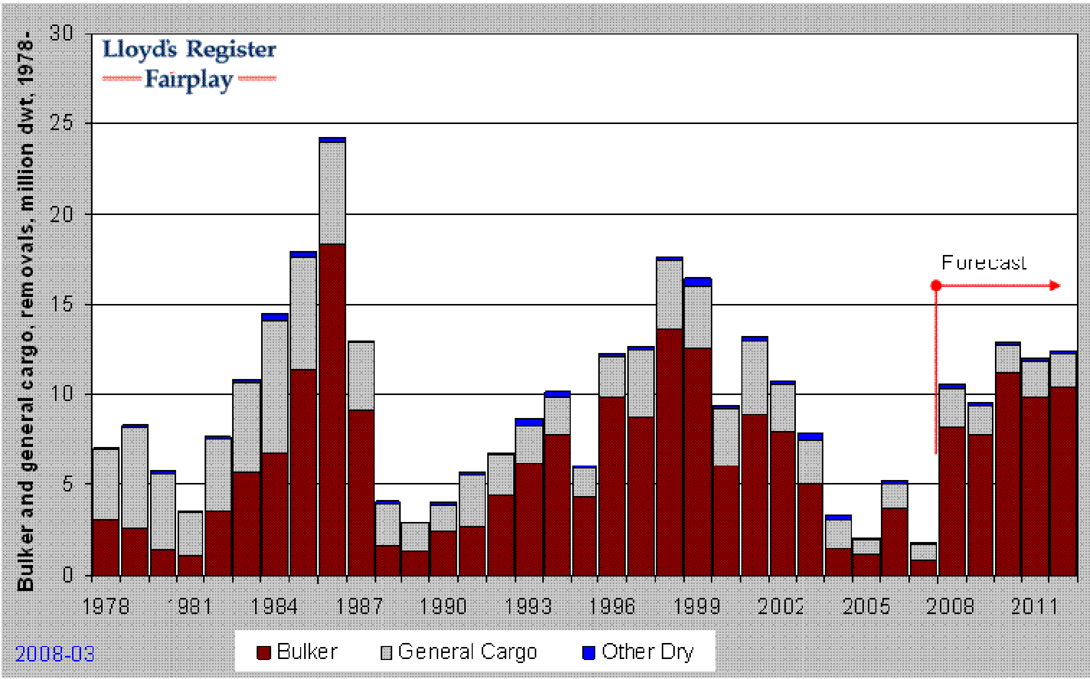

Figure F.39 : General cargo & Bulker removals DWT., (Source: Shipbuilding Market Forecast April 2008).

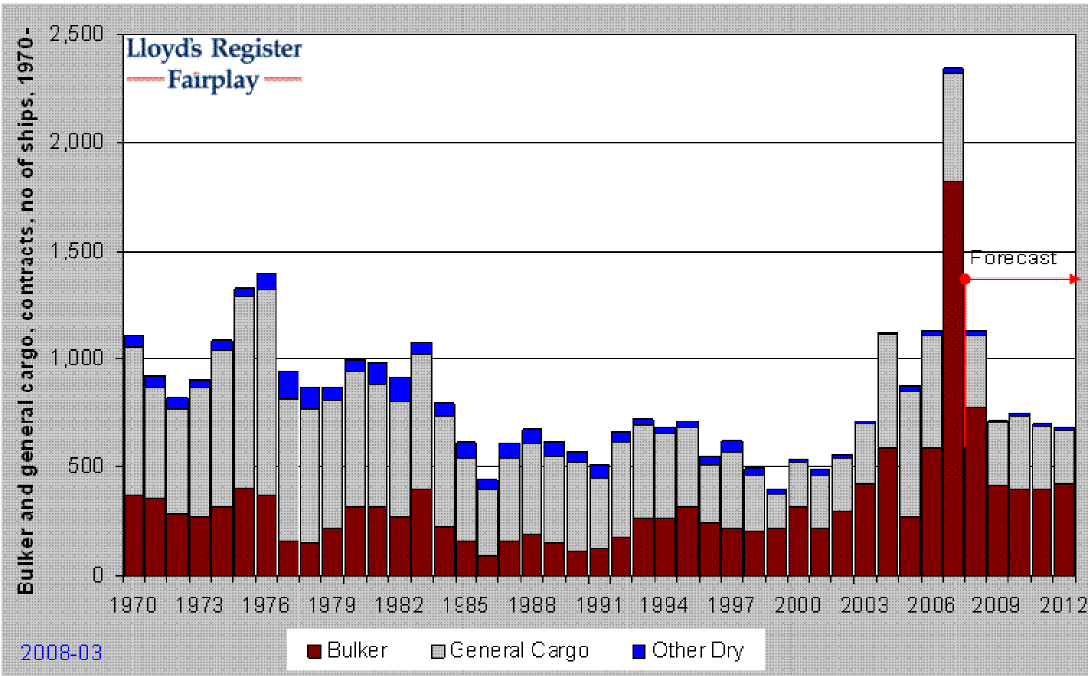

Figure F.40 : General cargo & Bulker contracts no., (Source: Shipbuilding Market Forecast April 2008).

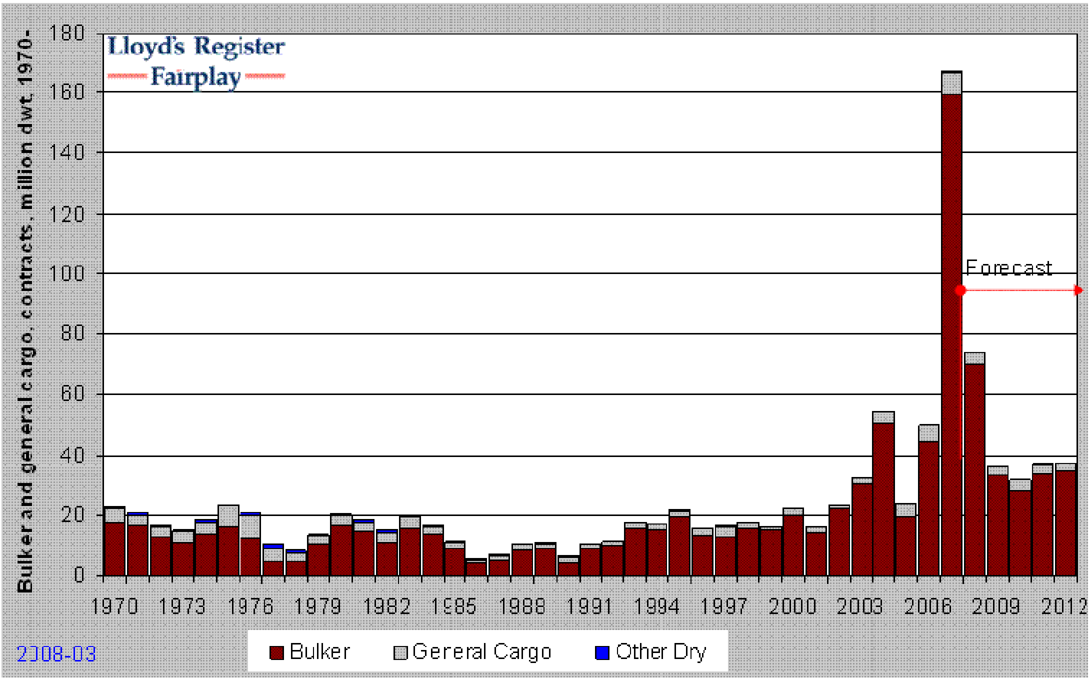

Figure F.41 : General cargo & Bulker contracts DWT., (Source: Shipbuilding Market Forecast April 2008).

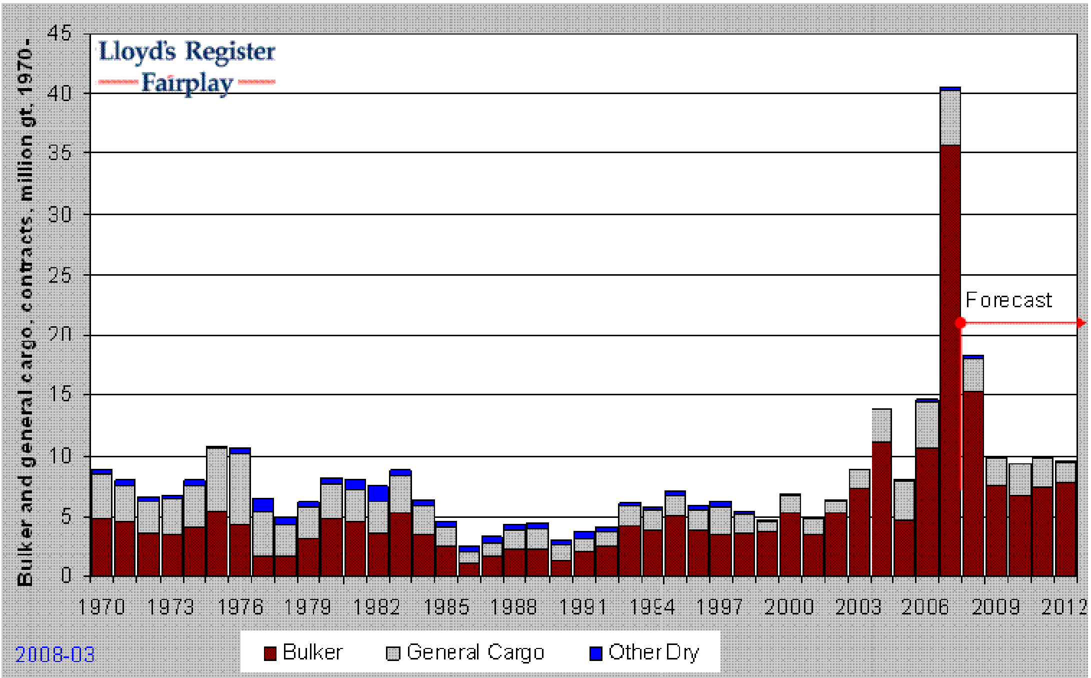

Figure F.42 : General cargo & Bulker contracts CGT., (Source: Shipbuilding Market Forecast April 2008).

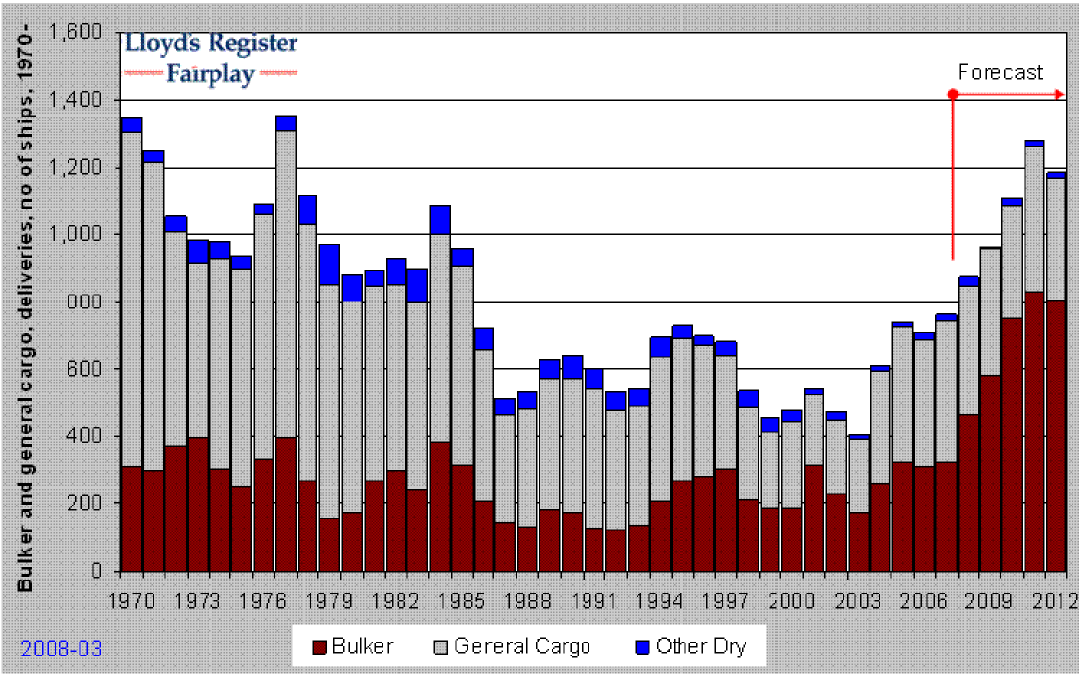

Figure F.43 : General cargo & Bulker deliveries no., (Source: Shipbuilding Market Forecast April 2008).

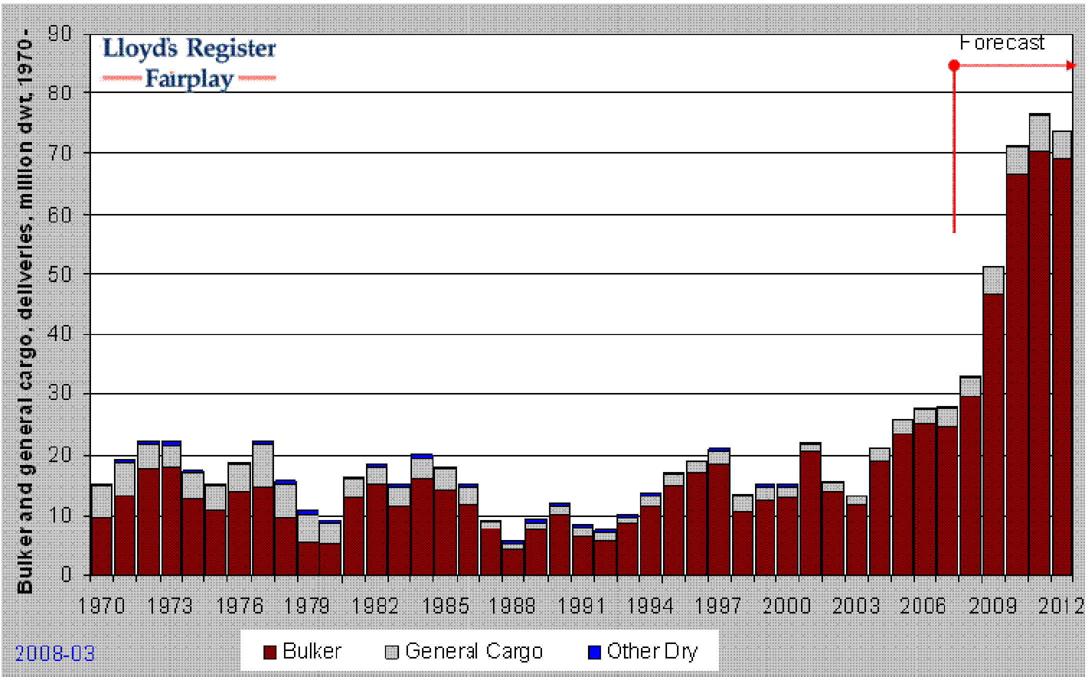

Figure F.44 : General cargo & Bulker contracts DWT., (Source: Shipbuilding Market Forecast April 2008).

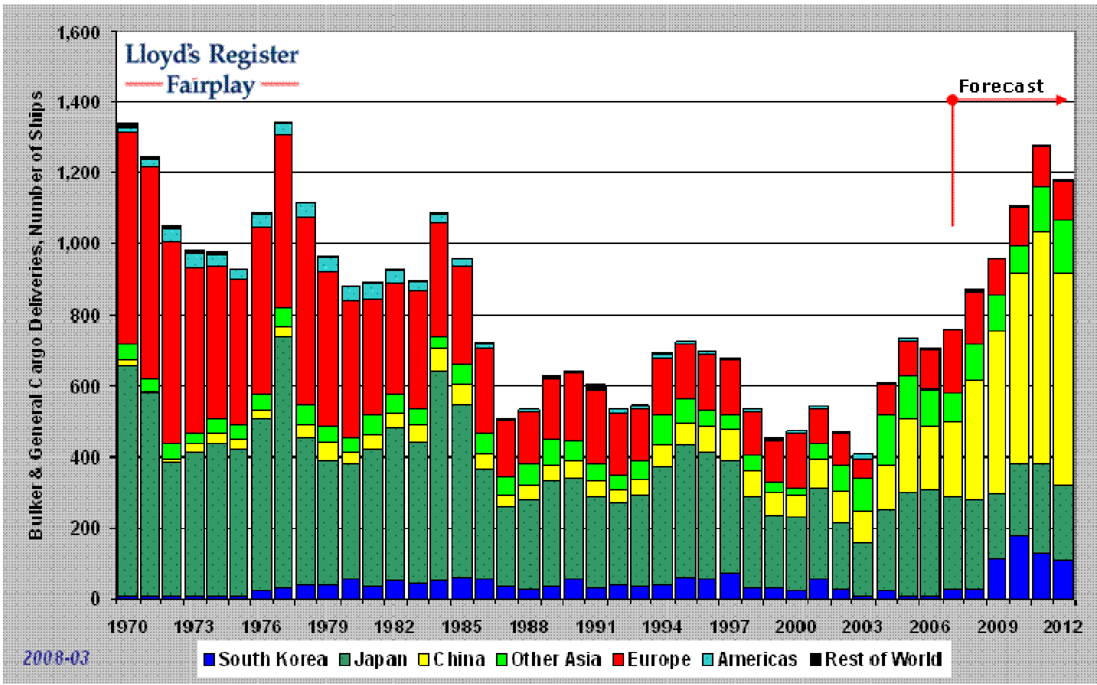

Figure F.45 : General cargo & Bulker deliveries, builders region no., (Source: Shipbuilding Market Forecast April 2008).

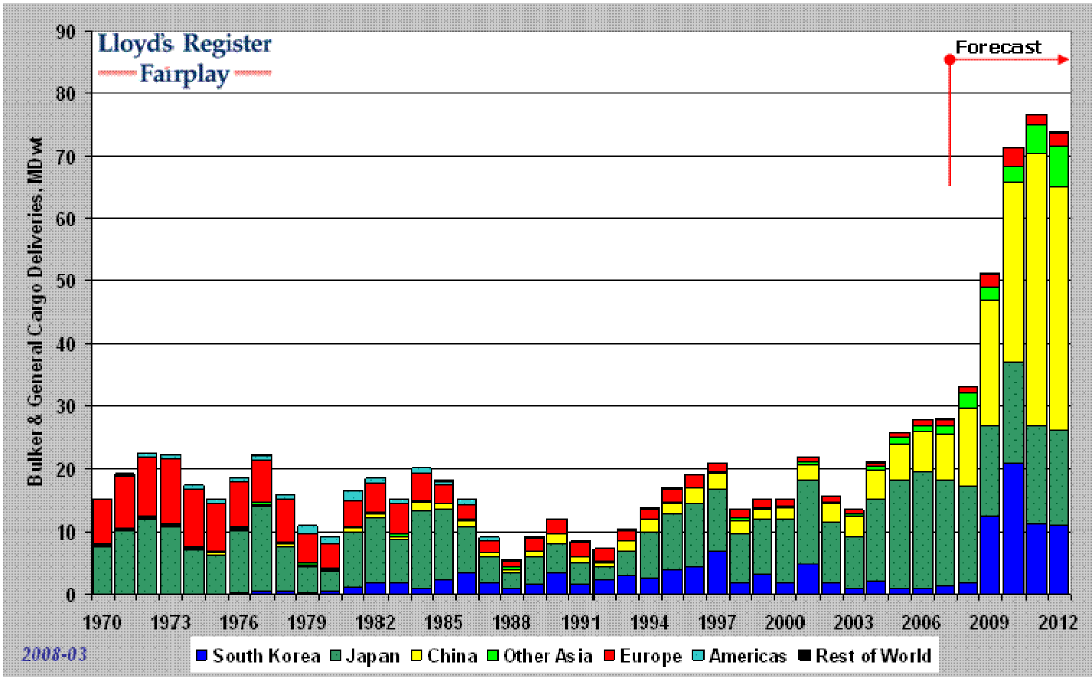

Figure F.46 : General cargo & Bulker deliveries, builder region DWT., (Source: Shipbuilding Market Forecast April 2008).

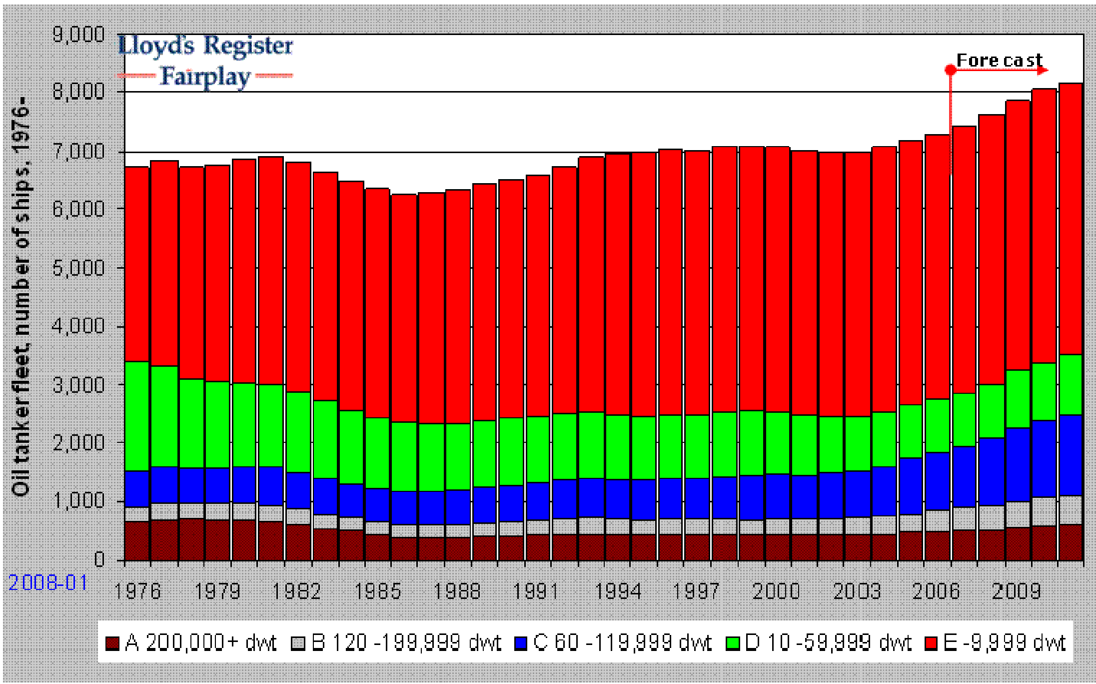

Figure F.47 : Oil tanker fleet no., (Source: Shipbuilding Market Forecast February 2008).

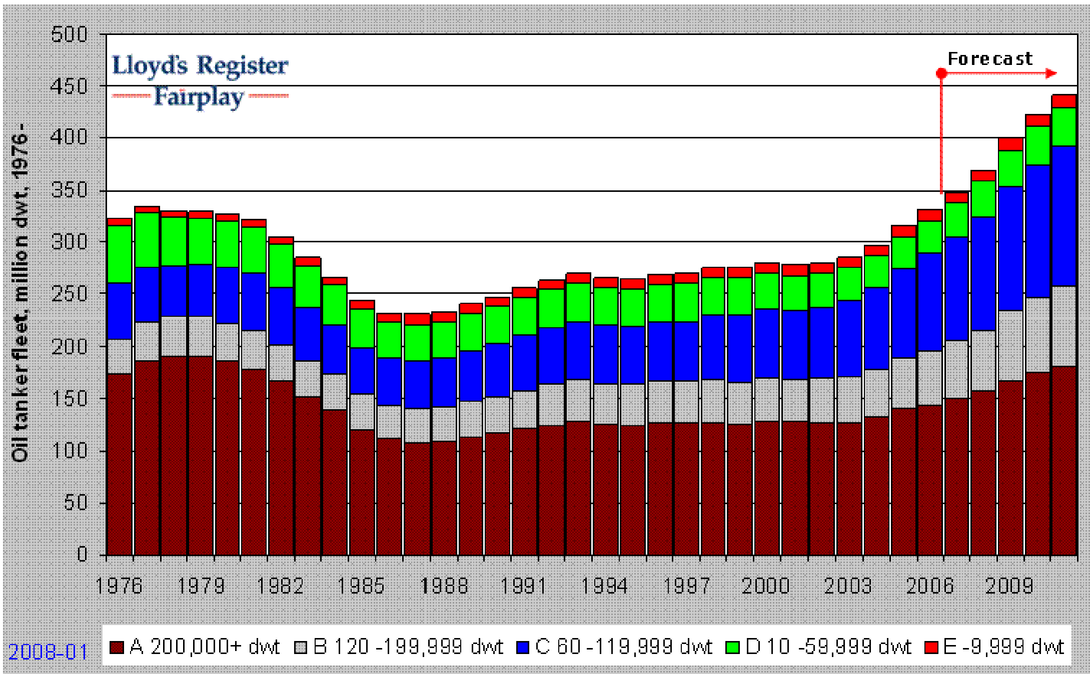

Figure F.48 : Oil tanker fleet DWT., (Source: Shipbuilding Market Forecast February 2008).

