2000

Optimum container handling equipment plan in Jakarta International Container Terminal (JICT) : a quantitative model using interger linear programming

Andi Isnovandiono
World Maritime University

WORLD MARITIME UNIVERSITY
Malmö, Sweden

OPTIMUM CONTAINER HANDLING EQUIPMENT PLAN IN JAKARTA INTERNATIONAL CONTAINER TERMINAL (JICT)

A Quantitative Model Using Integer Linear Programming

By

ANDI ISNOVANDIONO
The Republic of Indonesia

A dissertation submitted to the World Maritime University in partial fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE

in

PORT MANAGEMENT

2000

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

______________________________ (Signature)

August 21st , 2000

Supervised by:

Professor Toshio Hikima
Associate Professor, Maritime Education and Training
World Maritime University

Assessor:

Captain Jan Horck
Lecturer
World Maritime University

Co-assessor:

Gary Crook
Senior Economic Affairs Officer
Transport Section
Division of Services Infrastructures for Development and Trade Efficiency
United Nations Conference on Trade and Development (UNCTAD)
Visiting Professor, World Maritime University

DEDICATION

— This work is sincerely dedicated to my employer, Indonesia Port Corporation II, and all my family, who has supported me —

And

— To my father Indaryadi, to my mother Soemartini, to my wife Sita, to my brothers Anto, Ari, and Ade, and to my sister Retno (Alm.) —

ACKNOWLEDGEMENTS

Words can not express my highest appreciation to all of those who have contributed in one way or another to the success of my studies, particularly the achievement of this dissertation. Therefore:

I would like to express my deep gratitude to His Excellency Mr. Herman Prayitno, Managing Director of Indonesia Port Corporation II, and Mr. Harmani, Human Resources and General Affairs Director of Indonesia Port Corporation II, for nominating me as a participant to the Port Management Course at World Maritime University (WMU) in Sweden.

Similarly, I would like to express my appreciation to Mr. Edi Waluyo, Training and Education Body Secretary of Ministry of Communications for his excellent co-ordination and kind co-operation.

I shall express my sincere and deep gratitude to the Tokyo Foundation for awarding me a 21-month fellowship without which my studies at WMU would not have been possible.

I shall be thankful to Dr. Ma Shuo, Professor of Port and Shipping Management, for his special attention, advice, and directives, Dr. Bernard Francou, and all other lecturers and professors at WMU as well as visiting professors for all their advice, directives, and for sharing their immense knowledge and experience.

I wish to express my special thanks and appreciation to my supervisor Professor Toshio Hikima, Associate Professor of Maritime Education and Training, WMU and Inger Battista and other lecturers of English, for all their advice and directives.

I would like to thank to Mr. Bruce Browne, Lyndell Lundahl, and personnel of the Library, the Reception, Secretariat and all the Administration staff of WMU, for their assistance and co-operation.

I would like to thank to Hassan Ibrahim and Sajid Prijohutomo families for their moral support before and during this period.

My deepest gratitude and appreciation to my lovely wife, Sita Ilona, for her love and support during this period.

Finally, I am deeply grateful to my brothers, sisters, relatives and friends for taking care of me and my family during my stay in Sweden.

ABSTRACT

Title of Dissertation: **Optimum Container Handling Equipment Plan in Jakarta International Container Terminal (JICT) - A Quantitative Model Using Integer Linear Programming**

Degree: **MSc**

This dissertation discusses the procedures and ways to result the optimum equipment plan in JICT. Its purpose is to evaluate the existing equipment and propose the optimum container handling equipment plan to cope with the increase of container traffic up to 2009 and to meet the equipment demands. Ultimately, it will improve not only the performance and productivity but also the competitiveness of the terminal. The following describes how the problem should be solved.

A careful forecasting procedure of container traffic is followed to minimise the risks. It also considers the historical data of the container traffic and the changes in the environment of the JICT such as economy, trade, and transport. The data between 1994 and 1998 is used as a baseline for the forecast because of the data availability. The result shows a valid and very good forecasting model having a determinant (adjusted r^2) of 0.98. The forecast result is then used to calculate the equipment demands.