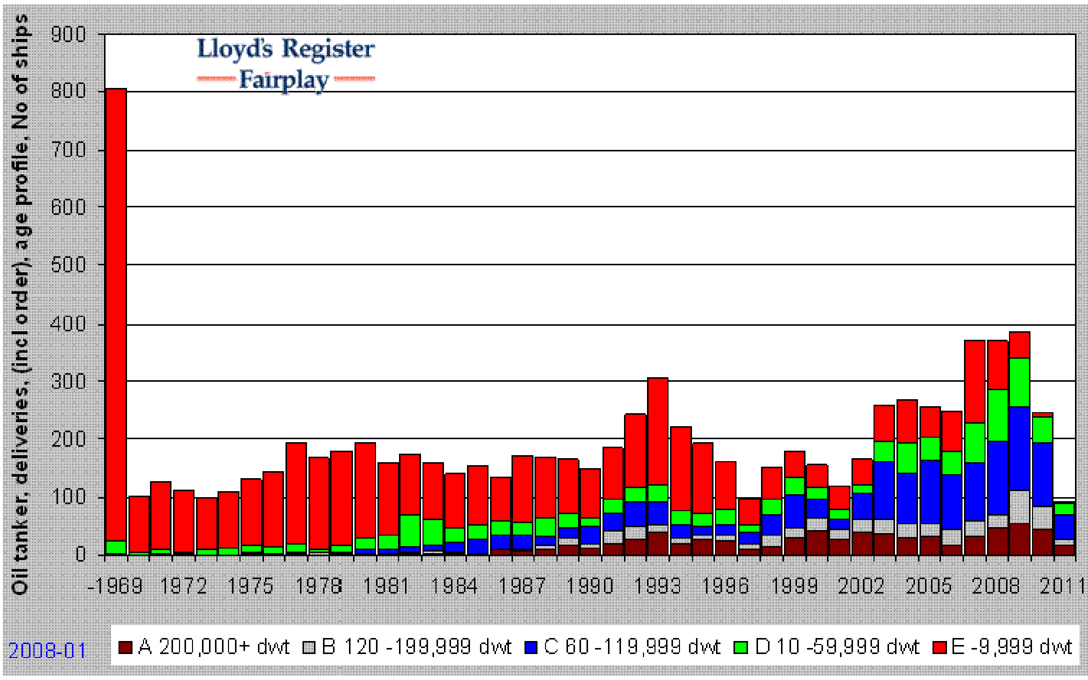

Figure F.49 : Oil tanker. age profile incl. orderbook no., (Source: Shipbuilding Market Forecast February 2008).

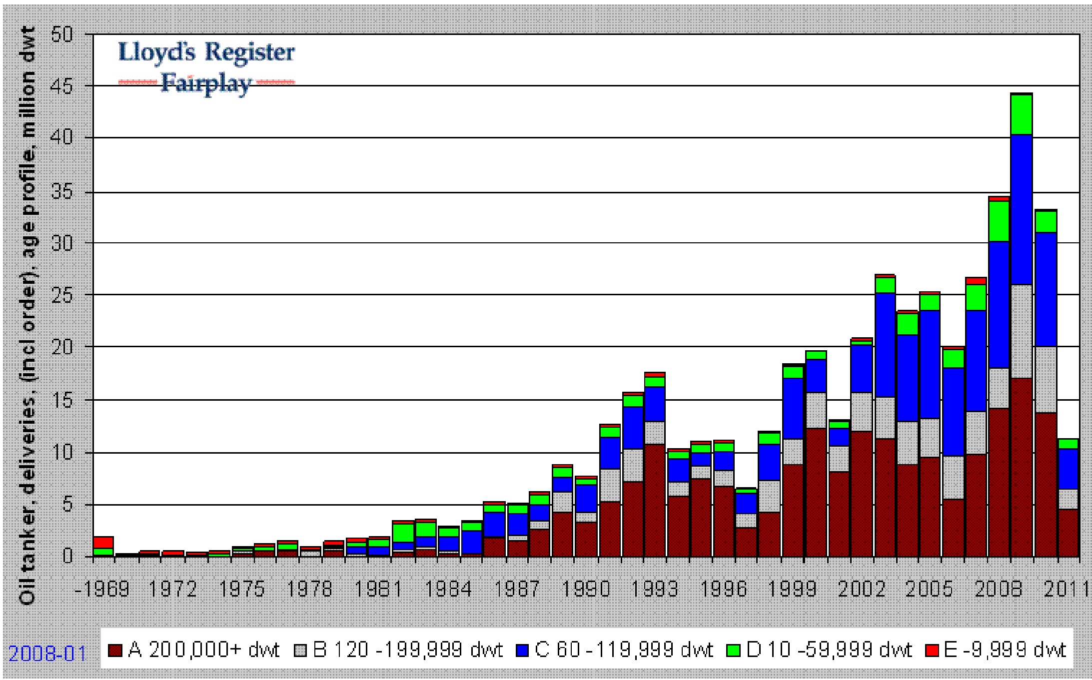

Figure F.50 : Oil tanker age profile incl. orderb. DWT., (Source: Shipbuilding Market Forecast February 2008).

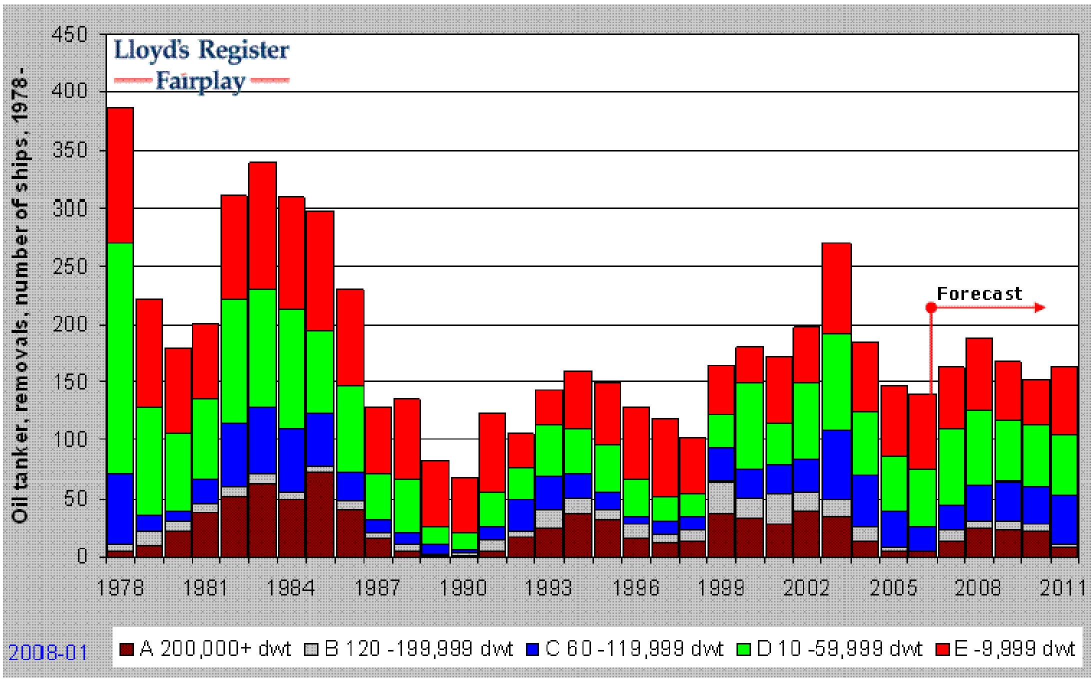

Figure F.51 : Oil tanker removals no., (Source: Shipbuilding Market Forecast February 2008).

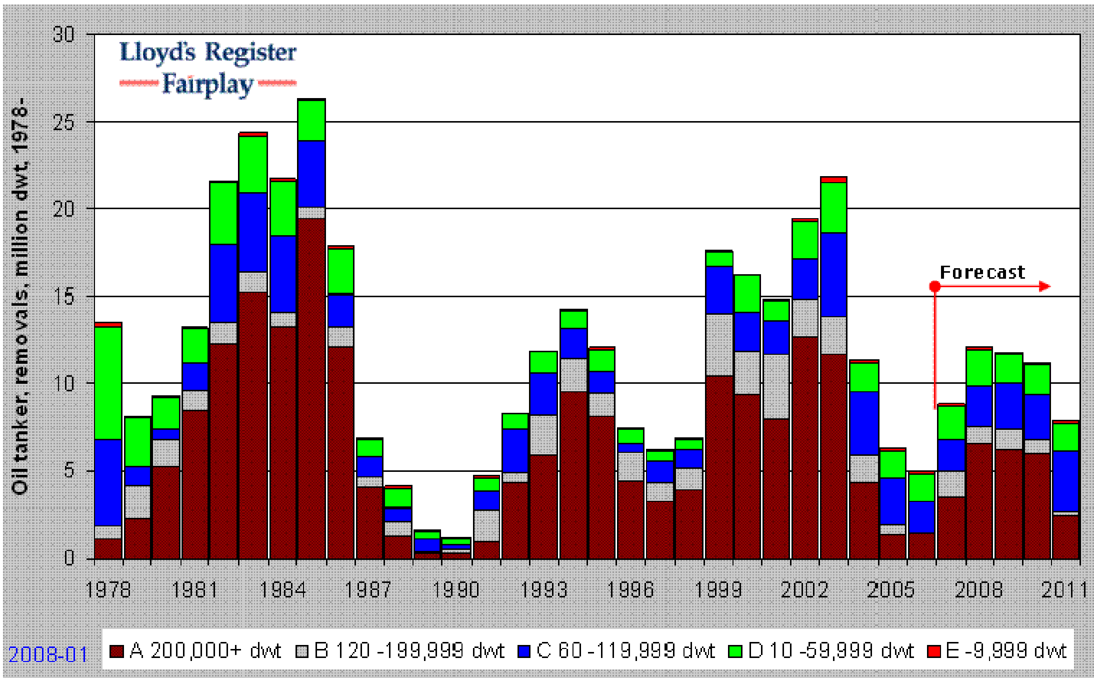

Figure F.52 : Oil tanker removals DWT., (Source: Shipbuilding Market Forecast February 2008).

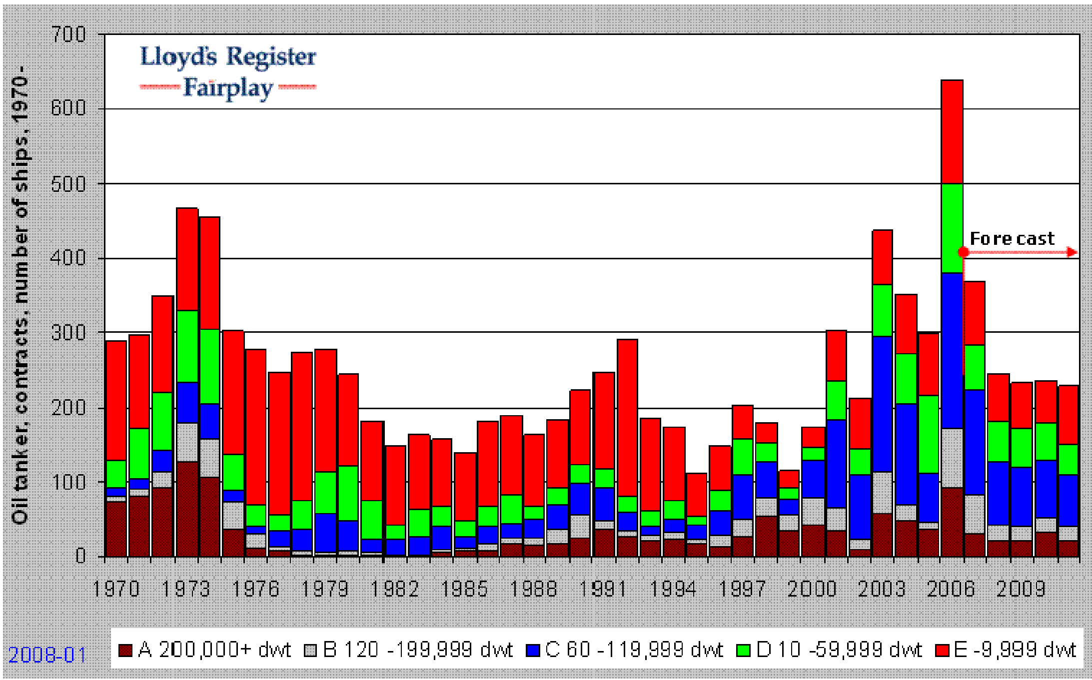

Figure F.53 : Oil tanker contracts no., (Source: Shipbuilding Market Forecast February 2008).

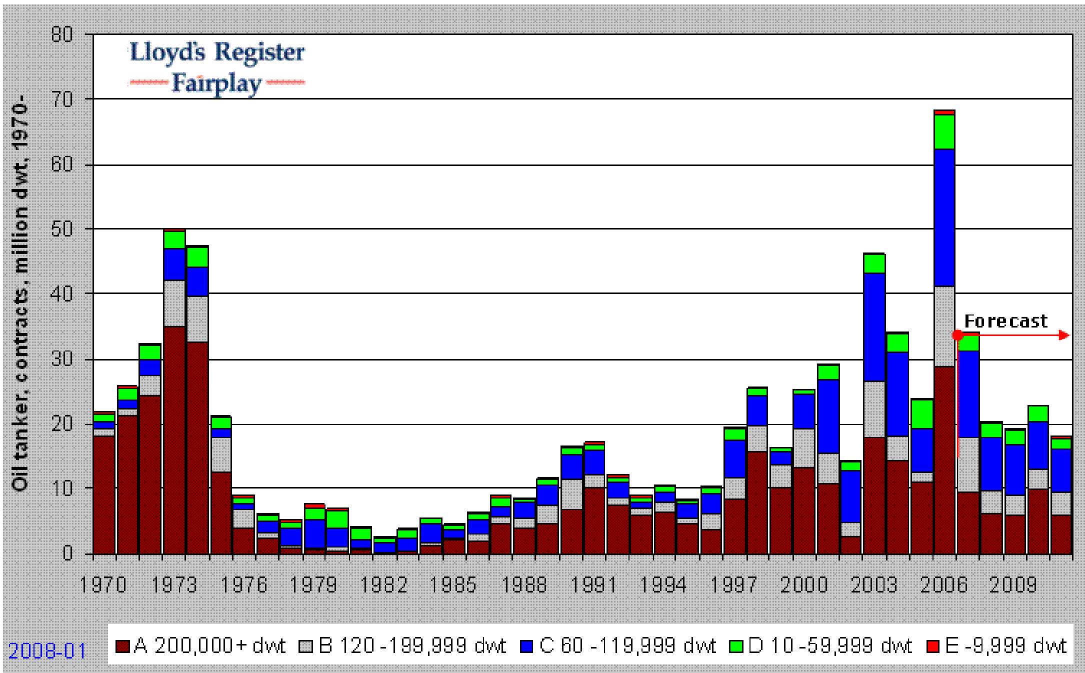

Figure F.54 : Oil tanker contracts DWT., (Source: Shipbuilding Market Forecast February 2008).

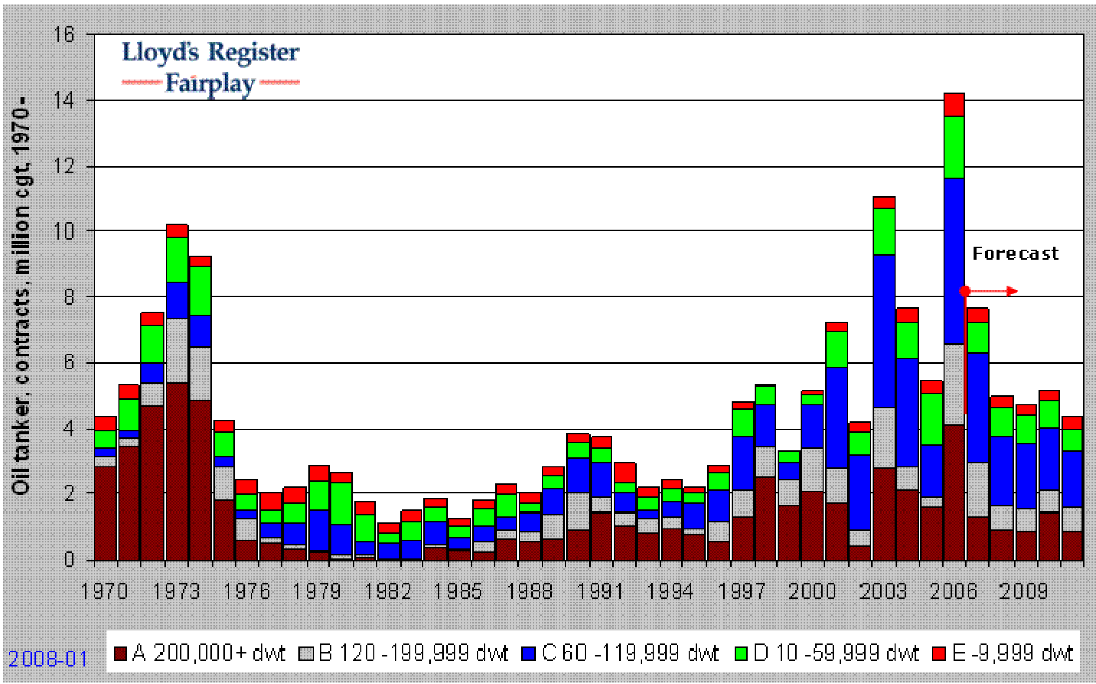

Figure F.55 : Oil tanker contracts CGT., (Source: Shipbuilding Market Forecast February 2008).

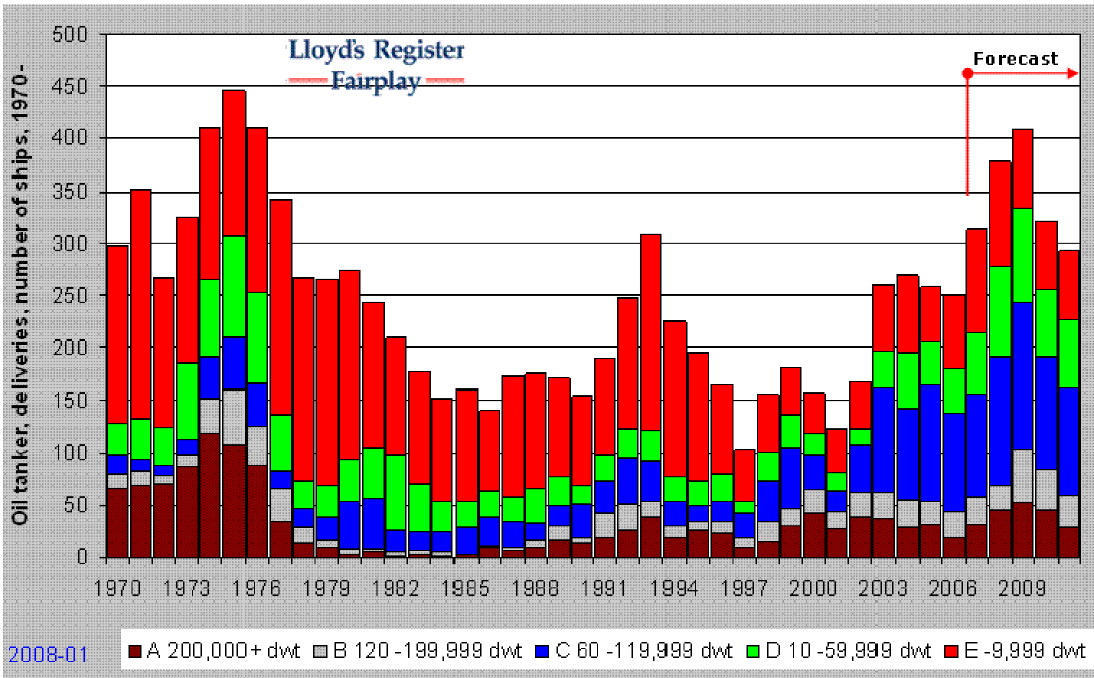

Figure F.56 : Oil tanker deliveries no., (Source: Shipbuilding Market Forecast February 2008).

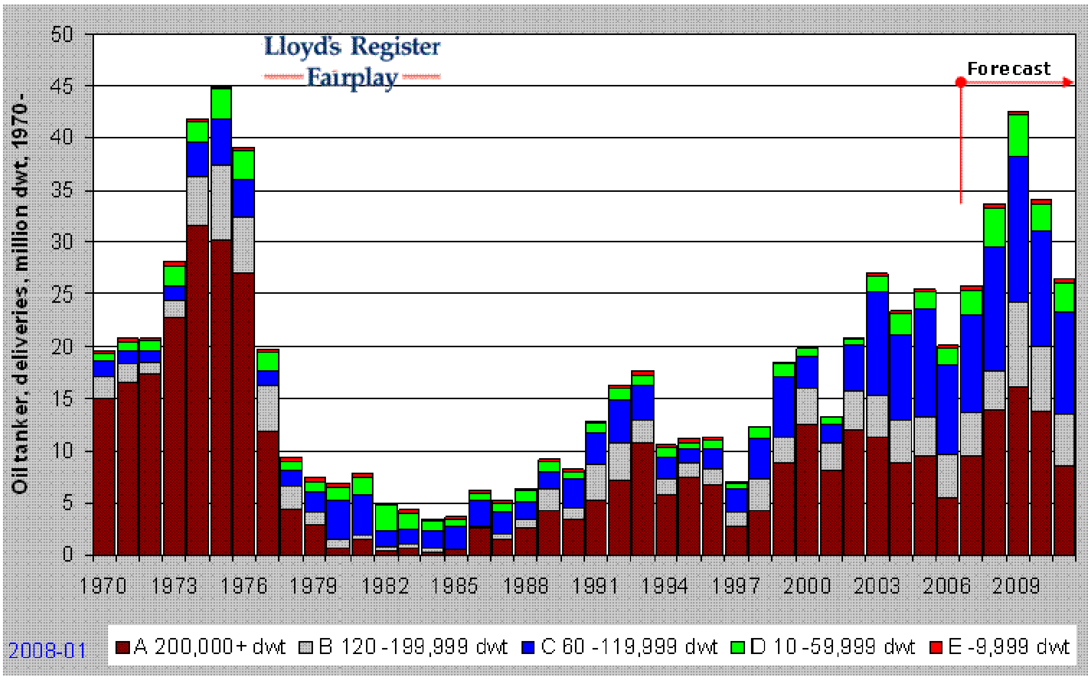

Figure F.57: Oil tanker deliveries DWT., (Source: Shipbuilding Market Forecast February 2008).

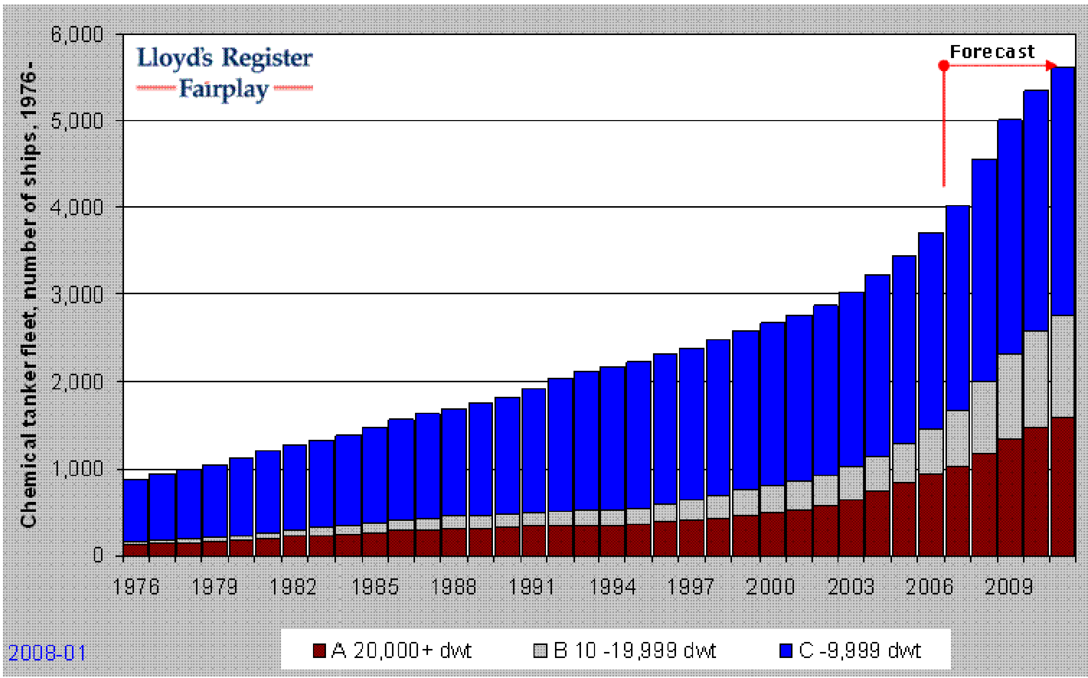

Figure F.58 : Chemical tanker fleet no., (Source: Shipbuilding Market Forecast February 2008).

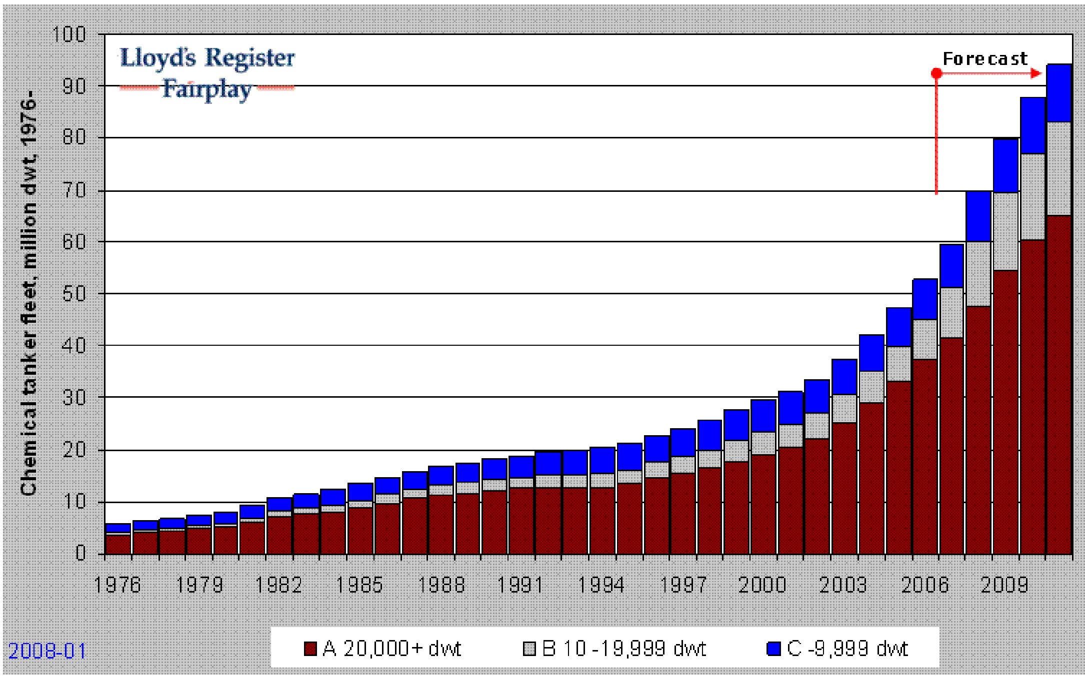

Figure F.59 : Chemical tanker fleet DWT., (Source: Shipbuilding Market Forecast February 2008).

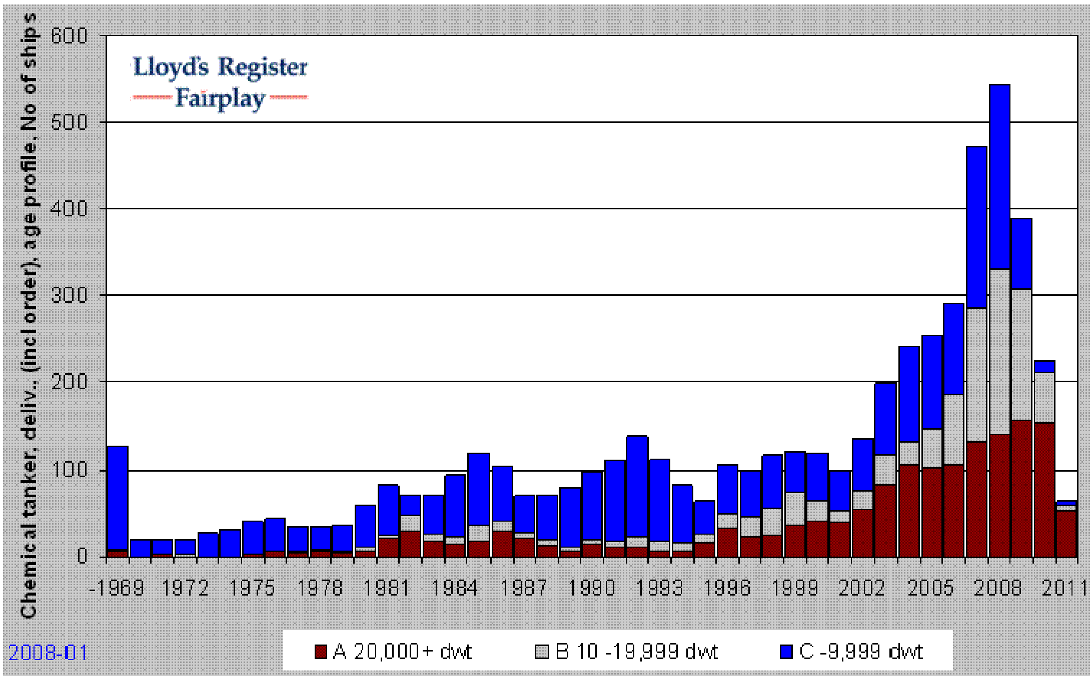

Figure F.60 : Chemical tanker age profile incl. orderbook no., (Source: Shipbuilding Market Forecast February 2008).

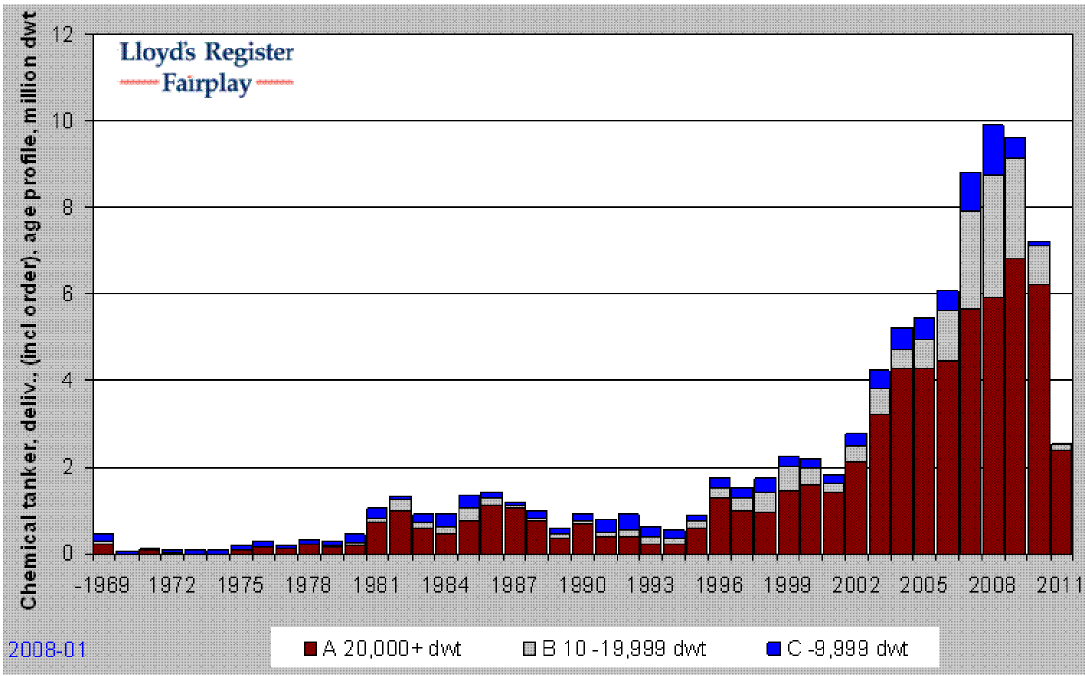

Figure F.61 : Chemical tanker age profile incl. orderb. DWT., (Source: Shipbuilding Market Forecast February 2008).

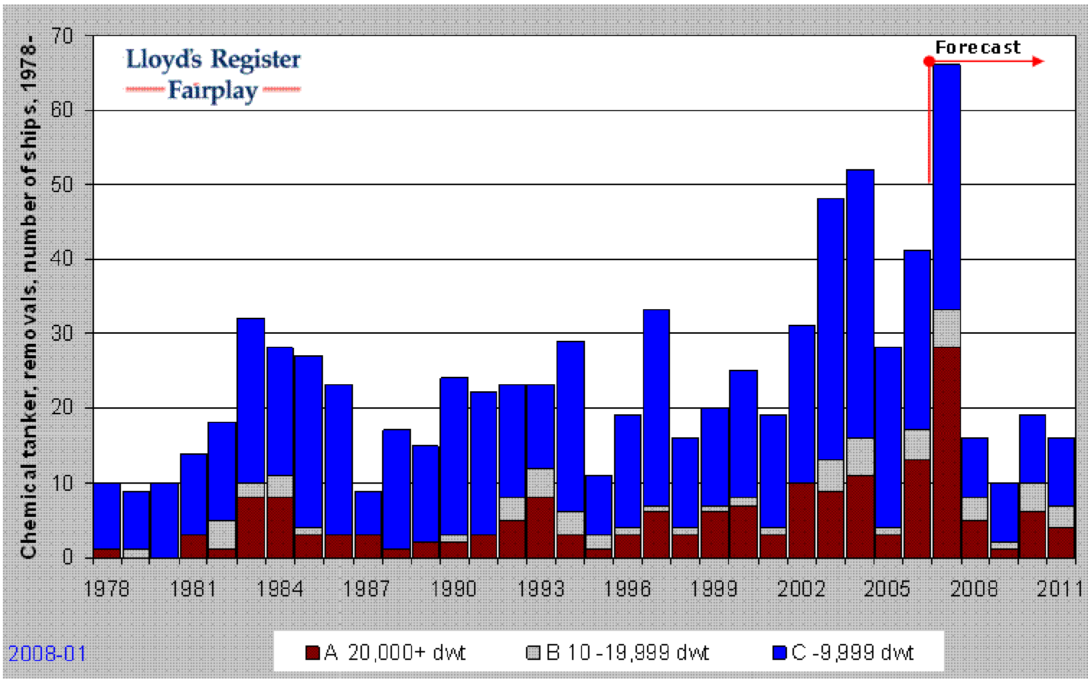

Figure F.62 : Chemical tanker removals no., (Source: Shipbuilding Market Forecast February 2008).

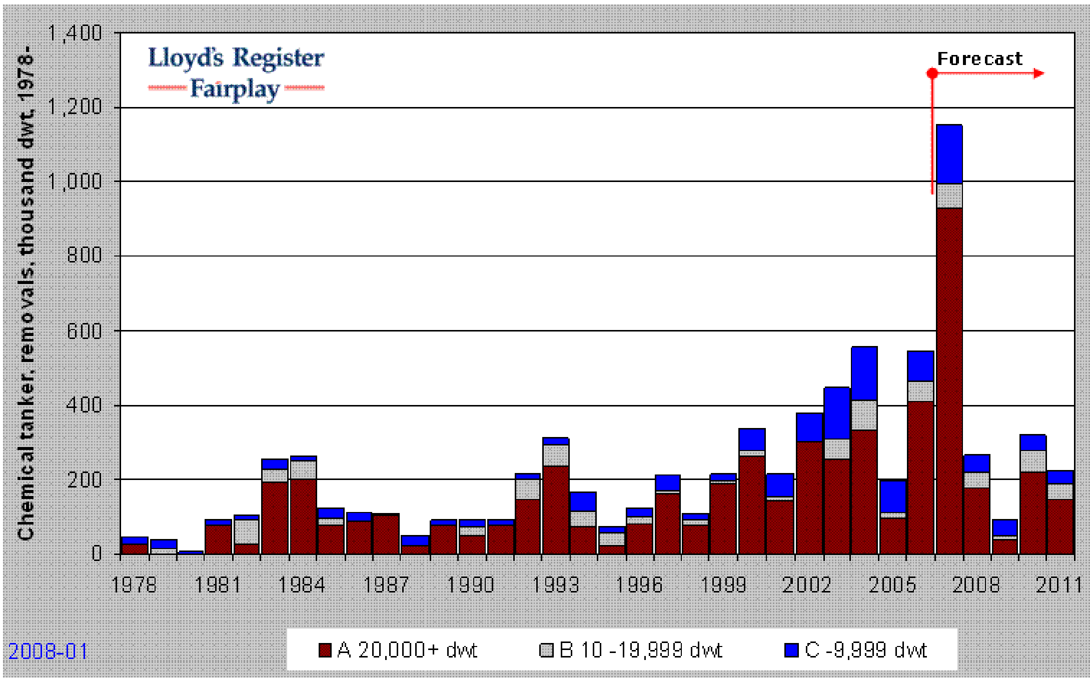

Figure F.63 : Chemical tanker removals DWT., (Source: Shipbuilding Market Forecast February 2008).

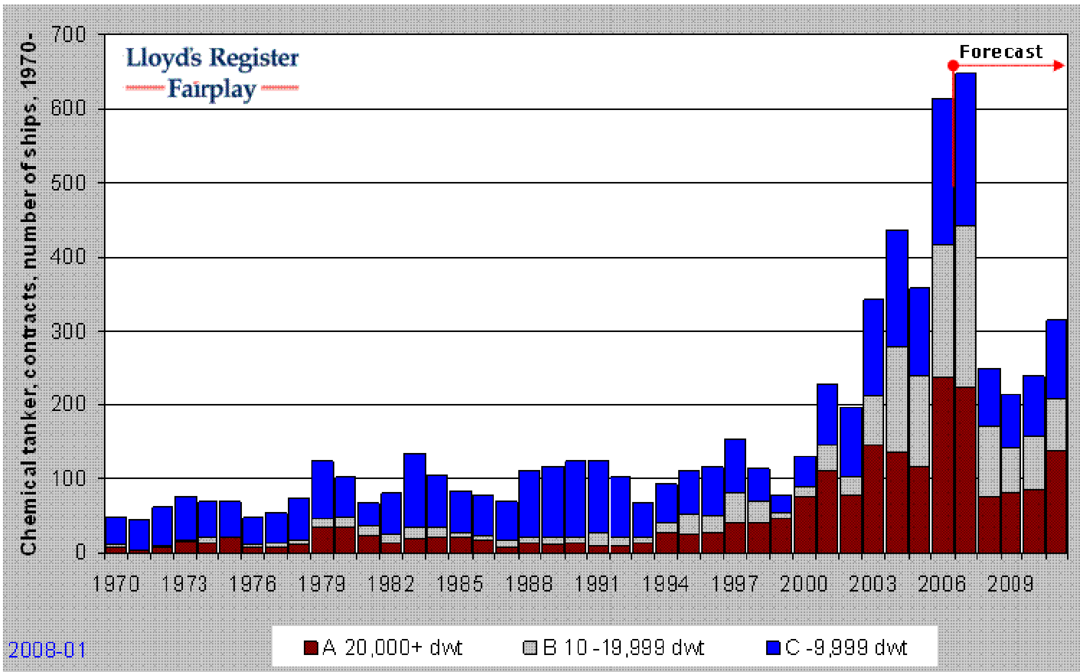

Figure F.64 : Chemical tanker contracts no., (Source: Shipbuilding Market Forecast February 2008).

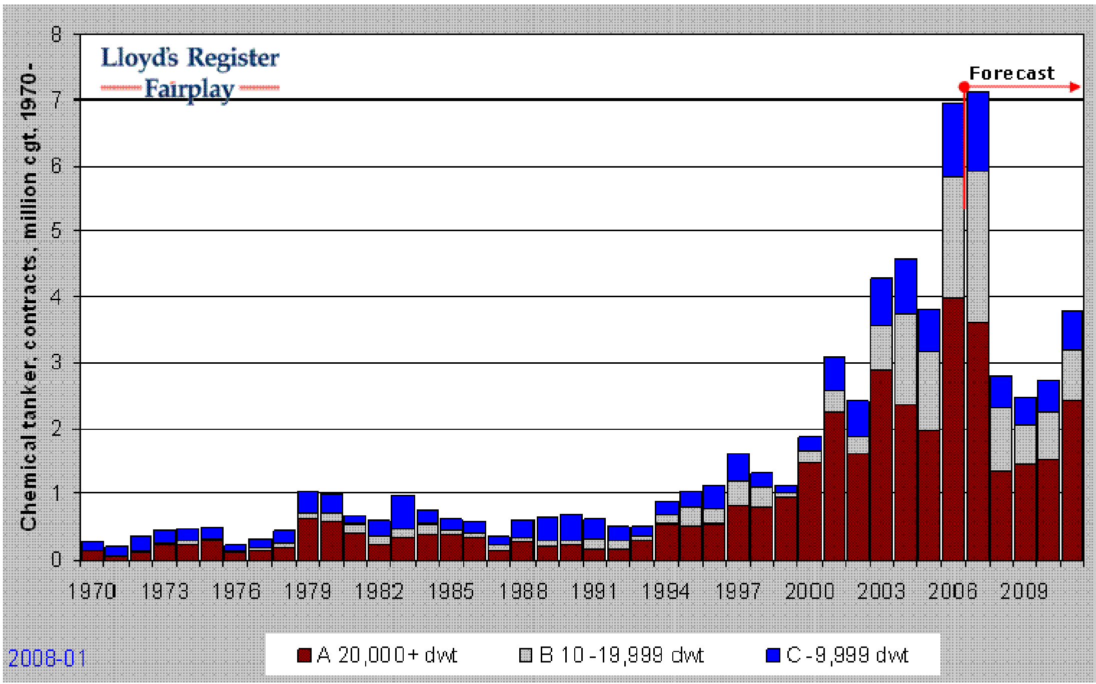

Figure F.65 : Chemical tanker contracts CGT., (Source: Shipbuilding Market Forecast February 2008).

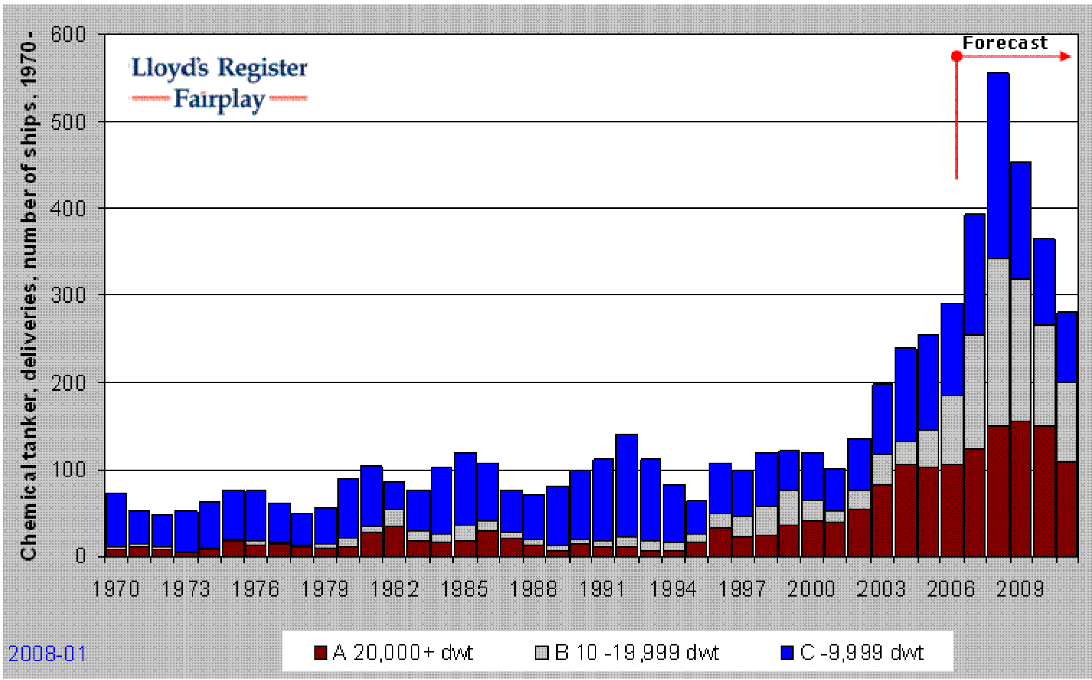

Figure F.66 : Chemical tanker deliveries no., (Source: Shipbuilding Market Forecast February 2008).

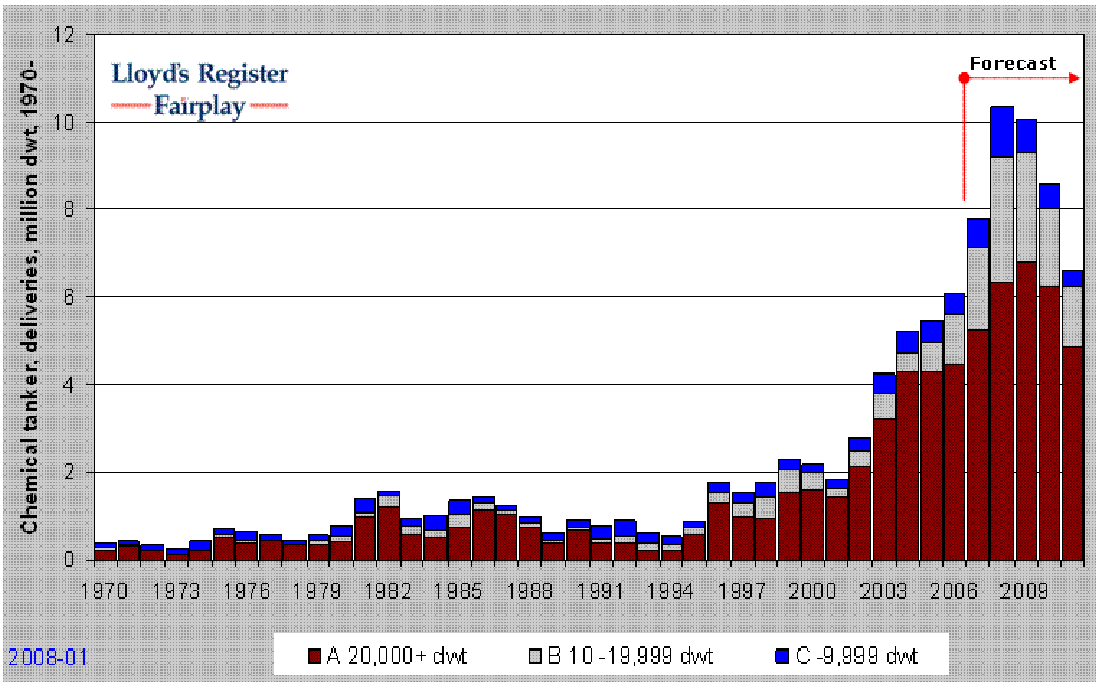

Figure F.67 : Chemical tanker deliveries DWT., (Source: Shipbuilding Market Forecast February 2008).

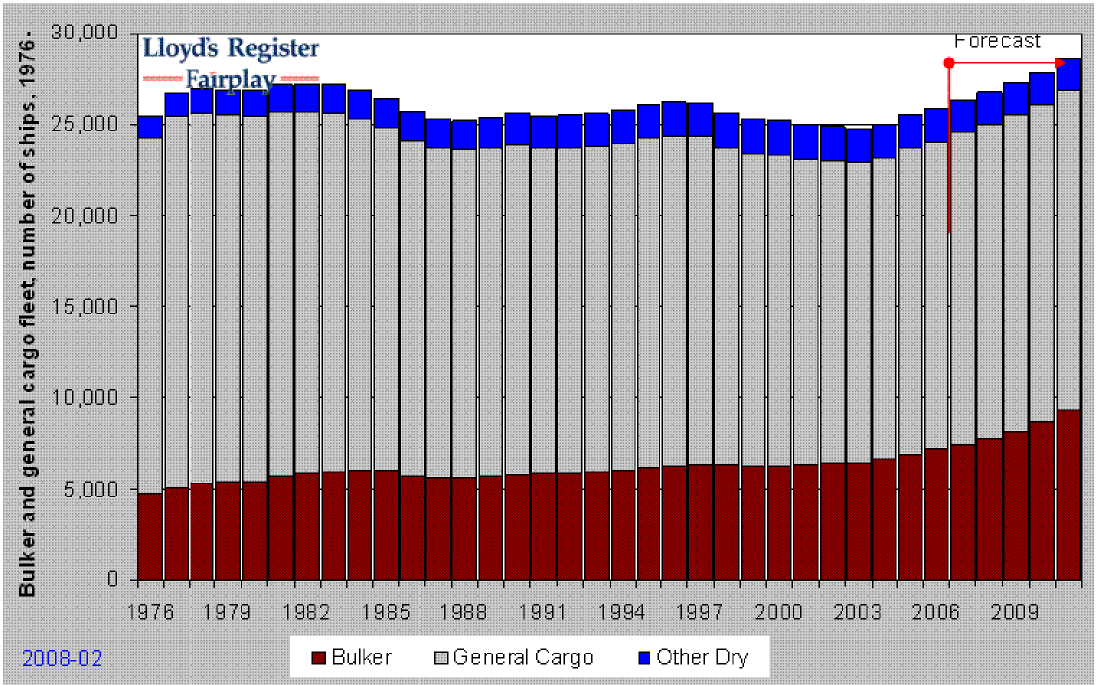

Figure F.68 : General cargo & Bulker fleet no., (Source: Shipbuilding Market Forecast March 2008).

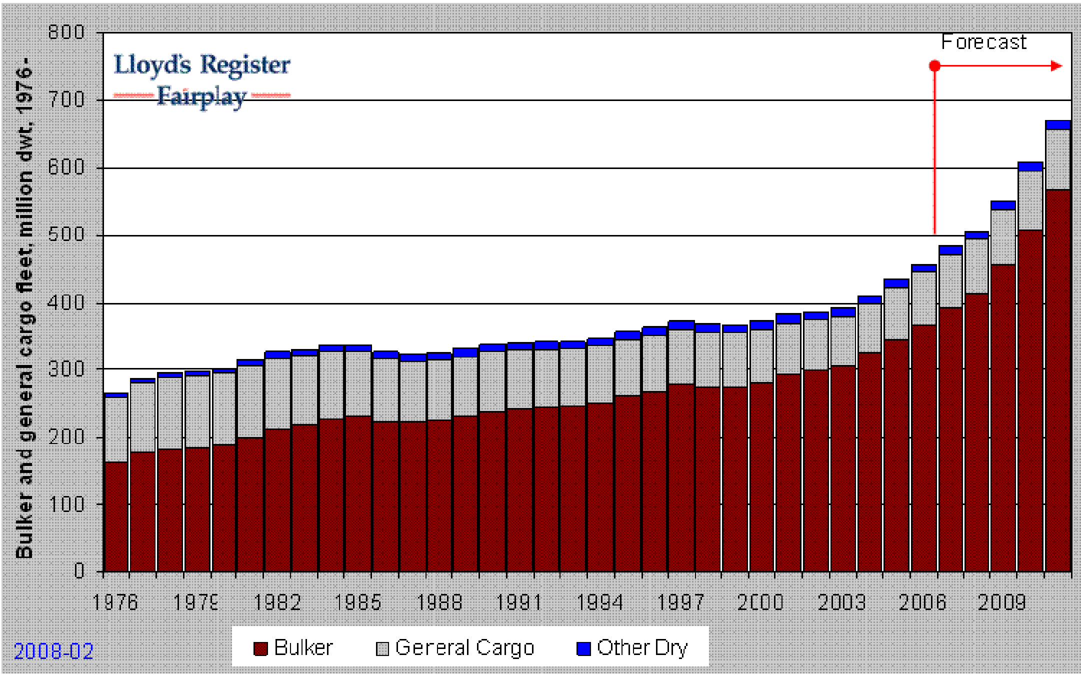

Figure F.69 : General cargo & Bulker fleet DWT., (Source: Shipbuilding Market Forecast March 2008).