The equipment plan is done by using a mathematical method namely *Integer Linear Programming*. By using this method, a mathematical model is built and an optimum number of equipment needed is resulted with the minimum cost configuration. So, the cost-benefit analysis has been incorporated into the model. The model has also already considered a number of potential alternatives for having a suitable equipment configuration to improve the quality of handling operations. However, some assumptions have been made to build the model.

Next, the equipment plan model and the results is described and analysed. Furthermore, the results are compared with traditional way of calculating it and analysed as to plan the equipment acquisitions, investments, and policies and other element related with the results, such as cost per move. The results derived from the equipment plan model show a better equipment plan or configuration with lower investments and total cost per move of container cranes.

Finally, some conclusions are made with emphasis on the procedures to calculate an optimum equipment plan using an equipment plan model. A number of recommendations to management and for further research are also made to be able to implement the proposed equipment plan model.

Key words: JICT, Container handling equipment, Econometric approach, Container traffic forecast, Trade and GDP, A mathematical model, Optimum equipment plan, Equipment acquisitions, investments and policy.

TABLE OF CONTENTS

Declaration	ii
Dedication	iii
Acknowledgements	iv
Abstract	vi
Table of Contents	viii
List of Tables	xii
List of Figures	xiii
List of Abbreviations	xv

1 Introduction

1.1	Overview	1
1.2	Identification of the problem	2
1.3	Objectives of the study	2
1.4	Scope of the study	3
1.5	Limitation of the study	3
1.6	Research methodology	3
1.7	Structure of the study	3

2 Selected country profiles and container terminal descriptions

2.1	Selected country profiles	5
2.1.1	Economy	5
2.1.1.1	Gross Domestic Product	6
2.1.1.2	Average currency rate	7
2.1.2	Trade	8
2.2	Container terminal descriptions	9
2.2.1	The hinterland and its connections	9
2.2.2	Container terminal throughput & ship calls	10
2.2.3	Container terminal handling system	11
2.2.4	Container terminal facilities	12

2.2.5 Container terminal equipment 13
2.2.5.1 Number of equipment 13
2.2.5.2 Equipment performance 13
2.2.5.3 The age and conditions of equipment 15
2.2.5.4 Annual maintenance and running costs 16
2.3 The development of container handling equipment 17
2.4 Other selected profiles 17
2.5 Summary 17

3 Container traffic forecasting
3.1 Container traffic forecasting framework 18
3.2 Container traffic 19
3.3 Forecasting methodology 21
3.4 Determinants of container traffic 23
3.4.1 Export traffic 23
3.4.1.1 Transport sector 23
3.4.1.2 Trade sector 25
3.4.1.3 Economy sector 27
3.4.2 Import traffic 29
3.4.2.1 Transport sector 29
3.4.2.2 Trade sector 30
3.4.2.3 Economy sector 32
3.5 Container traffic forecasting model 34
3.6 Model validation 36
3.7 Scenarios 36
3.8 Container traffic forecasts 38
3.9 Analysis of the forecasts results 40

4 Container handling equipment planning
4.1 Mathematical modelling framework 41
4.2 The problem solving approach 42
4.2.1 Key concept 42
4.2.2 Understand the problem 43

4.3 A mathematical model 44
4.3.1 Model formulation 44
4.3.1.1 Variables 44
4.3.1.2 Constraints 46
4.3.1.3 Objective function 47
4.3.2 Data needed to use the model 48
4.3.2.1 Handling rate 48
4.3.2.2 Daily demand for handling operations in quay side 49
4.3.2.3 Total annual costs 50
4.3.2.4 Capital costs of the equipment 51
4.4 The solution 52
4.5 The optimum equipment plan and acquisition policy 54
4.6 Summary 55