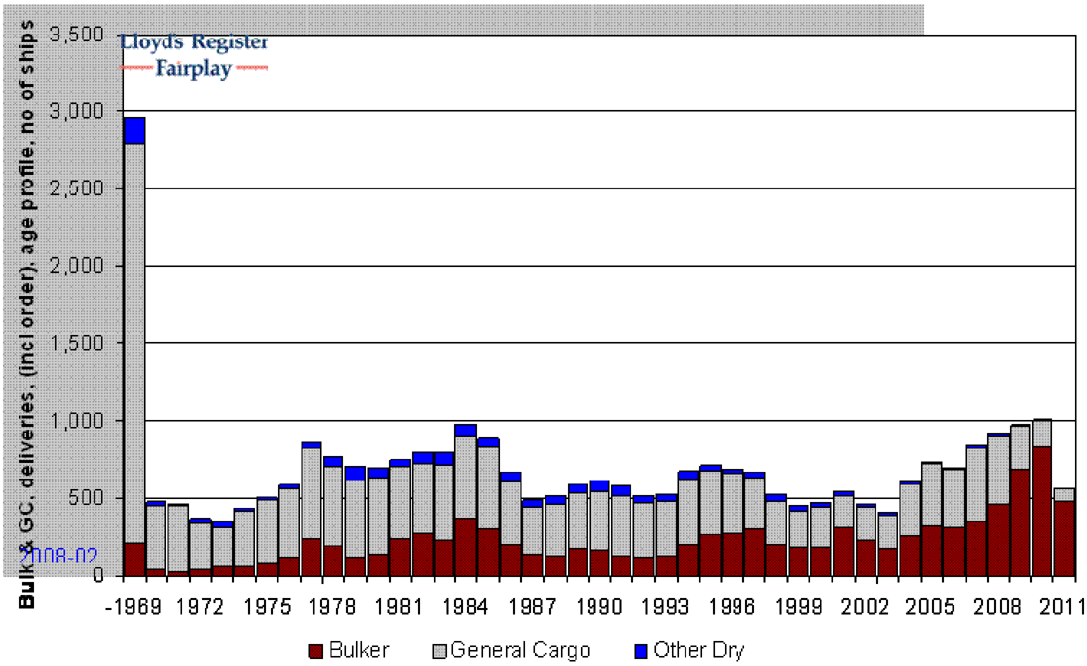

Figure F.70 : General cargo & Bulker age profile incl. orderbook no., (Source: Shipbuilding Market Forecast March 2008).

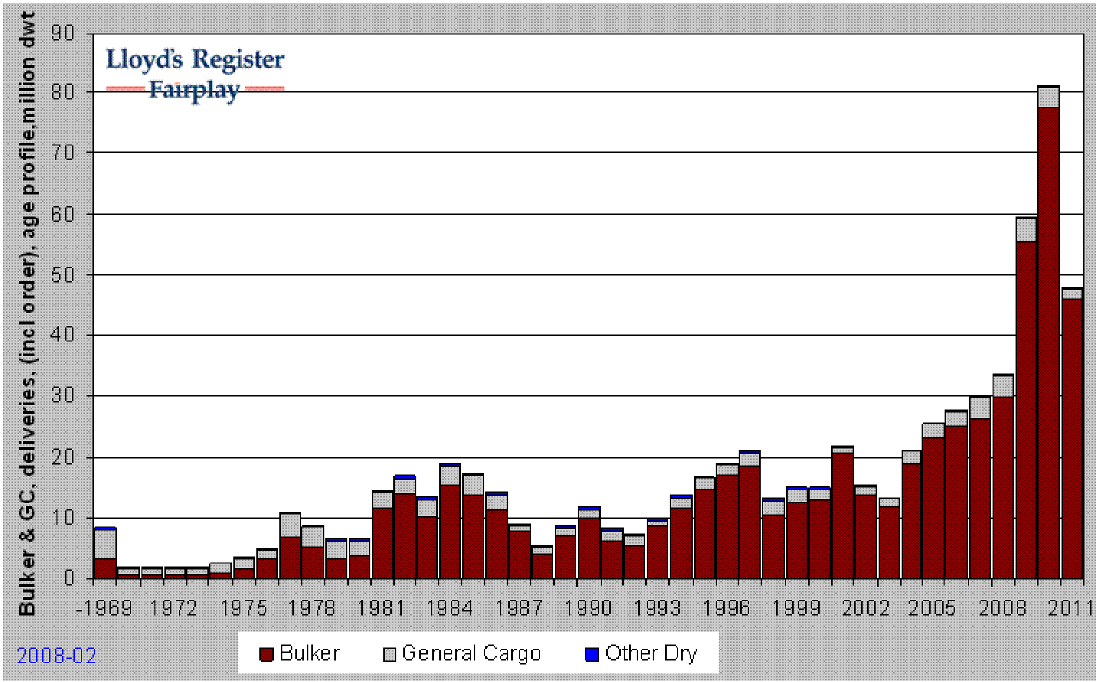

Figure F.71 : General cargo & Bulker age profile incl. orderb. DWT., (Source: Shipbuilding Market Forecast March 2008).

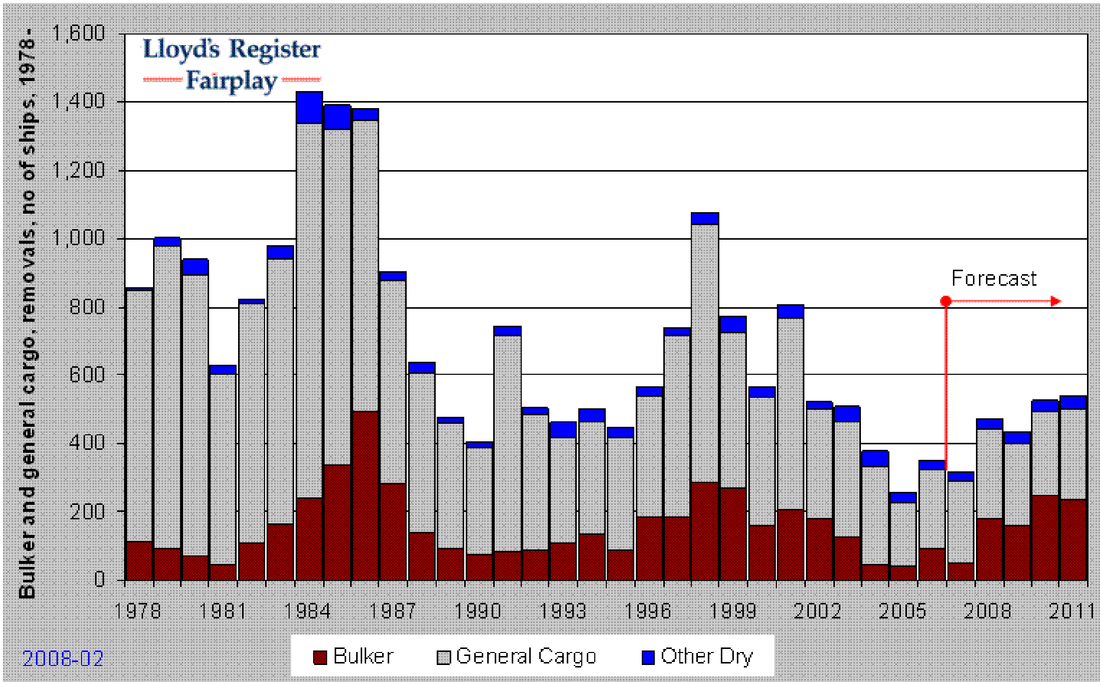

Figure F.72 : General cargo & Bulker. removals no., (Source: Shipbuilding Market Forecast March 2008).

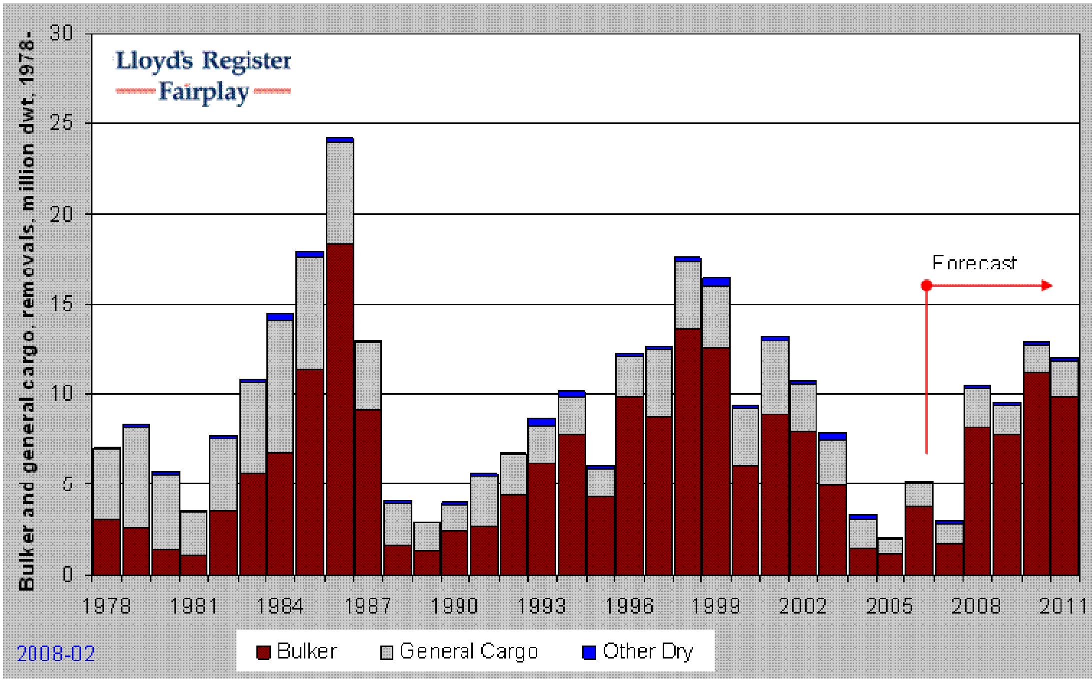

Figure F.73 : General cargo & Bulker removals DWT., (Source: Shipbuilding Market Forecast March 2008).

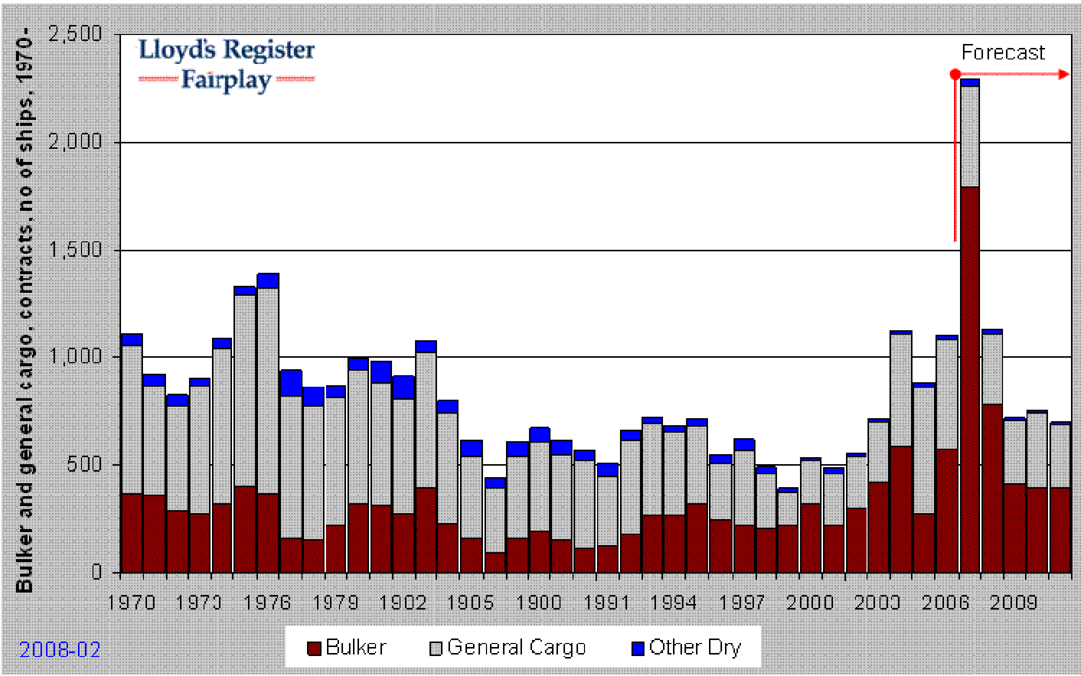

Figure F.74 : General cargo & Bulker contracts no., (Source: Shipbuilding Market Forecast March 2008).

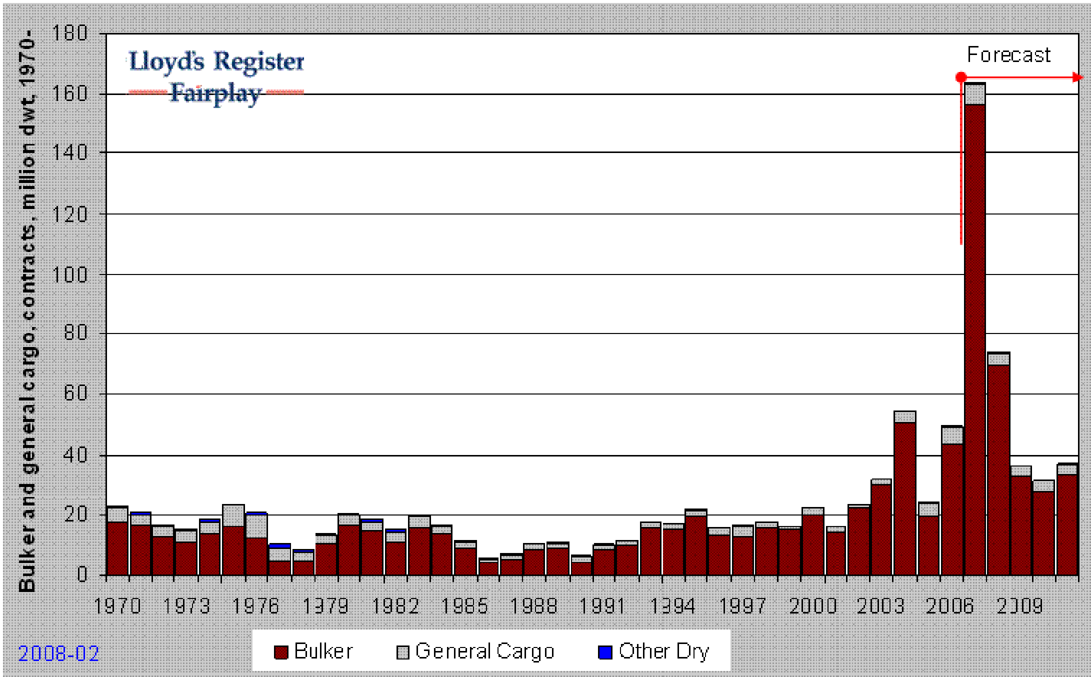

Figure F.75 : General cargo & Bulker contracts DWT., (Source: Shipbuilding Market Forecast March 2008).

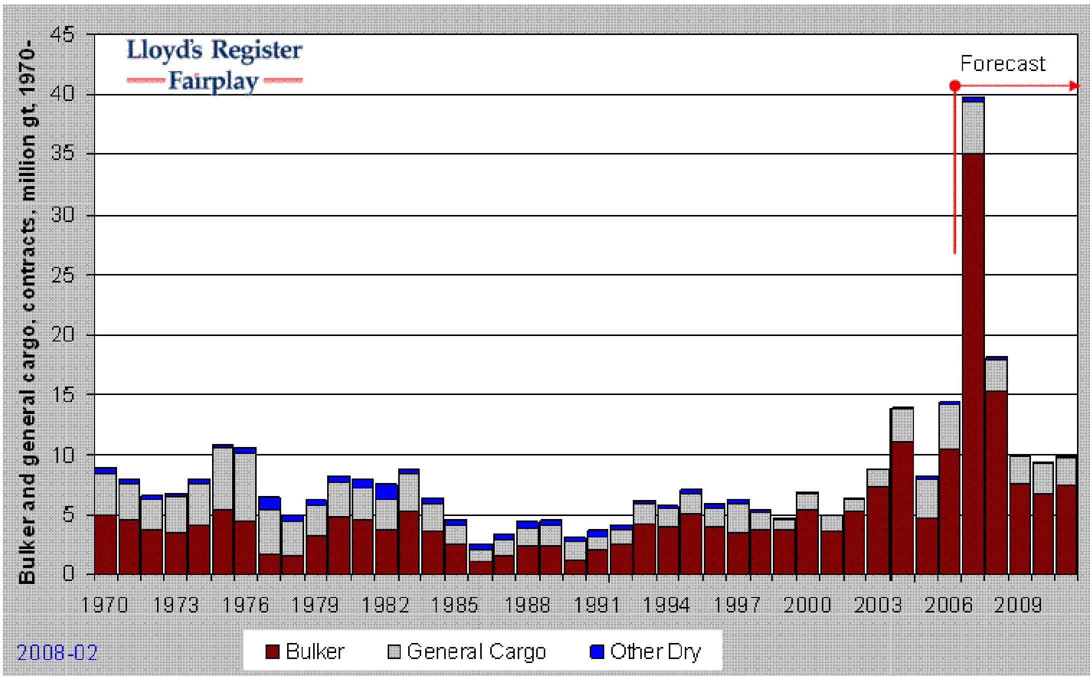

Figure F.76 : General cargo & Bulker contracts CGT., (Source: Shipbuilding Market Forecast March 2008).

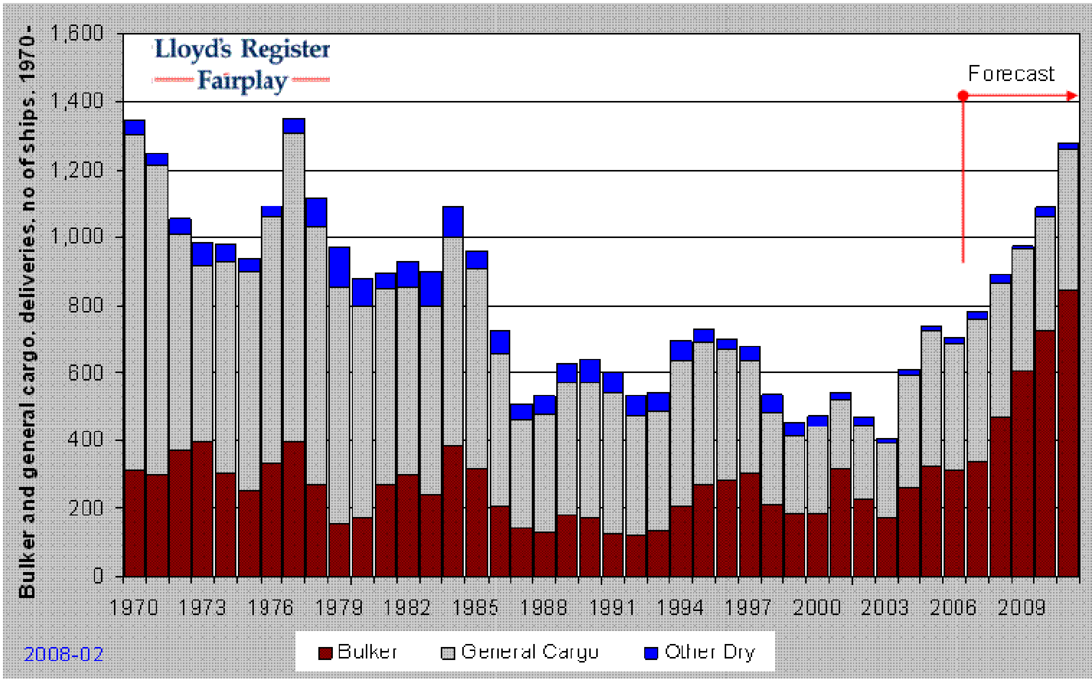

Figure F.77 : General cargo & Bulker deliveries No., (Source: Shipbuilding Market Forecast March 2008).

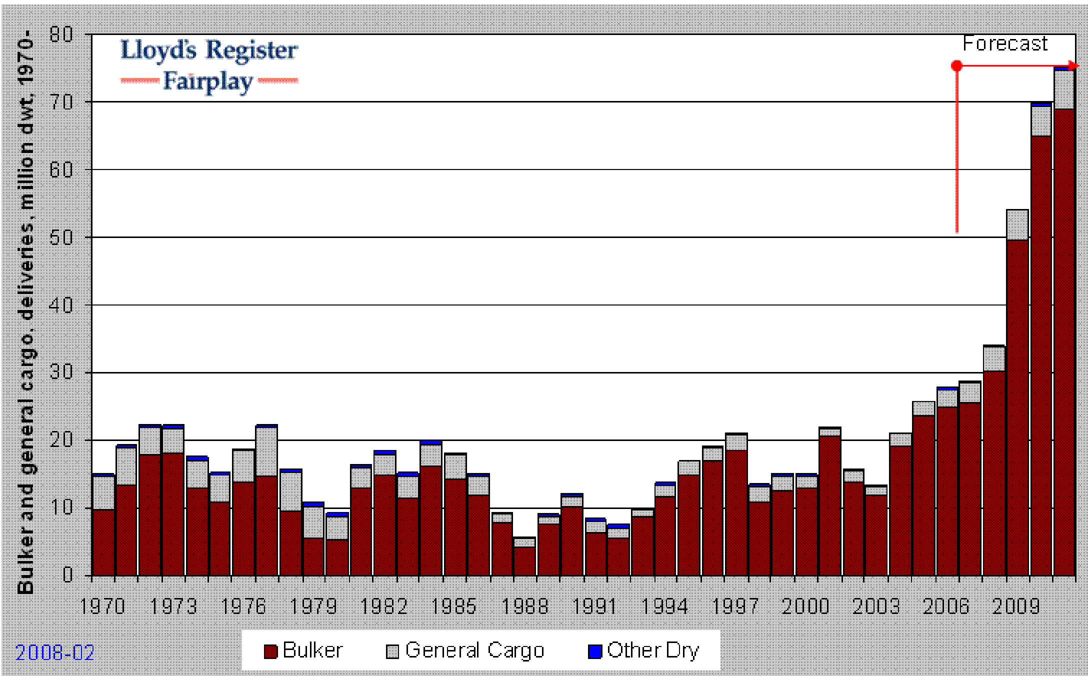

Figure F.78 : General cargo & Bulker deliveries DWT., (Source: Shipbuilding Market Forecast March 2008).

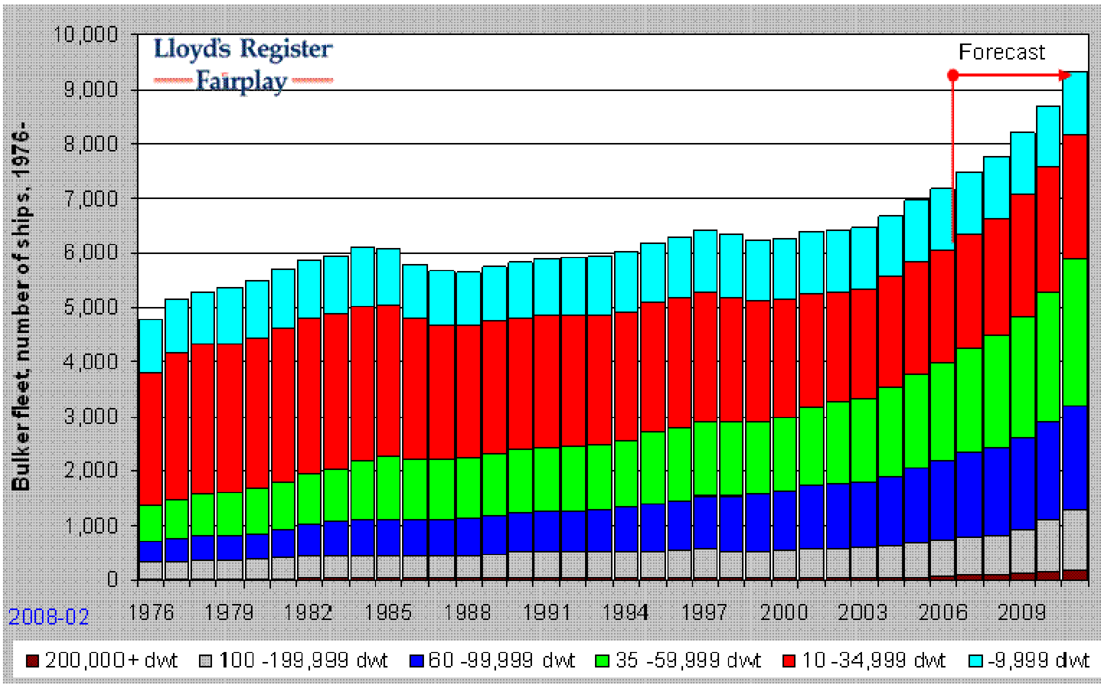

Figure F.79 : Bulker fleet no., (Source: Shipbuilding Market Forecast March 2008).

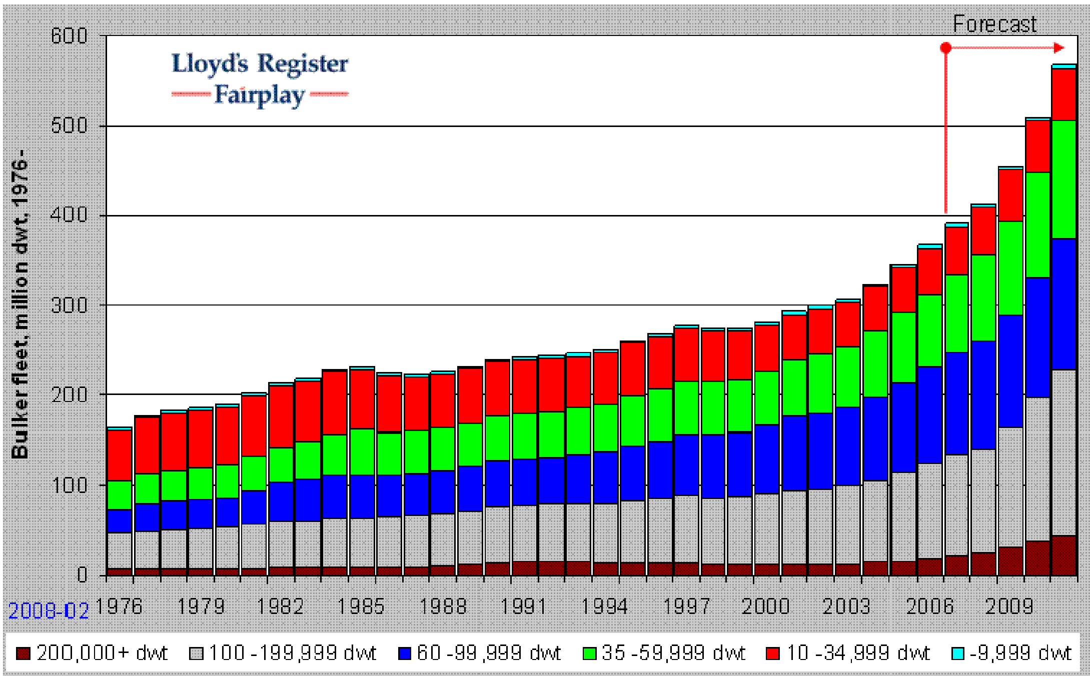

Figure F.80 Bulker fleet DWT., (Source: Shipbuilding Market Forecast March 2008).

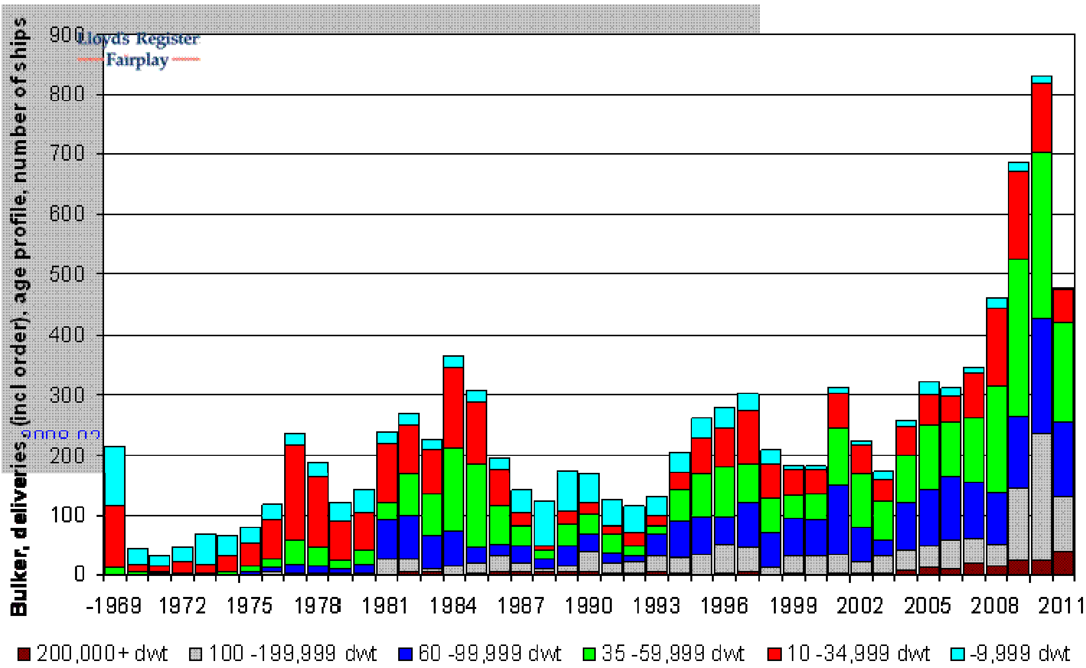

Figure F.81 : Bulker age profile incl. orderbook no., (Source: Shipbuilding Market Forecast March 2008).

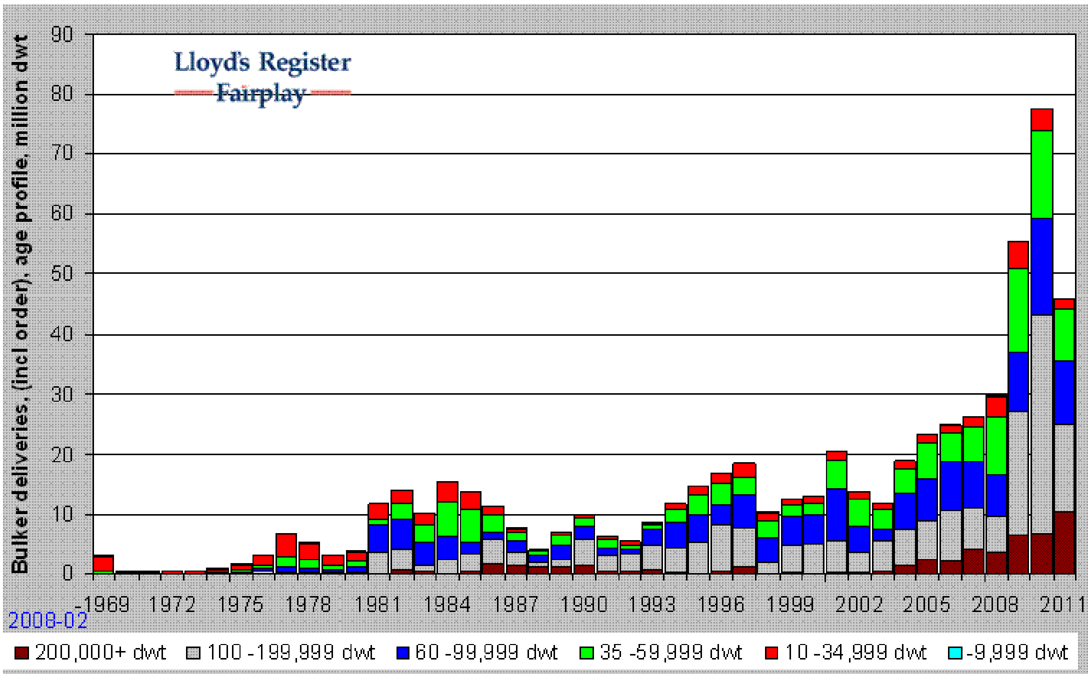

Figure F.82 : Bulker age profile incl. orderb. DWT., (Source: Shipbuilding Market Forecast March 2008).

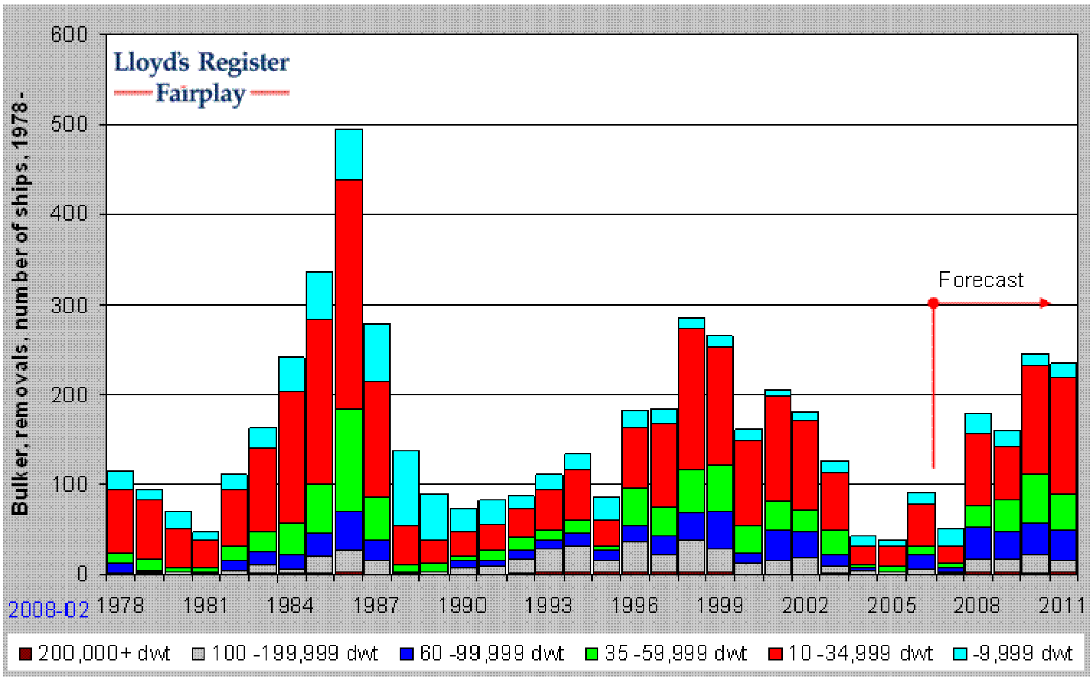

Figure F.83 : Bulker scrapping no., (Source: Shipbuilding Market Forecast March 2008).

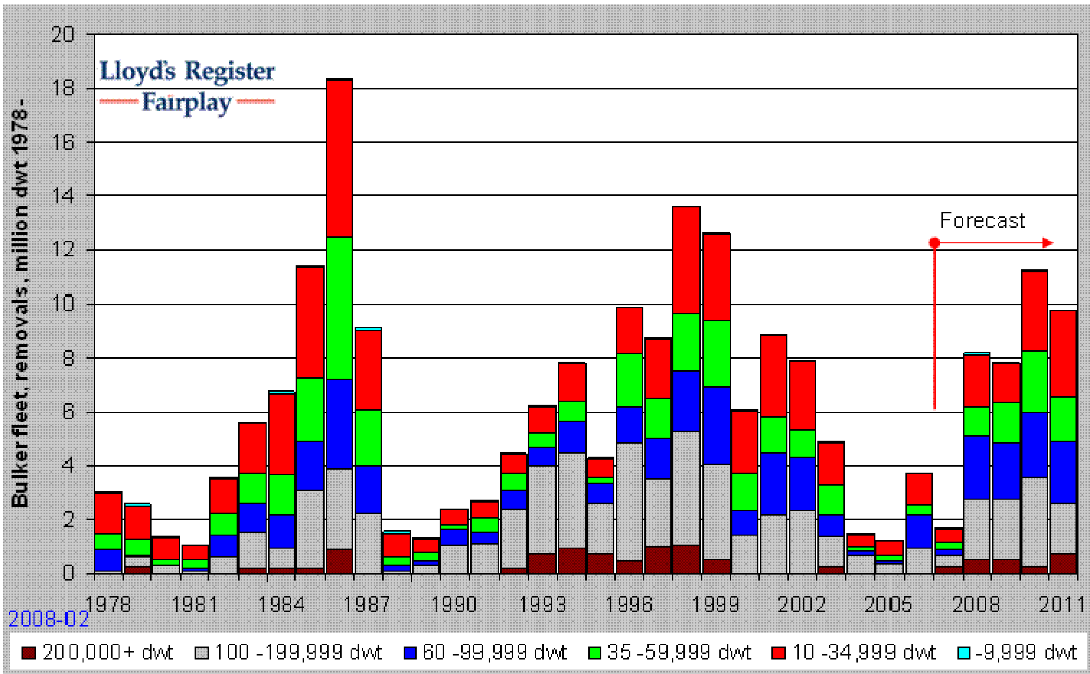

Figure F.84 : Bulker scrapping DWT., (Source: Shipbuilding Market Forecast March 2008).

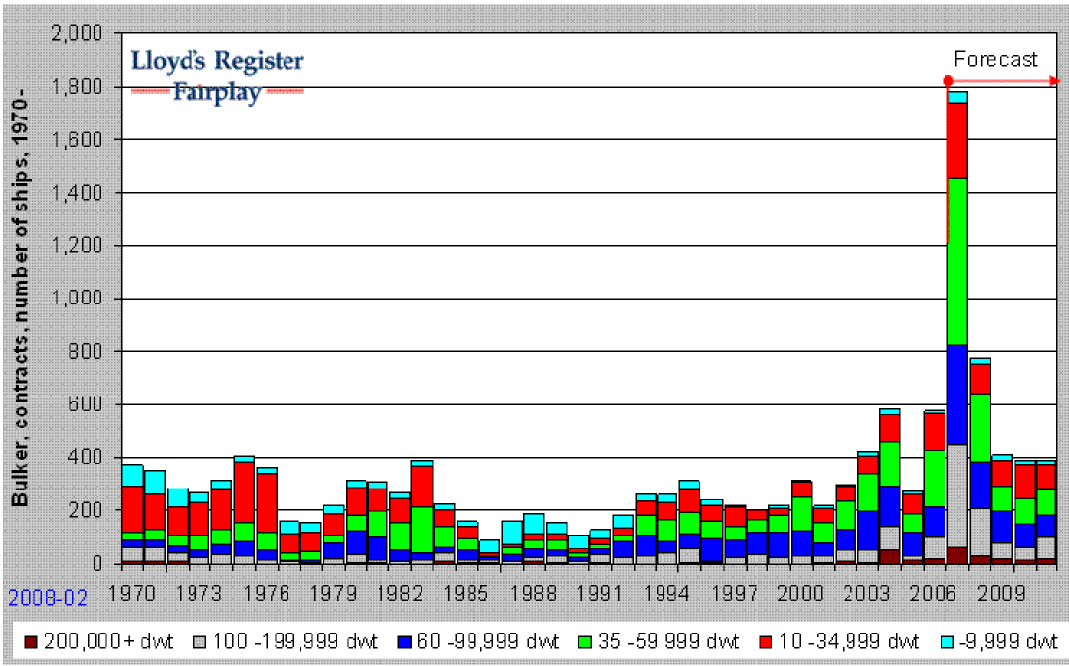

Figure F.85 : Bulker contracts no., (Source: Shipbuilding Market Forecast March 2008).

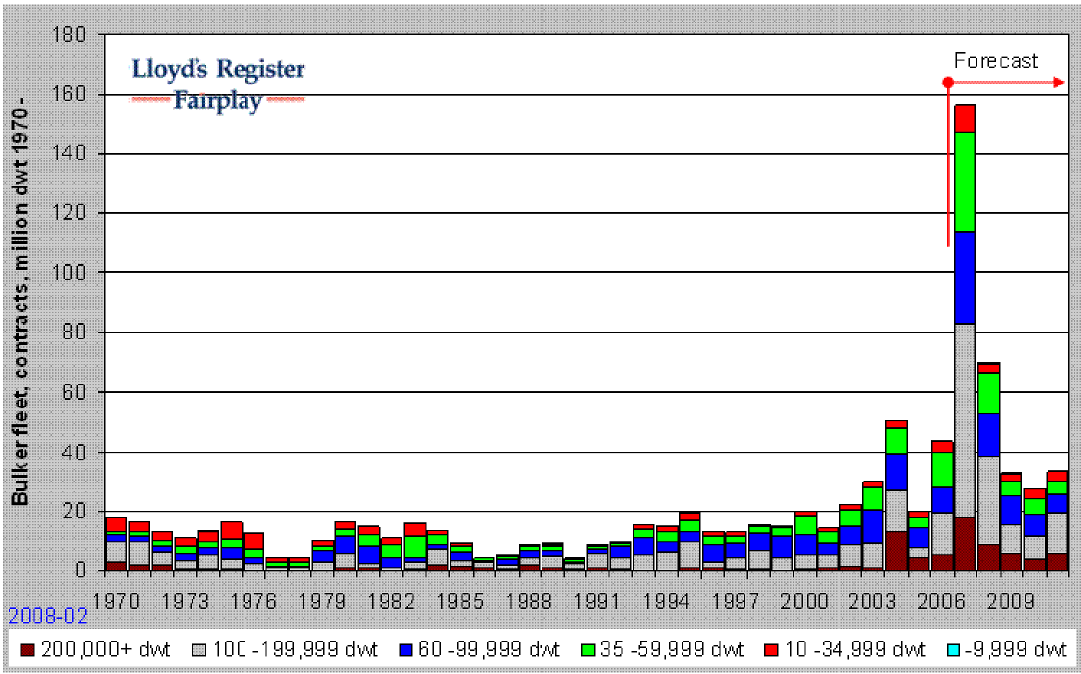

Figure F.86 : Bulker contracts DWT., (Source: Shipbuilding Market Forecast March 2008).

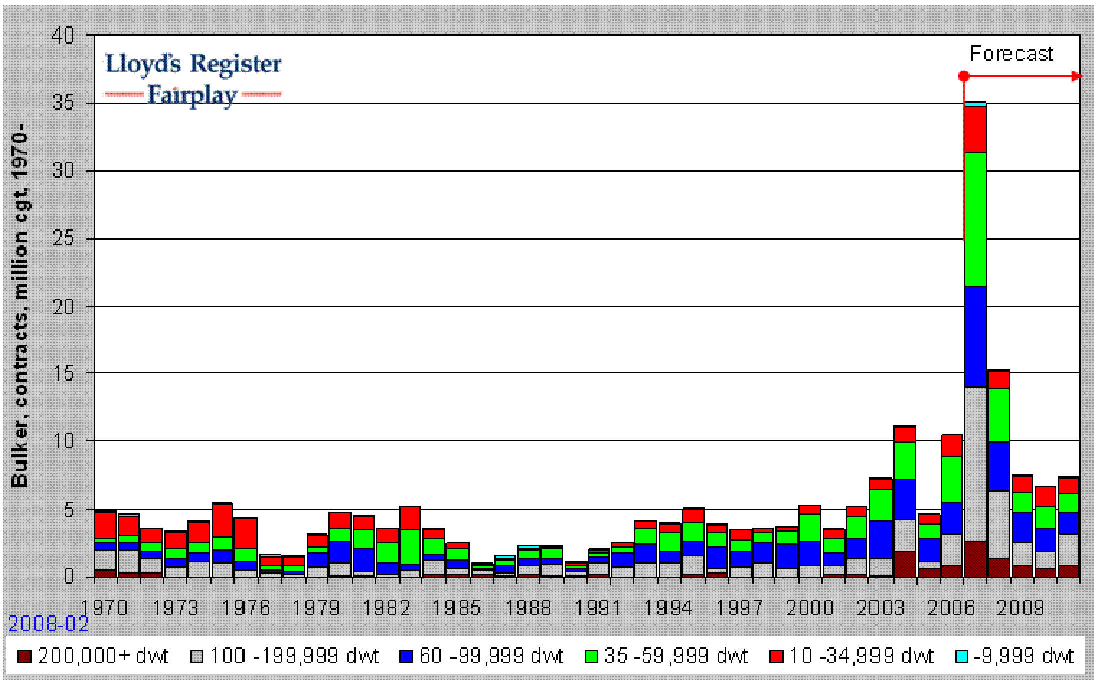

Figure F.87 : Bulker contracts CGT., (Source: Shipbuilding Market Forecast March 2008).

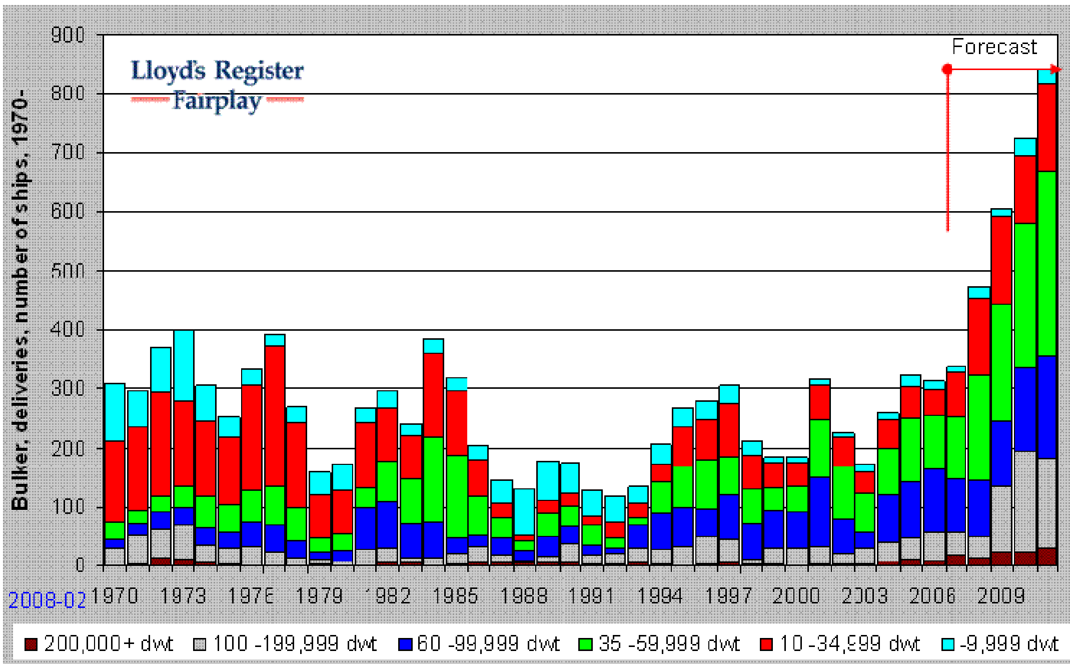

Figure F.88 : Bulker deliveries No., (Source: Shipbuilding Market Forecast March 2008).

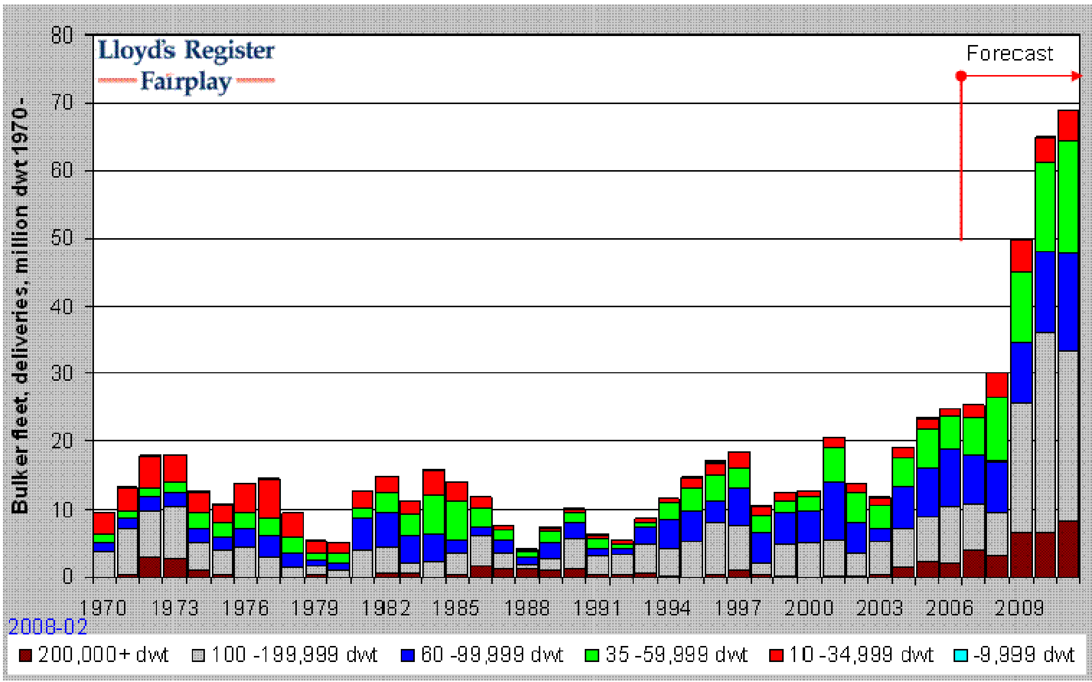

Figure F.89 : Bulker deliveries DWT., (Source: Shipbuilding Market Forecast March 2008).

Table F.1 Major seaborne trades, (Source: ABS, Activities, September 2007).

Projected Annual Trade Volume Growth

Ref. Case	Crude Oil Trade	Oil Product Trade	Bulk Trade	Container Trade	LNG Trade	LPG Trade
2007	3.0%	3.5%	4.4%	9.1%	6.6%	6.3%
2008	2.9%	3.3%	4.3%	8.9%	7.0%	6.7%
2009	2.7%	3.1%	4.1%	8.1%	8.3%	7.5%
2010	2.6%	2.9%	3.9%	7.5%	8.5%	8.0%
2011	2.4%	2.7%	3.6%	7.0%	6.7%	5.5%
2012	2.3%	2.6%	3.6%	6.8%	4.9%	3.5%
2013	2.2%	2.4%	3.6%	6.6%	4.2%	3.0%
2014	2.0%	2.3%	3.7%	6.4%	4.0%	2.4%
2015	1.9%	2.1%	3.7%	6.2%	3.8%	3.2%
2016	1.8%	2.0%	3.5%	5.8%	4.4%	2.3%
2017	1.7%	1.9%	3.5%	5.7%	4.1%	1.2%

Reference Case (probable) Outlook - based on world GDP expansion of 4% on average

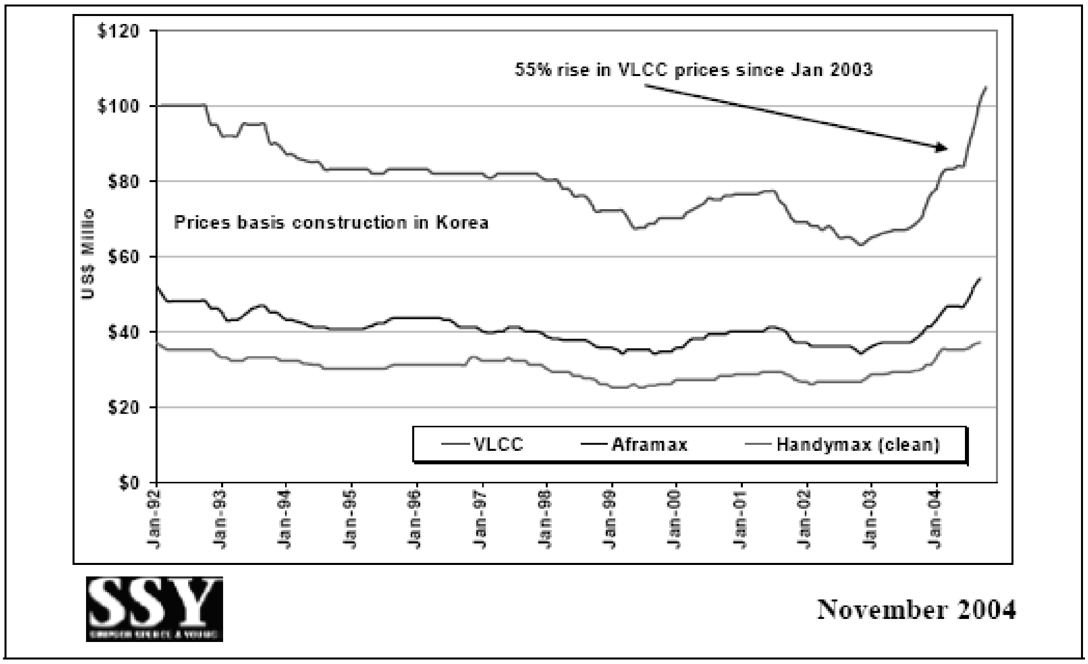

Figure F.90 : Tanker prices: newbuilding, (Source: SSY Consultancy & Research Ltd, November 2004).