5 Analysis
5.1 Analysis of the optimum equipment plan model 57
5.2 Analysis of the optimum equipment plan 58
5.2.1 Container cranes 58
5.2.1.1 Existing equipment 58
5.2.1.2 New equipment 59
5.2.2 Other container handling equipment 60
5.3 Investments 60
5.4 Cost per move of container cranes 62
5.5 Comparison between traditional way and the model 62
5.6 Summary 64

6 Conclusions and recommendations
6.1 Conclusions 65
6.2 Recommendations 67
6.2.1 Recommendations to JICT 67
6.2.2 Recommendations for further research 67

References 69

Appendices

Appendix 1	The age and conditions of the equipment (September 1999)	72
Appendix 2	Correlation between container traffic and other related data (base year: 1994 – 1998)	77
Appendix 3	Number of container movements of forecasted container traffic (2000 - 2009)	78
Appendix 4	Economic life calculation of equipment (container cranes)	79
Appendix 5	Summary of optimal solutions using Quant System 3.0 software	92
Appendix 6	Optimal container handling equipment plan (2000 - 2009)	108
Appendix 7	The comparison of number of container cranes needed, cost per move, and capital investment needed between the traditional way and the equipment plan model	112

LIST OF TABLES

Table 2.1	Indonesia merchandise trade (1994 – 1998)	9
Table 2.2	Container traffic in Jakarta International Container Terminal in TEU and Ton (1994 – 1999)	11
Table 2.3	Container terminal facilities	12
Table 2.4	Age of equipment (units)	15
Table 2.5	Annual maintenance and running costs of equipment	16
Table 3.1	Regression summary result for the aggregate model	34
Table 3.2	Economic scenarios based on the historical data	38
Table 3.3	Container traffic forecasts for year 2000 – 2009	38
Table 4.1	Decisions on equipment	43
Table 4.2	Handling rate of equipment (container cranes)	49
Table 4.3	Daily demand of container moves	49
Table 4.4	Annual total costs	51
Table 4.5	Number of new container cranes needed and its investments	53
Table 5.1	Investment in container handling equipment (2000 - 2009)	61

LIST OF FIGURES

Figure 2.1	Indonesia GDP and its annual percentage changes (1994 – 1998)	6
Figure 2.2	Agriculture/manufacturing share of Indonesia GDP (1980/1997)	7
Figure 2.3	Indonesia currency value and its depreciation (1994 – 1998)	8
Figure 2.4	Indonesia merchandise trade in value and its shares (1994 – 1998)	8
Figure 2.5	Map of hinterland of the container terminal	10
Figure 2.6	The number of equipment in JICT 1999	13
Figure 2.7	Equipment performance in JICT 1999	14
Figure 3.1	Container traffic forecasting framework	19
Figure 3.2	Container traffic import and export (in TEU)	20
Figure 3.3	Containerized traffic import and export (in Ton)	20
Figure 3.4	Level of influence to the port	22
Figure 3.5	Relationships between export of containerized traffic, fleet capacity and ship calls (1994 – 1998)	24
Figure 3.6	Export values and shares of seven main destination countries (January – October 1999)	25
Figure 3.7	Relationships between export of containerized traffic and export trade in values (1994 – 1998)	26
Figure 3.8	Relationships between export of containerized traffic and East Asia trade volume growth and trade volume change per annum (1994 – 1998)	27
Figure 3.9	Relationships between export of containerized traffic and real GDP growth of the country and GDP development in Asia (1994 – 1998)	28
Figure 3.10	Relationships between export of containerized traffic and the value of local currency rate per USD (1994 – 1998)	29
Figure 3.11	Relationships between import of containerized traffic, fleet capacity and ship calls (1994 – 1998)	30
Figure 3.12	Relationships between import of containerized traffic and import trade in value (1994 – 1998)	30

Figure 3.13	Import values and shares of seven main countries of origins (January – October 1999)	31
Figure 3.14	Relationships between import of containerized traffic and East Asia trade volume growth and trade volume change per annum (1994 – 1998)	32
Figure 3.15	Relationships between import of containerized traffic and GDP of the country (1994 – 1998)	33
Figure 3.16	Relationships between import of containerized traffic and real GDP growth of the country and GDP development in Asia (1994 – 1998)	33
Figure 3.17	Relationships between import of containerized traffic and the value of local currency rate per USD (1994 – 1998)	34
Figure 3.18	Comparison of containerized traffic, in Ton and TEU actual v.s. model (1994 – 1999)	36
Figure 3.19	Container traffic actual (1994 – 1999) and forecasted (2000 – 2009) in TEU	39
Figure 4.1	Mathematical modeling framework	41
Figure 4.2	The comparisons of the number of container cranes needed with different utilisation scenarios	54
Figure 5.1	The comparisons of the results between traditional way and the equipment plan model	63

LIST OF ABREVIATIONS

ADB	Asian Development Bank
CC	Container Crane
CFS	Container Freight Station
CY	Container Yard
EDI	Electronics Data Interchange
FD	Forklift Diesel
GDP	Gross Domestic Product
HMC	Harbor-Mobile Crane
HPH	Hutchinson Port Holdings
HT	Head Truck
ICBS	Indonesian Central Bureau of Statistics
IMF	International Monetary Fund
ITC	International Trade Center
JICT	Jakarta International Container Terminal
KOPEGMAR	Koperasi Pegawai Maritim (Maritime Employee's Co-operative)
RTG	Rubber-Tyred Gantry Crane
TEU	Twenty Feet Equivalent Units
UNCTAD	United Nations Conference of Trade and Development
USA	United States of America
USD	United States of America Dollar
USDOC	United States Department of Commerce
WMU	World Maritime University

CHAPTER 1
Introduction

"This chapter describes the overview, identification of the problems, objectives, scope, limitations, research methodology and structure of this study"

1.1 Overview

On April 1999, Hutchinson Port Holdings (HPH) completed the purchase of a 51% stake in the newly formed Jakarta International Container Terminal (JICT) from Indonesia Port Corporation II (IPC II) and IPC II's employee cooperative, Koperasi Pegawai Maritim (Kopegmar).

JICT has been formed to operate container terminals I and II at Tanjung Priok Seaport for a period of 20 years, to upgrade its facilities and systems to world class standards, and to undertake the construction and development of additional container handling capacity adjacent to container terminal I. The upgrading and expansion of JICT will further contribute to the country's economic development in facing the globalisation of the world economy and trade liberalisation.

Globalisation of the world economy and trade liberalisation has increased the global general cargo and container volumes. As stated in his article, Peters (BIMCO Review 2000, p.26) "the global general cargo and container volumes will continue to grow for many years to come". This also happened to JICT (formerly container terminals I and II), which is the largest container terminal in Indonesia and is one of the country's most important economic gateways, where the container traffic grew dramatically from 0.18 million TEUs in 1986 to 1.53 million TEUs in 1997 or more than eight times. Although this growth slightly decreased in 1999 to 1.47 million TEUs due to the post economic crisis in Indonesia, it is believed that the container traffic will continue to grow.

Despite that situation, JICT also has to fulfil the vision and mission of its mother company, IPC II, which is to be a world-class port operator. To achieve it, JICT should continuously provide high quality services as close as possible to the customer requirements. In order to do so, it is important to have an adequate inventory of the equipment, so the terminal can meet cargo handling needs and achieve its operational performance targets. In addition, “investment in port infrastructure and equipment is expensive and, given the highly dynamic and competitive nature of the maritime business, inherently risky” (McDonagh, 2000, p.24). Therefore, JICT needs to have a medium or long-term equipment plan to ensure that high quality services are being achieved with the minimum risks.

1.2 Identification of the problems

Preparing an equipment plan for the port is a complex process and full attention must be allocated to it. Furthermore, the accuracy of the equipment plan itself depends on the accuracy of the data available. If the data is not accurate, it can mislead the results. In addition, the planning process has to be carefully managed and prepared to minimise the risks. These risks can be limiting the future growth of container traffic and over-investment in equipment.

This study is trying to answer the following questions: How to deal with these risks? What problems do exist in relation with these risks? How to minimise these risks? How to determine the adequate (optimum) inventory of the equipment? What is the impact on the future of the container trade regarding investments, or costs per move? What actions should be taken to succeed the implementation of this study?