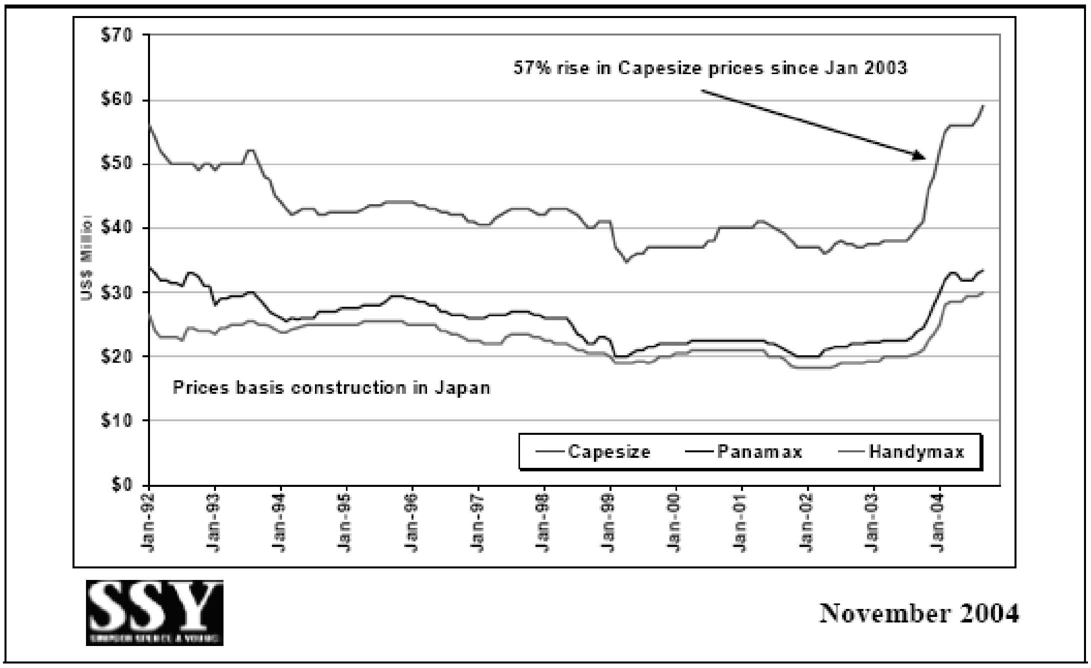

Figure F.91 : Bulk carrier prices: newbuilding, (Source: SSY Consultancy & Research Ltd, November 2004).

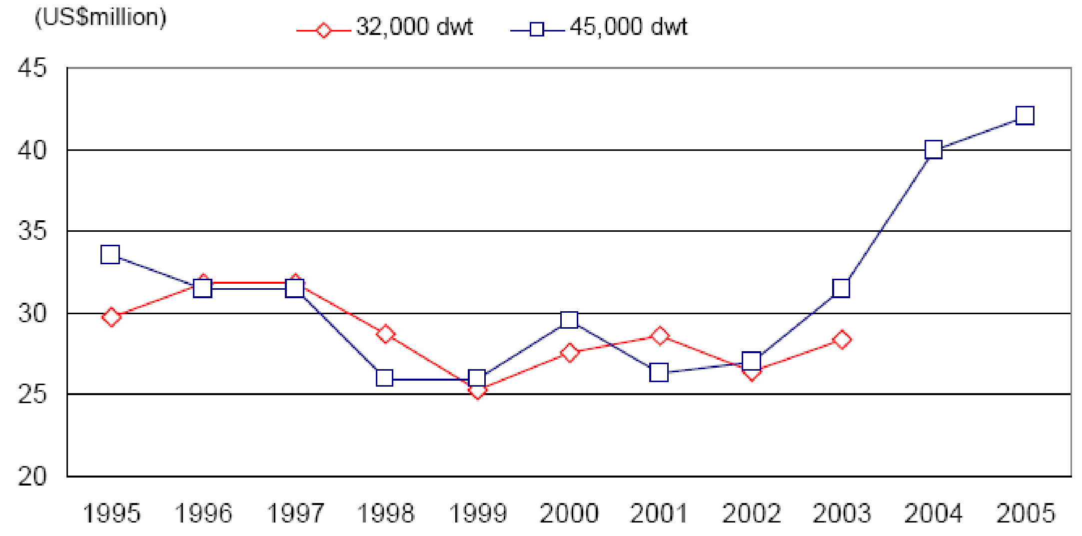

Figure F.92 : Product tanker newbuilding prices1995-2005, (Source: OSC/Clarkson Ocean Shipping Consultants LTD., 2006).

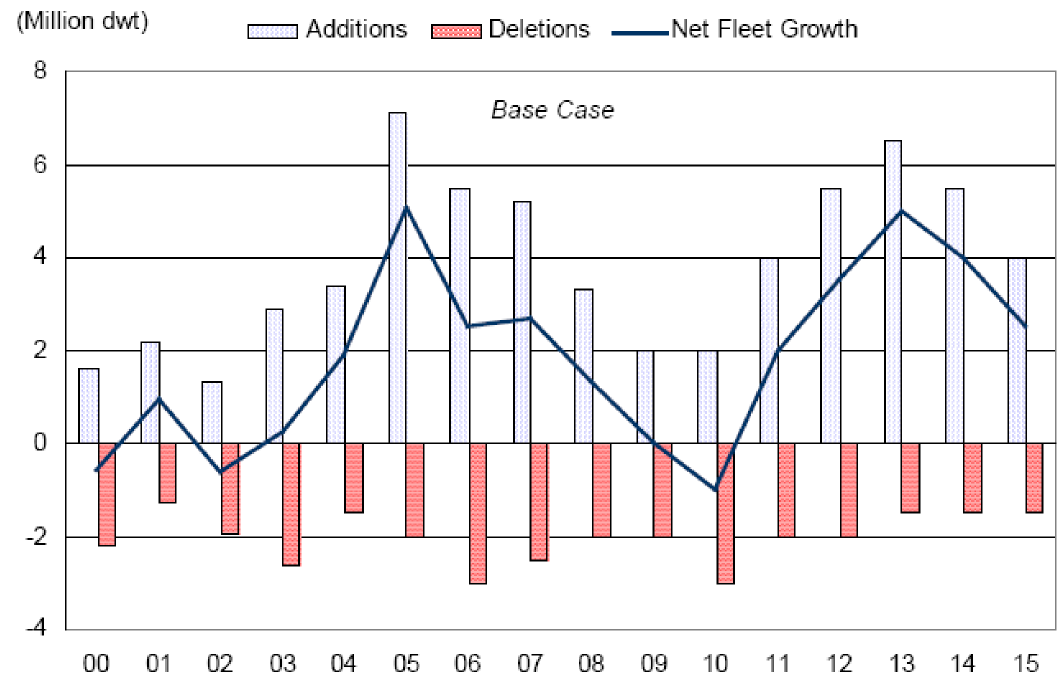

Figure F.93 : Forecast product tanker deliveries/scrapping to 2015, (Source: OSC – Ocean Shipping Consultants LTD., 2006).

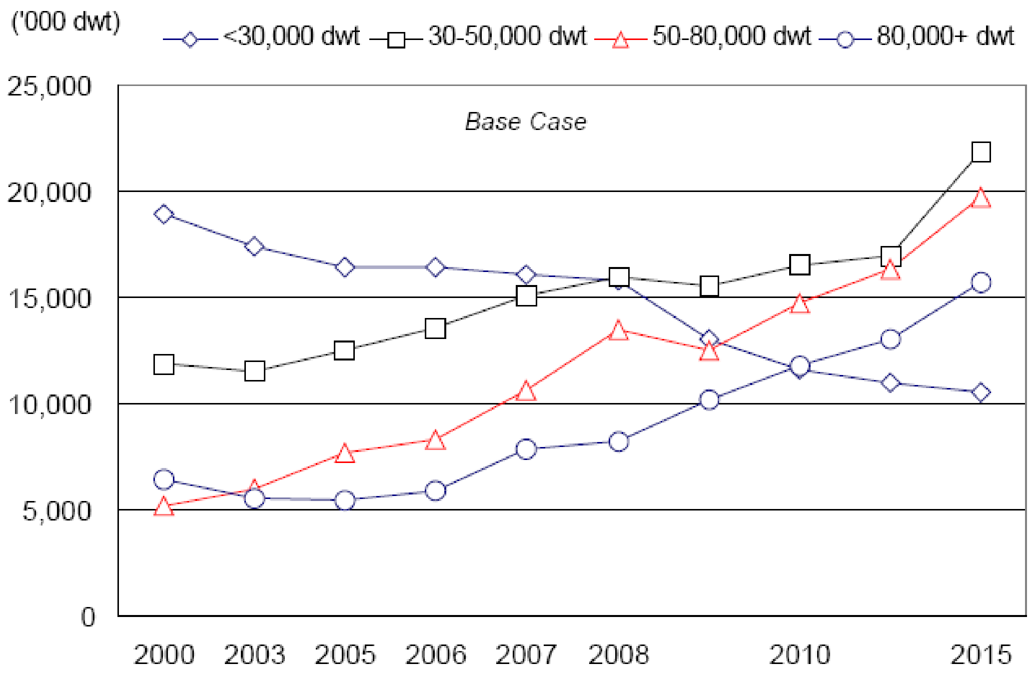

Figure F.94 : Major product tanker sector fleet development to 2015, (Source: OSC Ocean Shipping Consultants LTD., 2006).

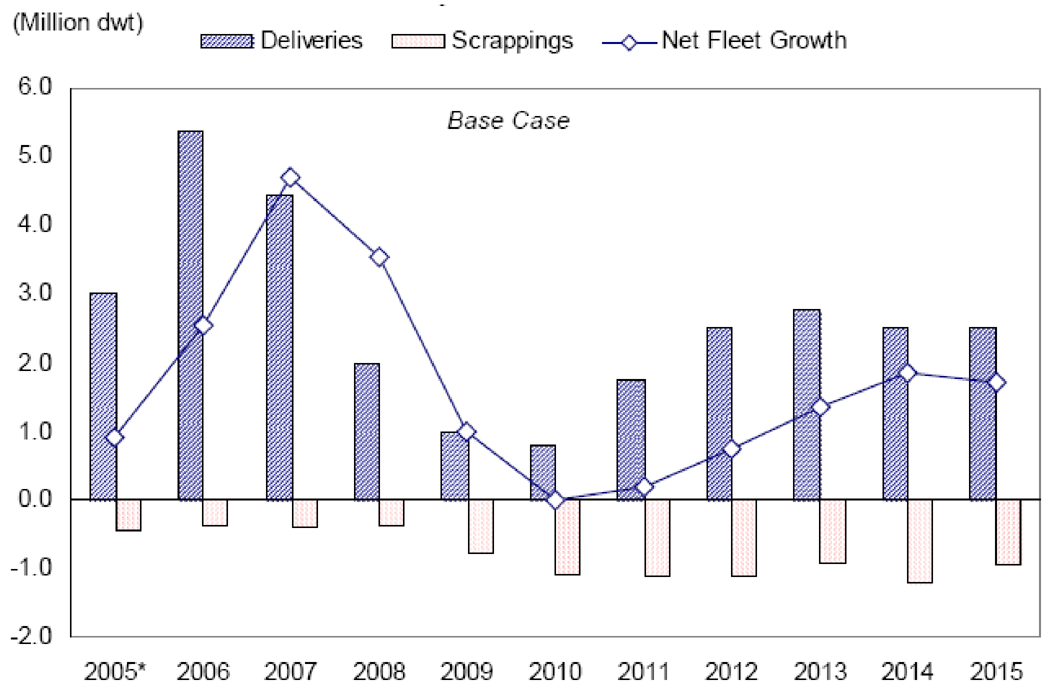

Figure F.95 : Chemical carrier fleet development 2005-2015, (Source: OSC - Ocean Shipping Consultants LTD., 2006).

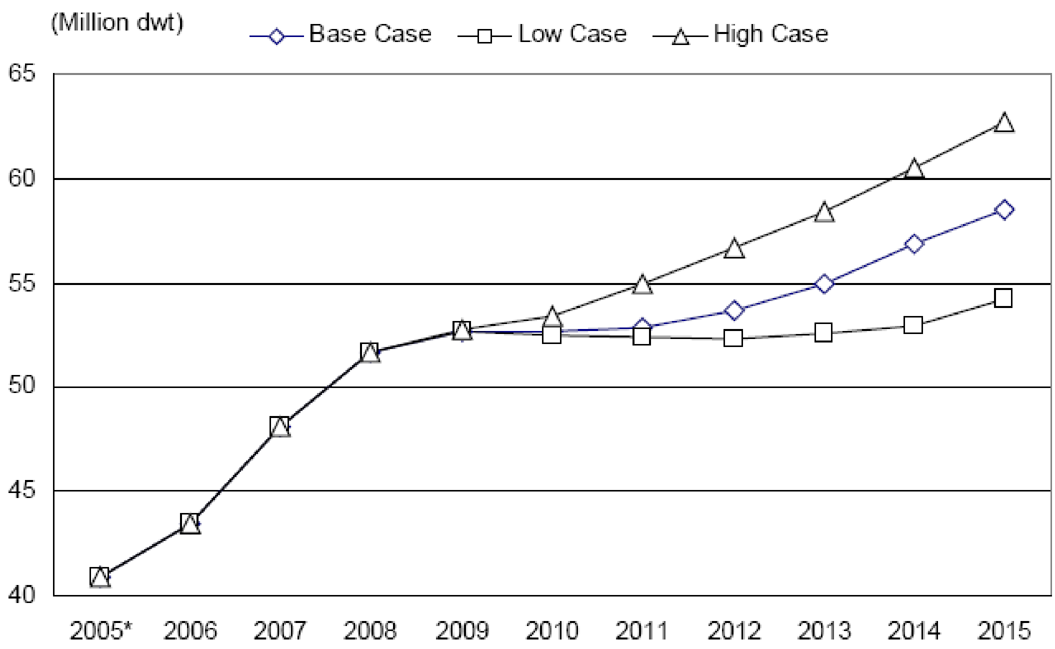

Figure F.96 : Chemical carrier fleet development 2005-2015 by Case, (Source: OSC Ocean Shipping Consultants LTD., 2006).

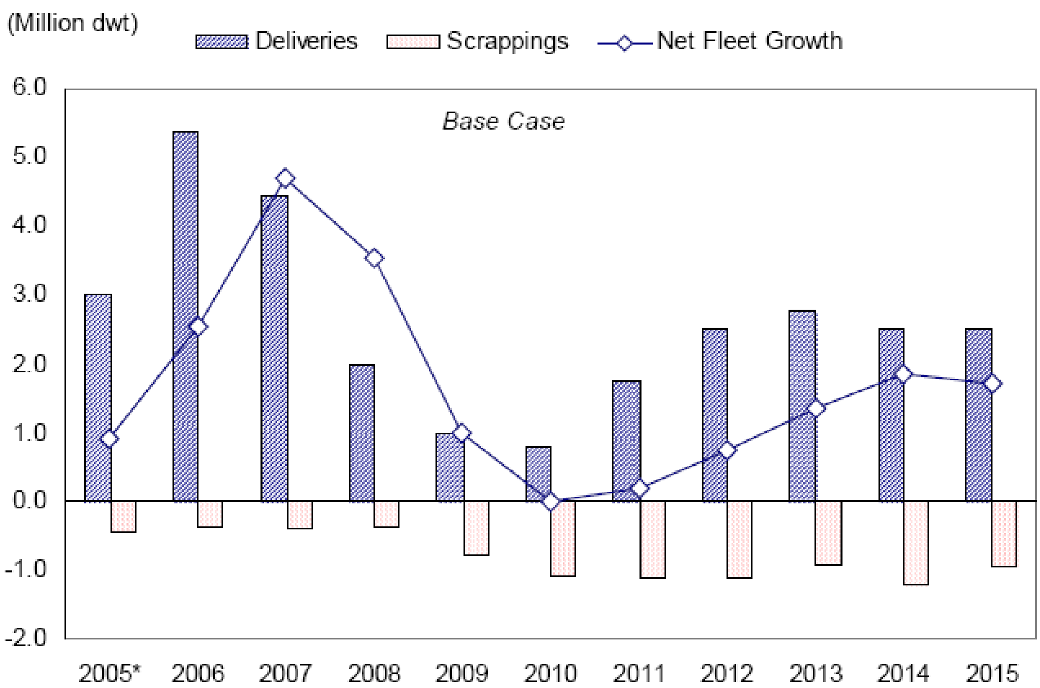

Figure F.97 : Chemical carrier fleet development 2005-2015, (Source: OSC - Ocean Shipping Consultants LTD., 2006).

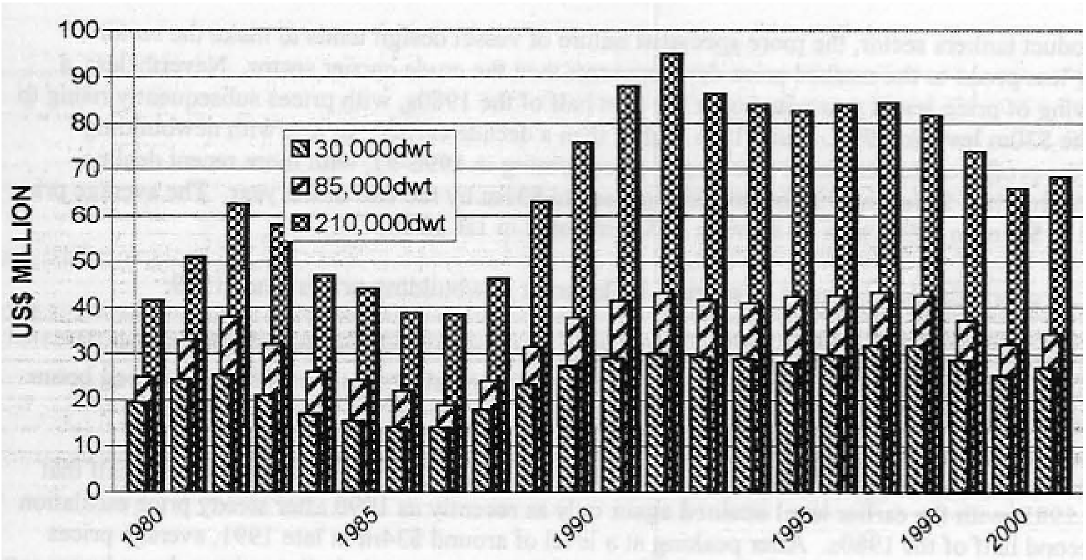

Figure F.98 : Tanker newbuilding prices 1979-2000, (Source: Ocean Shipping Consultants LTD., 2000).

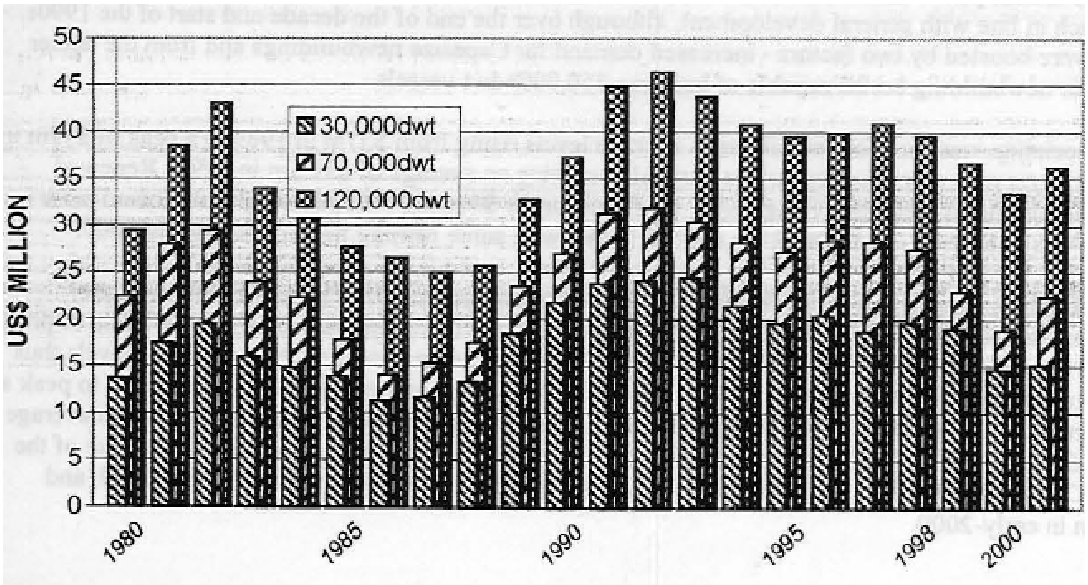

Figure F.99 : Bulk carrier newbuilding prices 1979-2000, (Source: OSC - Ocean Shipping Consultants LTD., 2000).

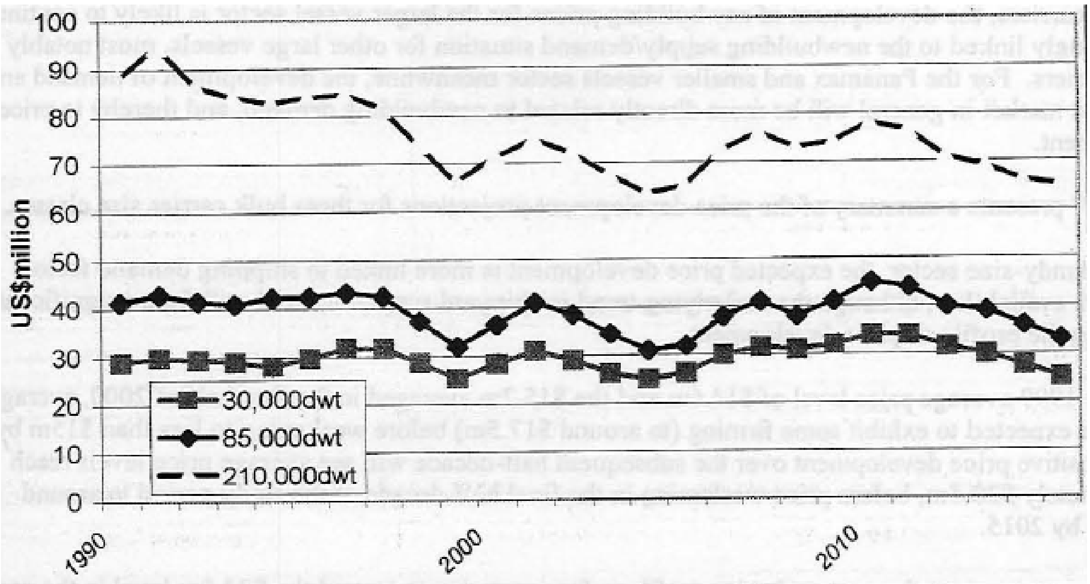

Figure F.100 : Forecast tanker newbuilding prices to 2015, (Source: OSC - Ocean Shipping Consultants LTD., 2000).

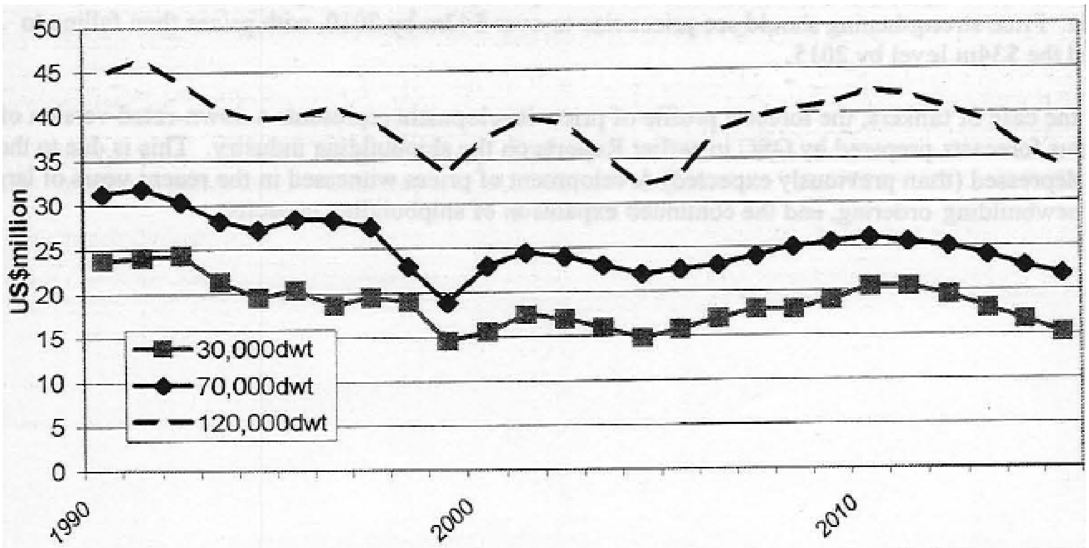

Figure F.101 : Forecast bulk carrier newbuilding prices to 2015, (Source: OSC – Ocean Shipping Consultants LTD., 2000).

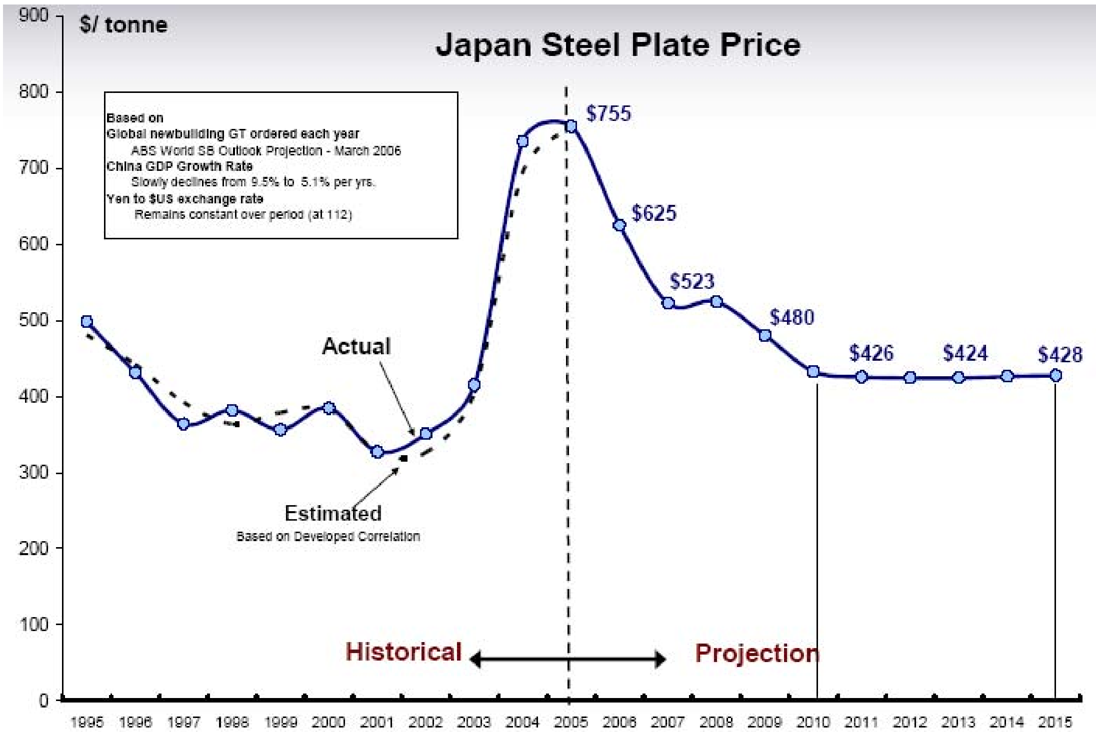

Figure F.102 : Steel plate price outlook - projection - using developed correlation, (Source: ABS New York Executive Office, April 2006).