1.3 Objectives of the study

Based on the background described in the previous paragraph, this study has the following general objectives:

- To ensure that the port has an adequate number of container handling equipment to cope with the increase in container traffic;
- To improve the competitiveness and quality of services of the container terminal through better container handling equipment planning;

- To give guidelines to management in applying equipment acquisition policies and investments;
- To provide management with a tool to calculate the optimum container handling equipment plan.

1.4 Scope of the study

The scope of the study is limited to determining the container handling equipment plan in JICT.

1.5 Limitation of the study

This study does not discuss the maintenance policies and procedures comprehensively but discusses how to determine the optimum container handling equipment plan. The optimum number of equipment is based on the assumption that the availability is set at a certain level. It means that there will be higher cost for preventive maintenance to achieve such availability of the equipment.

1.6 Research methodology

For this study, the primary data was collected directly from the company and the secondary data was collected from various sources (reports, magazines, internet). Literature research was done in the library to gain necessary information. In addition, the equipment planning process was done according to UNCTAD (1990, pp. 40-41). Furthermore, to have an optimum container handling equipment, the problem was solved by a mathematical model using *integer linear programming approach* using a Quant System software.

1.7 Structure of the study

Normally when dealing with planning, there are three main modules that should be dealt with, namely forecasting, planning, and simulation. In this dissertation, the author clearly does two of them: container traffic forecasting (Chapter 3) and equipment planning (Chapter 4). The latter, simulation, is done by applying scenarios in the forecasting and equipment planning process. Therefore, for the purpose of the study, this dissertation is a divided into six chapters:

Chapter 1 Introduction. This chapter describes the overview, identification of the problems, objectives, scope, limitation, research methodology, and the structure of the study.

Chapter 2 Selected country profiles and container terminal descriptions. This chapter describes the information of particular country profiles and the container terminals in JICT including the throughput, handling system, equipment types, numbers, performances, the age, conditions, annual maintenance and running costs, and the recent development of container handling equipment to see the possibilities to apply this new development of container handling equipment. The country profiles and the terminal throughput is used to forecast the container traffic and, ultimately, to calculate the optimum equipment plan.

Chapter 3 Container traffic forecasting. This chapter describes and discusses the container traffic forecast methodology and the factors affecting the container traffic to be able to have reliable container traffic forecast by using a specific statistical method (*an econometric approach*).

Chapter 4 Container handling equipment planning. This chapter describes, discusses, and analyses the framework of the equipment planning process, the operational scenarios, and how this problem can be solved by a mathematical approach using integer linear programming.

Chapter 5 Analysis. This chapter discusses and analyses the optimum equipment plan model, its results, and its implications to costs per move of container cranes, the company's investments and the comparisons between the traditional way and the equipment plan model of calculating the equipment plan.

Chapter 6 Conclusions and recommendations. This chapter describes the conclusions of the study and gives the recommendations to the management of JICT and for further research.

CHAPTER 2
Selected country profiles and container terminal descriptions

"This chapter describes selected country profiles, container terminal descriptions, and the development of container handling equipment and discusses them"

2.1 Selected country profiles

Basically, the selected country profiles discussed are economy and trade sectors. These profiles are needed to forecast the container traffic in the future.