Item	Production costs		Economic costs	
	Container	Bulk-carrier	Container	Bulk-carrier
Materials and equipment—domestic	18.37	5.72	13.76	3.61
Materials and equipment—imported	30.29	11.73	30.29	11.73
Direct production expenditure (*OS-5*)	3.81	1.77	3.16	1.47
Electrical energy	0.46	0.16	0.44	0.16
Administrative services	6.72	2.41	5.77	2.07
Freight	4.77	1.52	4.77	1.52
Import financing expenses	3.17	0	3.17	0
Custom duties	2.42	2.83	0	0
Taxes on inputs	5.82	0.89	0	0
Inputs trade and transport margin	0.66	0.32	0.547	0.30
Intermediate consumption	76.40	27.36	61.91	20.87
Production workers wages	3.27	2.75	2.79	2.34
Administrative workers wages	0.44	0.37	0.38	0.32
Charges on wages	1.32	1.11	1.13	0.95
Financial costs	0	2.54	0	0
Depreciation	1.05	0.64	0.83	0.51
Profit/capital opportunity cost	1.99	1.25	1.50	0.94
Value added	8.09	8.66	6.63	5.06
Direct taxes	1.68	0.98	0	0
Base price/base economic cost	86.16	37.00	68.55	25.93

Figure F.103 : Brazilian shipbuilding adjusted cost structure (million US$), (Source: Pires F. C. M. JR., 2001).

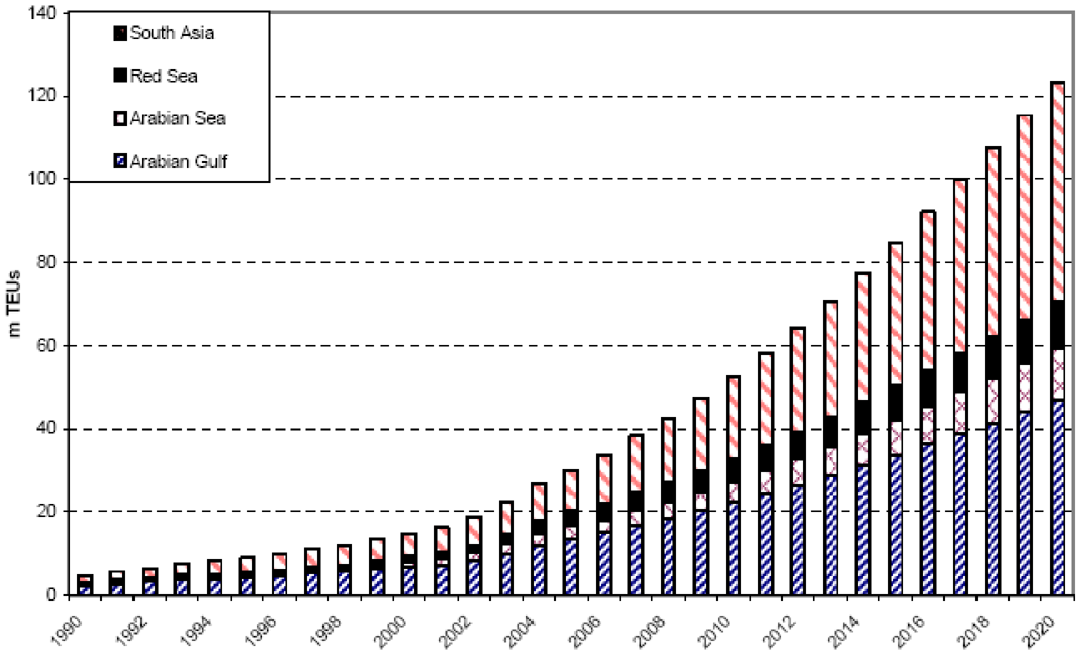

Figure F.104 : Middle East/South Asia:containerport demand to 2020 by port range-Case I, (Source: OSC–Ocean Shipping Consultants LTD., 2000).

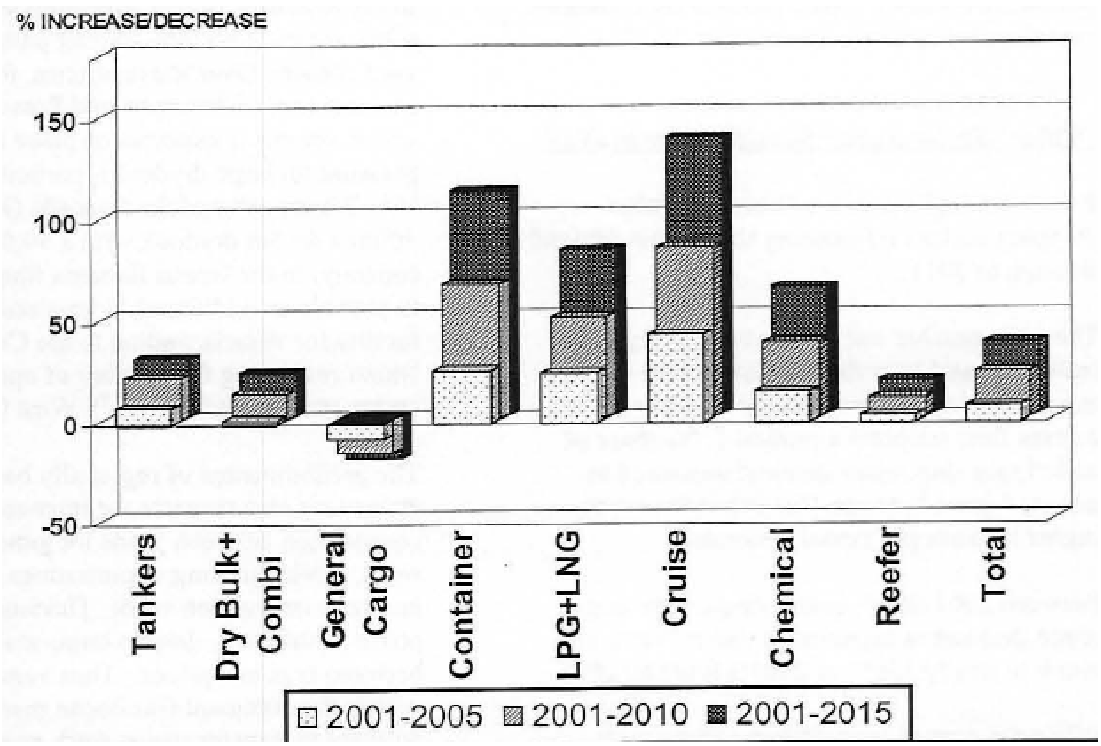

Figure F.105 : Forecast world repair demand growth by vessel sector, (Source: OSC – Ocean Shipping Consultants LTD., 2006).

APPENDIX G. CASE STUDY RESULTS AND FIGURES

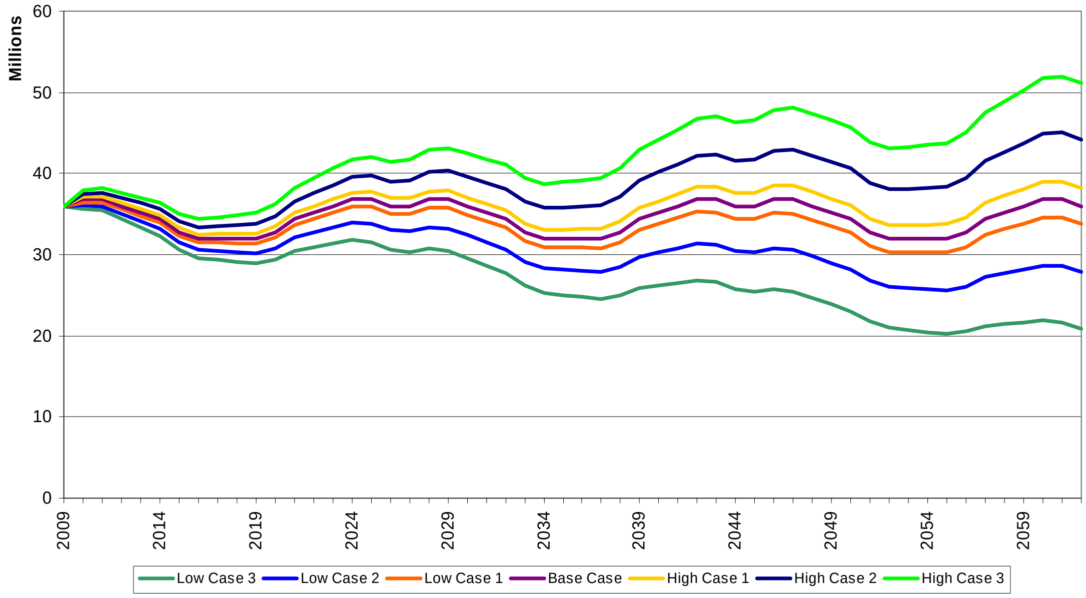

Figure G.1 : Sales price forecast 30.000 DWT Tanker - D/Hull.

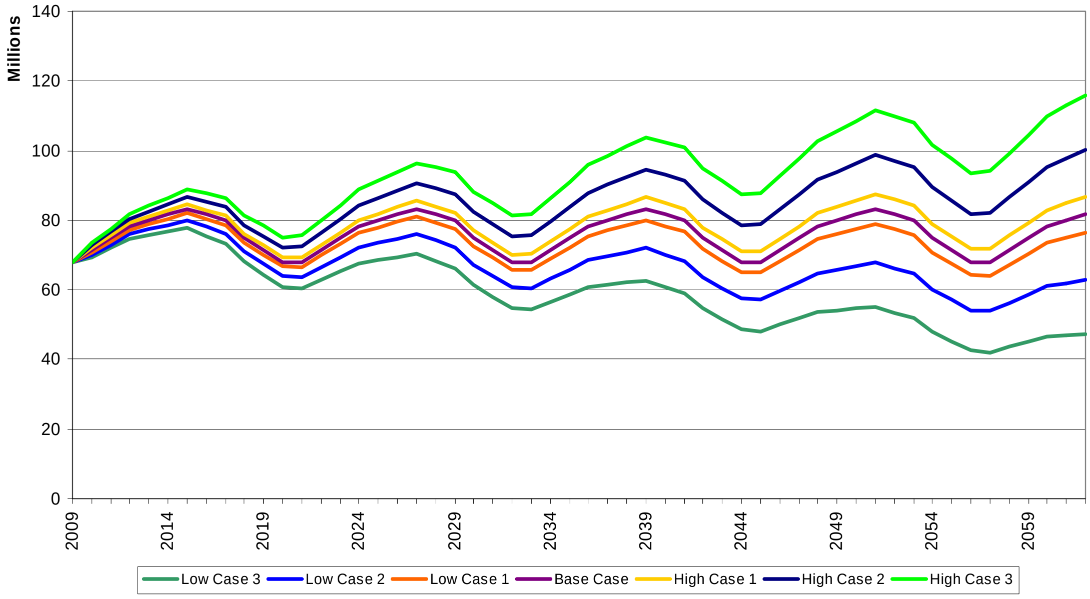

Figure G.2 : Sales price forecast 115.000 DWT Bulker.

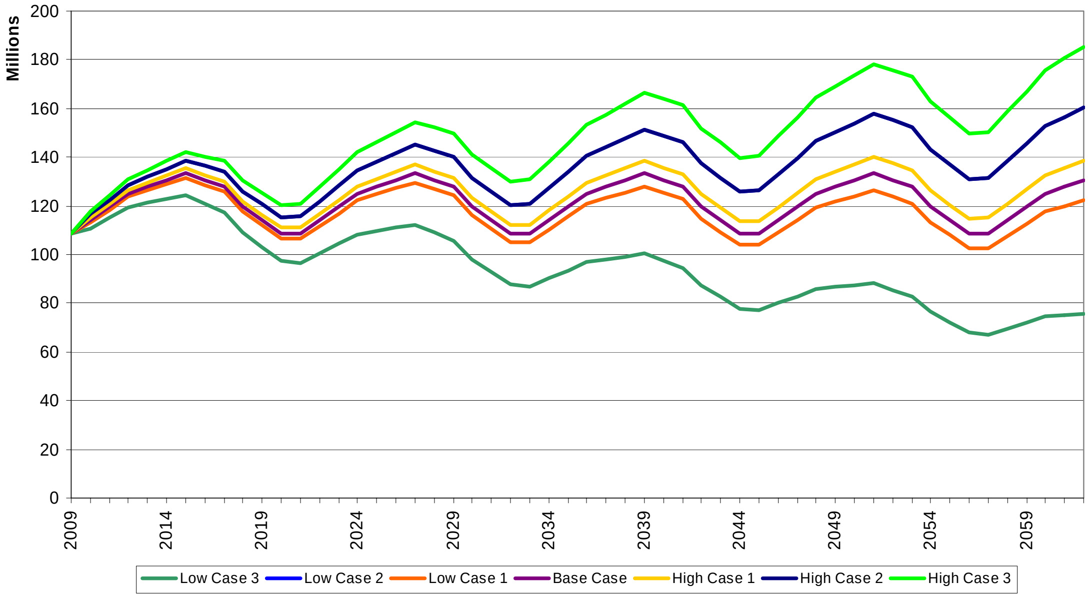

Figure G.3 : Sales price forecast 180.000 DWT Tanker - D/Hull.

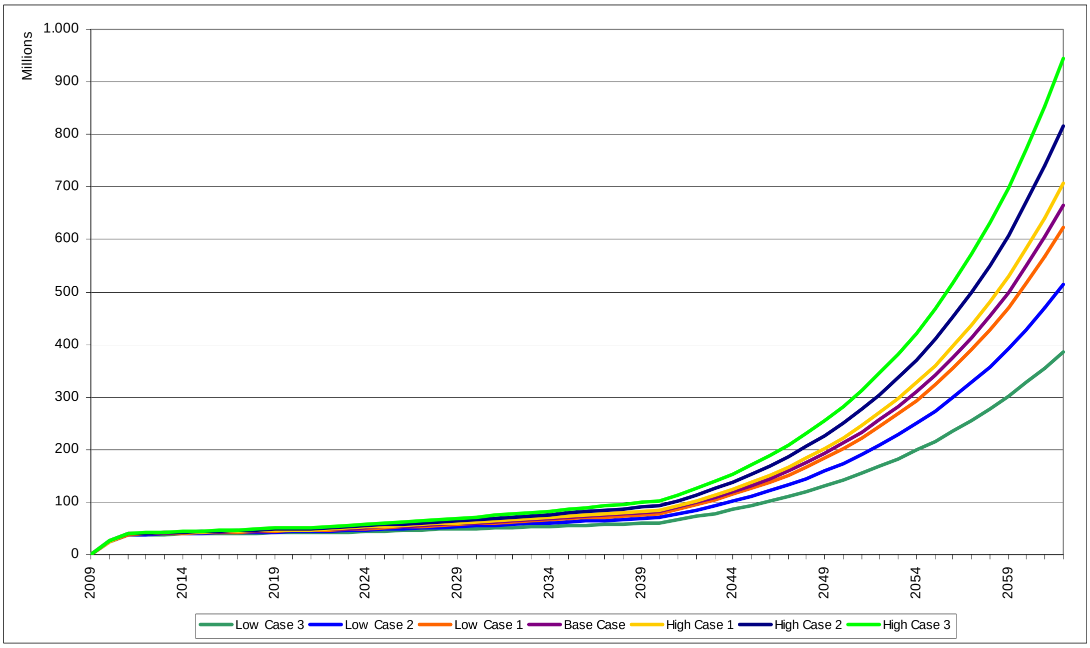

Figure G.4 : Sales price forecast PORREP Bulker Port.

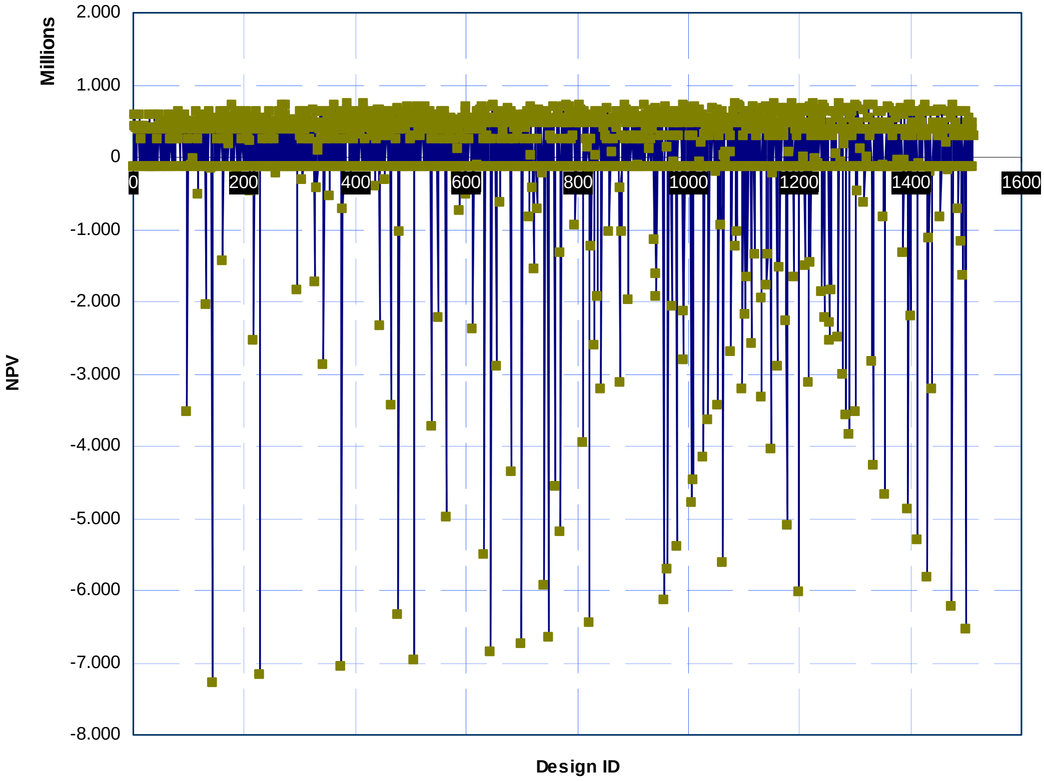

Figure G.5 : History chart – NPV.

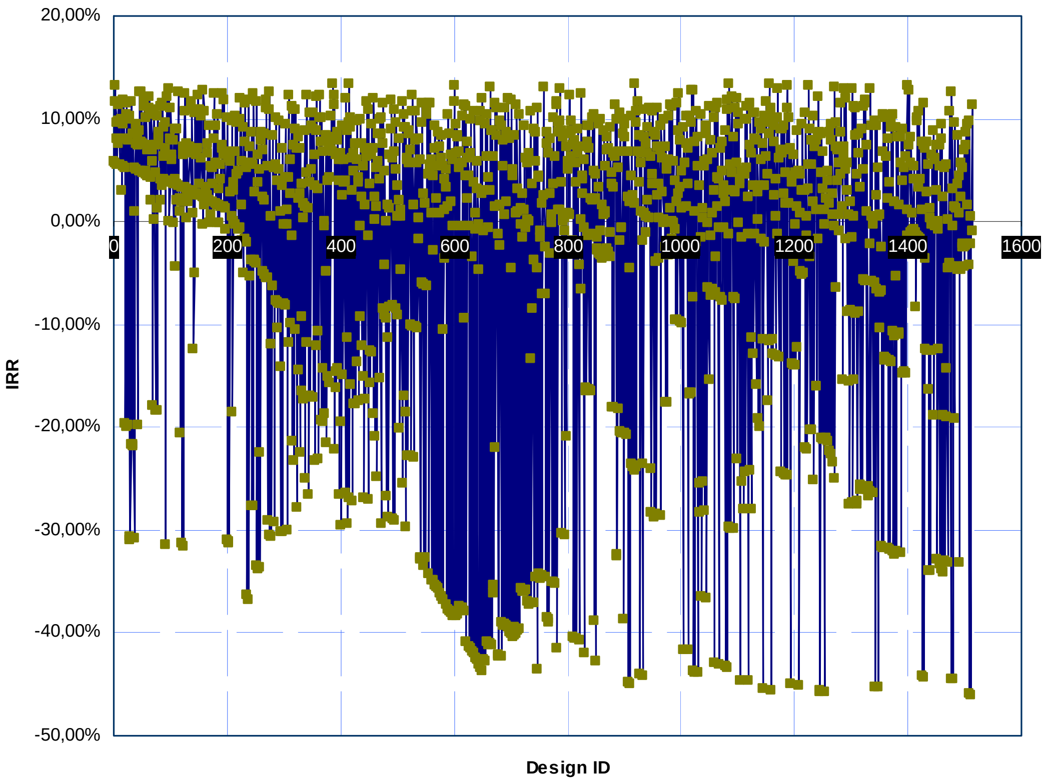

Figure G.6 : History chart – IRR.

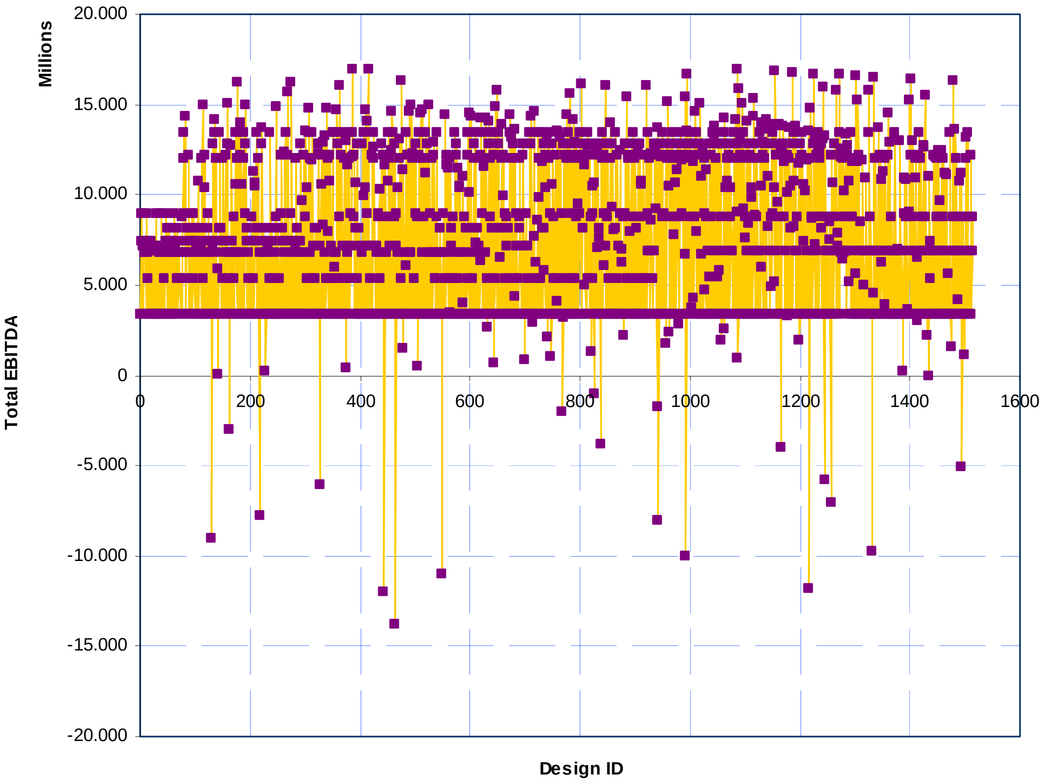

Figure G.7 : History chart – Total EBITDA.

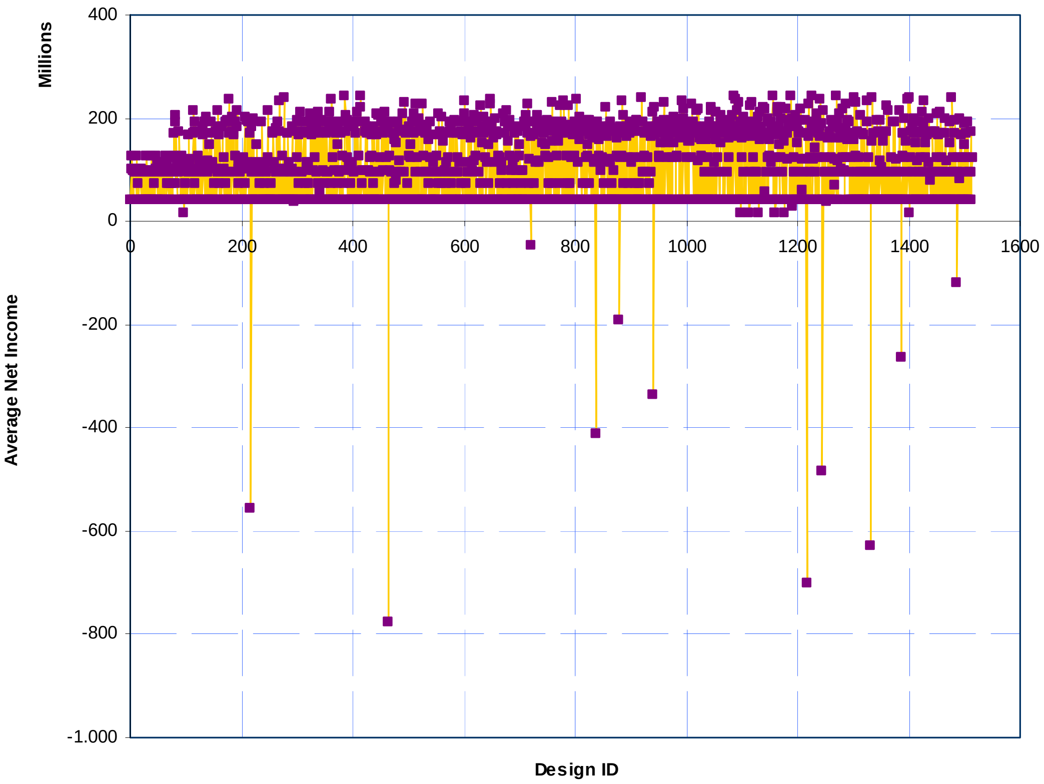

Figure G.8 : History chart – Average net income.

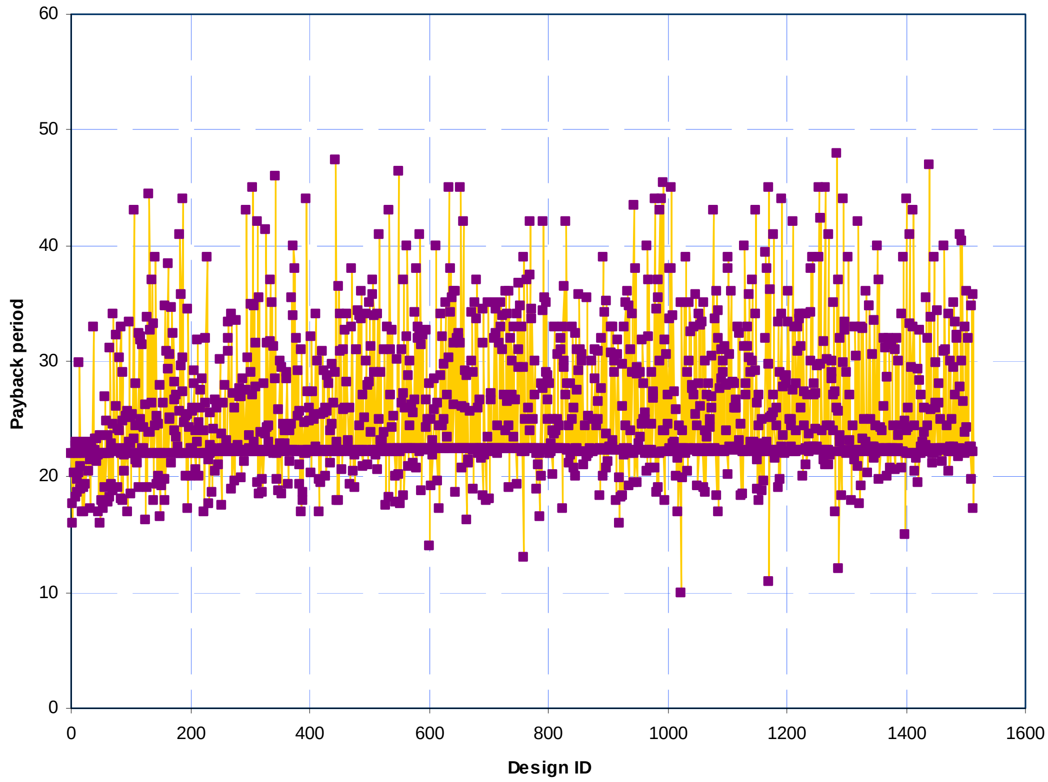

Figure G.9 : History chart – Payback period.

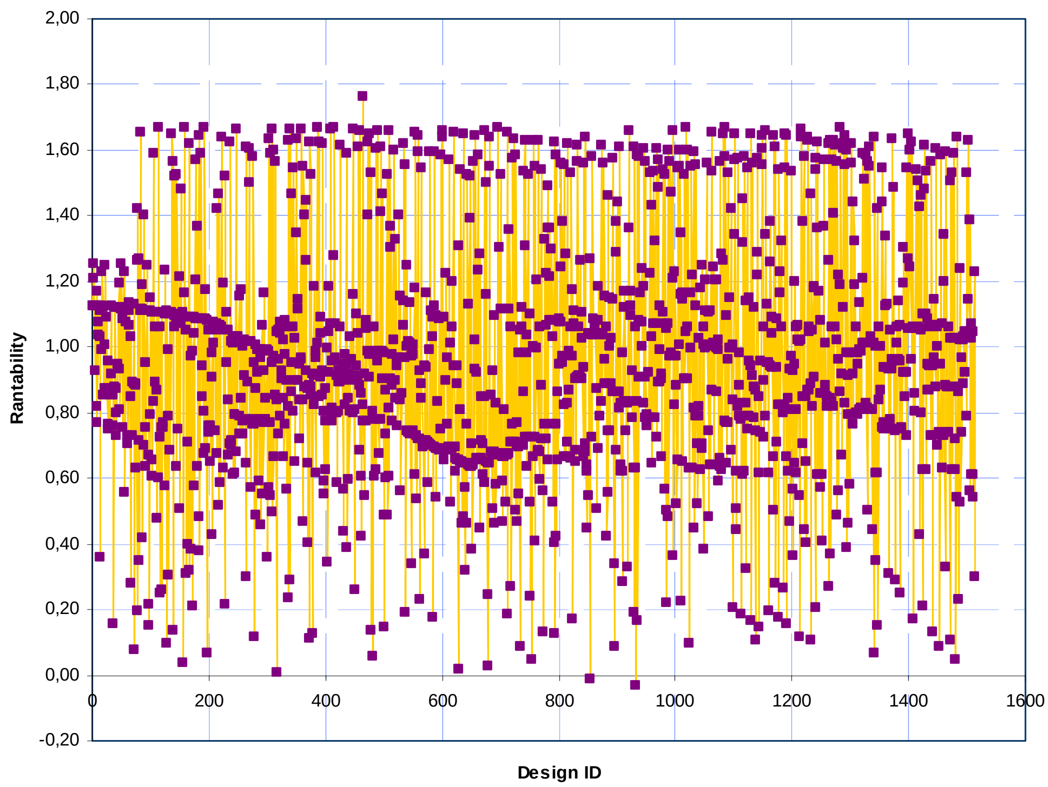

Figure G.10 : History chart – Rantability.

Table G.1 : Design space table (partial screen view).

	Case	NPV	IRR	Total EBITDA	Average Net Income	Payback period	Rantability	Investment Distribution % 1st year	Investment Distribution % 2 nd year
1 S	BC	-141.654.051	5,77%	3.340.664.000	42.007.902	22	1,13	60%	20%
2 S	HC3	581.697.708	13,27%	8.934.617.291	124.894.809	16	1,26	25%	25%
3 S	BC	-141.654.049	5,67%	3.340.664.001	42.007.900	22	1,13	60%	20%
4 S	HC1	437.991.762	11,70%	7.408.404.501	102.268.073	18	1,21	27%	27%
5 S	BC	409.146.954	9,63%	7.129.615.856	98.122.946	20	0,93	37%	37%
6 S	BC	-141.654.047	5,57%	3.340.664.002	42.007.898	22	1,13	60%	20%
7 S	BC	409.066.954	8,03%	7.129.607.856	98.113.346	23	0,77	46%	46%
8 S	HC1	437.971.762	11,30%	7.408.402.501	102.265.673	18	1,17	29%	29%
9 S	LC2	378.355.380	7,54%	6.813.277.937	93.417.996	23	0,82	47%	47%
10 S	LC2	378.465.380	9,74%	6.813.288.937	93.431.196	20	1,04	35%	35%
11 S	BC	-141.654.045	5,47%	3.340.664.003	42.007.896	22	1,12	60%	20%
12 S	HC3	581.607.708	11,47%	8.934.608.291	124.884.009	19	1,08	35%	35%
13 S	HC1	437.901.762	9,90%	7.408.395.501	102.257.273	20	1,03	37%	37%
14 S	LC2	378.125.380	2,94%	6.813.254.937	93.390.396	30	0,36	72%	72%
15 S	LC3	241.700.130	9,61%	5.375.345.091	72.126.070	19	1,11	28%	28%
16 S	BC	-141.654.043	5,37%	3.340.664.004	42.007.894	22	1,12	60%	20%
17 S	HC1	437.881.762	9,50%	7.408.393.501	102.254.873	21	0,99	39%	39%
18 S	BC	409.256.954	11,83%	7.129.626.856	98.136.146	17	1,23	25%	25%
19 S	BC	-141.654.041	5,27%	3.340.664.005	42.007.892	22	1,12	60%	20%
20 S	HC1	437.811.762	8,10%	7.408.386.501	102.246.473	23	0,85	47%	47%
21 S	BC	-141.653.543	-19,63%	3.340.664.254	42.007.394	22	0,87	35%	-5%
22 S	BC	409.186.954	10,43%	7.129.619.856	98.127.746	19	1,01	33%	33%
23 S	LC1	380.502.146	11,56%	6.850.847.210	94.001.818	17	1,25	25%	25%
24 S	BC	-141.653.537	-19,93%	3.340.664.257	42.007.388	22	0,87	34%	-6%
25 S	LC1	380.422.146	9,96%	6.850.839.210	93.992.218	19	1,09	34%	34%
26 S	BC	-141.653.541	-19,73%	3.340.664.255	42.007.392	22	0,87	35%	-6%
27 S	BC	409.056.954	7,83%	7.129.606.856	98.112.146	23	0,75	47%	47%
28 S	BC	-141.653.321	-30,73%	3.340.664.365	42.007.172	22	0,76	24%	-17%
29 S	HC3	581.547.708	10,27%	8.934.602.291	124.876.809	21	0,96	42%	42%
30 S	BC	-141.653.317	-30,93%	3.340.664.367	42.007.168	22	0,76	23%	-17%
31 S	BC	-141.653.503	-21,63%	3.340.664.274	42.007.354	22	0,85	33%	-7%
32 S	BC	409.246.954	11,63%	7.129.625.856	98.134.946	17	1,13	26%	26%
33 S	BC	-141.653.499	-21,83%	3.340.664.276	42.007.350	22	0,85	32%	-8%
34 S	LC2	378.405.380	8,54%	6.813.282.937	93.423.996	22	0,92	42%	42%
35 S	BC	-141.653.501	-21,73%	3.340.664.275	42.007.352	22	0,85	33%	-8%
36 S	BC	-141.653.319	-30,83%	3.340.664.366	42.007.170	22	0,76	23%	-17%
37 S	LC2	378.025.380	0,94%	6.813.244.937	93.378.396	33	0,16	83%	83%
38 S	BC	-141.654.039	5,17%	3.340.664.006	42.007.890	22	1,12	59%	19%

Table G.1 (continued) **:** Design space table (partial screen view).

	Case	NPV	IRR	Total EBITDA	Average Net Income	Payback period	Rantability	Investment Distribution % 1st year	Investment Distribution % 2 nd year
39 S	HC3	581.507.708	9,47%	8.934.598.291	124.872.009	22	0,88	46%	46%
40 S	BC	-141.654.037	5,07%	3.340.664.007	42.007.888	22	1,12	59%	19%
41 S	BC	409.046.954	7,63%	7.129.605.856	98.110.946	23	0,73	48%	48%
42 S	BC	-141.653.539	-19,83%	3.340.664.256	42.007.390	22	0,87	34%	-6%
43 S	LC2	378.345.380	7,34%	6.813.276.937	93.416.796	23	0,80	48%	48%
44 S	LC3	241.620.130	8,01%	5.375.337.091	72.116.470	21	0,95	37%	37%
45 S	BC	-141.654.035	4,97%	3.340.664.008	42.007.886	22	1,12	59%	19%
46 S	HC3	581.667.708	12,67%	8.934.614.291	124.891.209	17	1,20	28%	28%
47 S	HC1	437.851.762	8,90%	7.408.390.501	102.251.273	22	0,93	43%	43%
48 S	HC1	437.791.762	7,70%	7.408.384.501	102.244.073	24	0,81	49%	49%
49 S	BC	-141.654.033	4,87%	3.340.664.009	42.007.884	22	1,12	59%	19%
50 S	HC2	502.883.192	12,64%	8.095.159.403	112.450.798	16	1,25	25%	25%
51 S	BC	-141.654.031	4,77%	3.340.664.010	42.007.882	22	1,12	59%	19%
52 S	HC2	502.633.192	7,64%	8.095.134.403	112.420.798	24	0,75	53%	53%
53 S	BC	409.226.954	11,23%	7.129.623.856	98.132.546	18	1,09	28%	28%
54 S	BC	-141.654.029	4,67%	3.340.664.011	42.007.880	22	1,12	59%	19%
55 S	HC1	438.001.762	11,90%	7.408.405.501	102.269.273	17	1,23	26%	26%
56 S	BC	-141.654.027	4,57%	3.340.664.012	42.007.878	22	1,12	59%	19%
57 S	LC2	378.225.380	4,94%	6.813.264.937	93.402.396	27	0,56	61%	61%
58 S	LC2	378.485.380	10,14%	6.813.290.937	93.433.596	19	1,08	33%	33%
59 S	BC	-141.654.025	4,47%	3.340.664.013	42.007.876	22	1,11	59%	19%
60 S	HC1	437.751.762	6,90%	7.408.380.501	102.239.273	25	0,73	54%	54%
61 S	BC	-141.654.023	4,37%	3.340.664.014	42.007.874	22	1,11	59%	19%
62 S	BC	409.036.954	7,43%	7.129.604.856	98.109.746	24	0,71	49%	49%
63 S	HC3	581.637.708	12,07%	8.934.611.291	124.887.609	18	1,14	32%	32%
64 S	BC	409.216.954	11,03%	7.129.622.856	98.131.346	18	1,07	29%	29%
65 S	BC	-141.654.021	4,27%	3.340.664.015	42.007.872	22	1,11	59%	19%
66 S	LC2	378.085.380	2,14%	6.813.250.937	93.385.596	31	0,28	77%	77%
67 S	HC2	502.773.192	10,44%	8.095.148.403	112.437.598	19	1,03	37%	37%
68 S	LC3	241.570.130	7,01%	5.375.332.091	72.110.470	23	0,85	43%	43%
69 S	BC	-141.653.577	-17,93%	3.340.664.237	42.007.428	22	0,89	36%	-4%
70 S	LC3	241.510.130	5,81%	5.375.326.091	72.103.270	25	0,73	49%	49%
71 S	HC1	437.951.762	10,90%	7.408.400.501	102.263.273	19	1,13	32%	32%
72 S	LC2	377.985.380	0,14%	6.813.240.937	93.373.596	34	0,08	88%	88%
73 S	BC	-141.653.569	-18,33%	3.340.664.241	42.007.420	22	0,89	36%	-4%
74 S	LC3	241.590.130	7,41%	5.375.334.091	72.112.870	22	0,89	40%	40%
75 S	LC3	241.460.130	4,81%	5.375.321.091	72.097.270	26	0,63	55%	55%

Table G.1 (continued) **:** Design space table (partial screen view).

	Total Present Worth of Net Benefit	Total Present Worth of Net Cost	Average EBITDA	Total Net Income	Total Net Revenue	Average Net Revenue	Total Taxable Income	Average Taxable Income	Total After Tax Profit Margin
387 P	570.606.793	834.258.734	-110.646.570	12.380.003.024	16.788.446.432	287.309.087	16.431.069.268	-947.860.162	3446%
388 P	3.529.207.209	2.117.984.853	249.216.192	10.375.261.880	13.717.573.484	254.029.139	12.969.860.392	240.182.600	3441%
389 P	3.307.961.938	1.986.088.391	226.281.391	9.384.521.802	12.460.097.968	230.737.370	11.731.567.160	217.211.799	3398%
390 S	3.087.272.506	2.739.053.670	61.864.428	2.268.426.402	5.018.112.280	92.927.720	2.852.850.600	52.830.276	1642%
391 P	2.741.705.614	1.907.790.514	162.469.025	6.628.566.885	8.958.118.149	165.841.818	8.287.280.380	153.093.433	3182%
392 P	766.337.723	923.852.734	-87.082.770	12.422.916.822	16.812.019.036	289.056.065	16.431.636.800	-878.286.362	3448%
393 S	3.087.272.567	2.739.053.609	61.864.367	2.268.426.463	5.018.112.219	92.927.781	2.852.850.478	52.830.337	1648%
394 S	6.783.699.550	5.391.393.935	149.870.359	6.071.543.086	8.997.923.402	166.576.359	7.607.045.443	140.476.767	1300%
395 P	-735.313.482	-1.273.528.151	237.968.988	11.632.511.870	15.301.550.888	279.780.700	14.567.688.949	266.606.008	3410%
396 S	3.087.272.585	2.739.053.591	61.864.349	2.268.426.481	5.018.112.201	92.927.799	2.852.850.442	52.830.355	1650%
397 S	5.349.677.520	4.541.576.109	99.481.483	3.893.762.180	6.098.613.310	112.856.913	4.887.069.131	89.889.891	988%
398 S	3.087.272.463	2.739.053.713	61.864.471	2.268.426.359	5.018.112.323	92.927.677	2.852.850.686	52.830.233	1638%
399 S	6.782.399.550	5.375.793.935	149.844.359	6.071.023.086	8.992.723.402	166.446.359	7.606.850.443	140.216.767	1170%
400 S	3.087.272.534	2.739.053.642	61.864.400	2.268.426.430	5.018.112.252	92.927.748	2.852.850.544	52.830.304	1645%
401 S	6.268.484.126	5.436.278.126	131.978.127	5.298.311.874	7.967.797.300	147.484.394	6.641.422.896	122.476.535	1174%
402 S	3.087.272.433	2.739.053.743	61.864.501	2.268.426.329	5.018.112.353	92.927.647	2.852.850.746	52.830.203	1635%
403 S	6.095.302.412	4.994.495.660	126.150.184	5.045.427.806	7.636.913.770	141.395.811	6.325.318.977	116.918.592	1275%
404 P	3.413.984.573	2.605.153.120	237.656.791	9.878.051.841	13.070.435.726	241.923.254	12.350.023.776	227.777.200	2959%
405 S	3.087.272.579	2.739.053.597	61.864.355	2.268.426.475	5.018.112.207	92.927.793	2.852.850.454	52.830.349	1649%
406 P	3.526.107.209	2.080.784.853	249.154.192	10.374.021.880	13.705.173.484	253.719.139	12.969.395.392	239.562.600	3131%
407 P	3.087.774.706	1.883.149.142	21.408.535	8.974.732.053	11.988.425.071	25.664.909	11.269.920.907	12.050.943	3216%
408 S	3.087.272.464	2.739.053.712	61.864.470	2.268.426.360	5.018.112.322	92.927.678	2.852.850.684	52.830.234	1638%
409 P	3.053.182.663	1.692.624.639	272.163.890	11.651.215.660	15.334.393.692	283.385.543	14.569.065.073	269.280.602	3451%
410 P	668.472.258	879.055.734	-98.864.670	12.401.459.923	16.800.232.734	288.182.576	16.431.353.034	-913.073.262	3447%
411 S	3.087.272.616	2.739.053.560	61.864.318	2.268.426.512	5.018.112.170	92.927.830	2.852.850.380	52.830.386	1653%
412 S	7.187.190.732	5.700.600.971	165.411.876	6.743.439.663	9.836.581.290	182.101.876	8.446.473.331	155.982.284	1339%
413 S	3.087.272.435	2.739.053.741	61.864.499	2.268.426.331	5.018.112.351	92.927.649	2.852.850.742	52.830.205	1635%
414 P	277.010.398	699.867.734	-145.992.270	12.315.632.327	16.753.087.526	284.688.620	16.430.217.970	-1.052.220.862	3443%
415 P	4.093.763.533	2.446.950.734	313.501.830	13.152.451.388	17.212.753.304	318.754.691	16.441.284.844	304.468.238	3482%
416 S	3.087.272.459	2.739.053.717	61.864.475	2.268.426.355	5.018.112.327	92.927.673	2.852.850.694	52.830.229	1637%
417 S	6.270.184.126	5.456.678.126	132.012.127	5.298.991.874	7.974.597.300	147.654.394	6.641.677.896	122.816.535	1344%
418 S	5.352.277.520	4.572.776.109	99.533.483	3.894.802.180	6.109.013.310	113.116.913	4.887.459.131	90.409.891	1248%
419 S	3.087.272.570	2.739.053.606	61.864.364	2.268.426.466	5.018.112.216	92.927.784	2.852.850.472	52.830.340	1648%
420 S	6.268.284.126	5.433.878.126	131.974.127	5.298.231.874	7.966.997.300	147.464.394	6.641.392.896	122.436.535	1154%
421 S	3.087.272.457	2.739.053.719	61.864.477	2.268.426.353	5.018.112.329	92.927.671	2.852.850.698	52.830.227	1637%
422 P	3.303.861.938	1.936.888.391	226.199.391	9.382.881.802	12.443.697.968	230.327.370	11.730.952.160	216.391.799	2988%

Table G.1 (continued) **:** Design space table (partial screen view).

	Total Interest Expenses	Average Interest Expenses	% of Interest Expenses to Total Credit	Average EBITDA / Average Net Revenue	Average EBIT	Total EBIT	Average EBIT / Average Net Revenue	Total Loan Amount	Average EBITDA / Average Taxable Income	Average EBIT / Average Taxable Income
1416 P	87.733.960	1.466.184	29%	90%	218.797.984	11.819.291.120	87%	232.000.000	96%	93%
1417 S	87.813.960	1.626.185	44%	74%	54.456.741	2.940.664.000	66%	239.999.993	124%	96%
1418 P	87.693.960	1.386.184	25%	86%	241.688.784	13.057.494.352	83%	228.000.000	92%	89%
1419 S	87.813.960	1.626.185	44%	74%	54.456.741	2.940.664.000	66%	239.999.993	124%	96%
1420 S	87.403.960	806.184	-4%	48%	119.050.134	6.450.232.210	43%	199.000.000	67%	60%
1421 P	87.763.960	1.526.184	32%	93%	213.987.127	11.557.929.867	90%	235.000.000	99%	96%
1422 S	87.813.960	1.626.185	44%	74%	54.456.741	2.940.664.000	66%	239.999.993	124%	96%
1423 P	87.503.960	1.006.184	6%	67%	154.789.617	8.374.914.340	62%	209.000.000	75%	70%
1424 S	87.293.960	586.184	-15%	37%	118.940.134	6.450.067.210	32%	188.000.000	56%	49%
1425 P	84.469.308	-1.753.865	10%	71%	168.445.101	15.743.466.142	69%	236.546.970	76%	74%
1426 S	87.813.959	1.626.185	87%	117%	54.456.741	2.940.664.000	109%	239.999.950	167%	53%
1427 P	87.602.280	266.302	-17%	44%	269.935.126	11.571.288.115	42%	-1.445.560.050	49%	47%
1428 P	85.460.316	-752.369	18%	79%	209.230.085	15.976.246.190	77%	237.570.090	84%	82%
1429 S	87.813.959	1.626.185	87%	117%	54.456.741	2.940.664.001	109%	239.999.950	167%	53%
1430 P	87.653.960	1.306.184	21%	82%	154.939.617	8.375.139.340	77%	224.000.000	90%	85%
1431 P	87.653.240	593.681	-4%	57%	270.294.680	12.314.180.200	55%	-1.295.732.490	62%	60%
1432 S	87.813.960	1.626.185	55%	85%	54.456.741	2.940.664.000	77%	239.999.982	135%	85%
1433 S	87.623.960	1.246.184	18%	70%	119.270.134	6.450.562.210	65%	221.000.000	89%	82%
1434 P	75.633.960	1.146.184	7%	68%	212.657.127	11.556.534.867	65%	-978.000.000	74%	71%
1435 S	87.813.960	1.626.185	55%	85%	54.456.741	2.940.664.000	77%	239.999.982	135%	85%
1436 P	83.478.300	-2.755.361	2%	63%	127.660.117	15.510.686.094	61%	235.523.850	68%	66%
1437 P	87.633.960	1.266.184	19%	80%	154.919.617	8.375.109.340	2275%	222.000.022	88%	83%
1438 S	87.813.960	1.626.185	76%	106%	54.456.741	2.940.664.000	98%	239.999.960	157%	63%
1439 P	84.816.092	138.182	-24%	27%	73.645.648	12.432.256.480	24%	84.410.176	33%	30%
1440 S	87.813.960	1.626.185	76%	106%	54.456.741	2.940.664.000	98%	239.999.960	157%	63%
1441 S	87.253.960	506.184	-19%	33%	118.900.134	6.450.007.210	28%	184.000.000	52%	45%
1442 S	87.813.960	1.626.185	55%	85%	54.456.741	2.940.664.000	77%	239.999.982	135%	85%
1443 P	87.553.960	1.106.184	11%	72%	218.617.984	11.819.021.120	69%	214.000.000	78%	75%
1444 S	87.813.960	1.626.185	43%	73%	54.456.741	2.940.664.000	65%	239.999.994	123%	97%
1445 S	87.673.960	1.346.184	23%	75%	119.320.134	6.450.637.210	70%	226.000.000	94%	87%
1446 S	87.813.960	1.626.185	61%	91%	54.456.741	2.940.664.000	83%	239.999.975	142%	78%
1447 P	87.555.240	-35.894	-29%	32%	269.603.230	10.885.541.575	30%	-1.895.042.730	37%	35%
1448 S	87.813.960	1.626.185	43%	73%	54.456.741	2.940.664.000	65%	239.999.994	123%	97%
1449 P	87.533.960	1.066.184	9%	70%	213.757.127	11.557.584.867	67%	212.000.000	76%	73%
1450 P	87.453.960	906.184	1%	62%	154.739.617	8.374.839.340	57%	204.000.000	70%	65%
1451 P	83.973.804	-2.254.613	6%	67%	148.052.609	15.627.076.118	65%	236.035.410	72%	70%

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