2.1.1 Economy

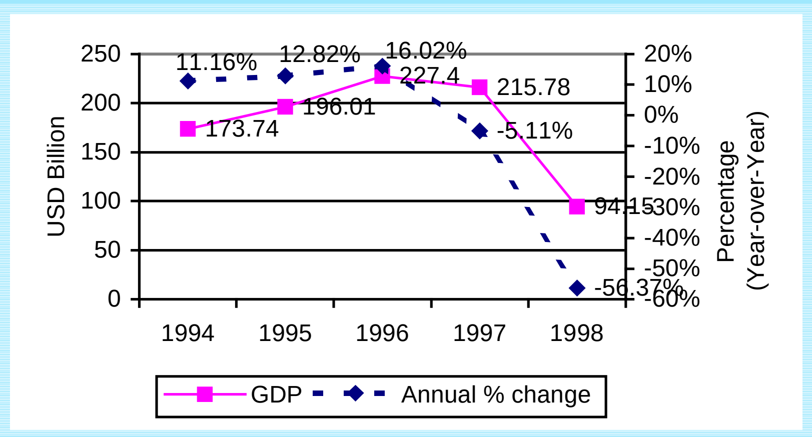
Prior to independence, Indonesia's economy was oriented to providing raw materials to the Netherlands. Subsistence agriculture, primarily the production of rice, was the mainstay of most of the population; but the economy also relied on plantation agriculture, including the production of sugar and rubber. Industry was not promoted so as to avoid competing with the Netherlands.

In the 1970s, the economic policy was to expand foreign investment and increase trade. When export revenues from oil declined in the early and mid-1980s, Indonesia was forced to expand other exports. To make these exports more competitive internationally, the government deregulated parts of the economy such as coastal transportation, finance, and banking.

Indonesia's economy grew impressively during the 1980s and much more in the 1990s, largely on the strength of its natural resources, which include a large population, solid energy reserves, substantial mineral deposits, and fertile farmland.

2.1.1.1 Gross Domestic Product

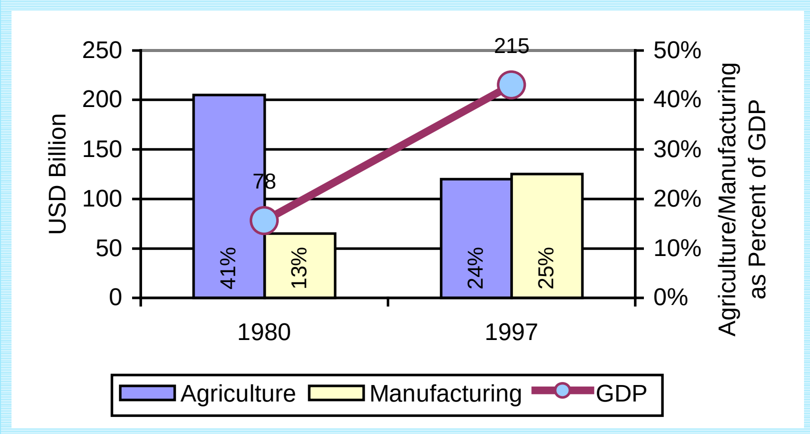
Indonesia's gross domestic product (GDP) was USD 227 billion in 1996, the largest in Southeast Asia. Between 1994 and 1996, the GDP grew by about 30.9%. Between 1994 and 1996, the growth was always positive with an average growth 13.3%. But in mid-1997 an economic crisis developed in Asia whereby investors lost confidence in certain debt-laden economies. As the crisis spread to Indonesia, the value of the Indonesian currency plummeted, which threatened the capacity of the government, banks, and businesses to repay their foreign debts. As an impact, the GDP growth fell to negative (-5.1%) and even much worse in 1998 when the growth sharply declined to –56.4% (see Figure 2.1).



Source: Indonesian Central Bureau of Statistics, Bank Indonesia, Ministry of Finance, World Bank, U.S. Department of Commerce (USDOC).

Figure 2.1
Indonesia GDP and its annual percentage change
(1994 – 1998)

In addition, between 1980 and 1997 there were significant shifts in the structure of the Indonesian economy. Agriculture shrunk from 41 to 24 percent. The industry as a whole remained stable, but manufacturing, the largest component of the industry, grew from 13 to 25 percent of the GDP (see Figure 2.2). Consequently, Indonesia is more dependent on manufacturing as its main economy sources. Therefore, as a result of this crisis, in the period of January and October 1999, "the manufacturing product *export values increased* by USD 2.67 billions (or 13.80%) to USD 21.99 billions but *import values decreased* by USD 4.41 billions (or 27.28%)" (ICBS, 1999) compared with the same period the year before.



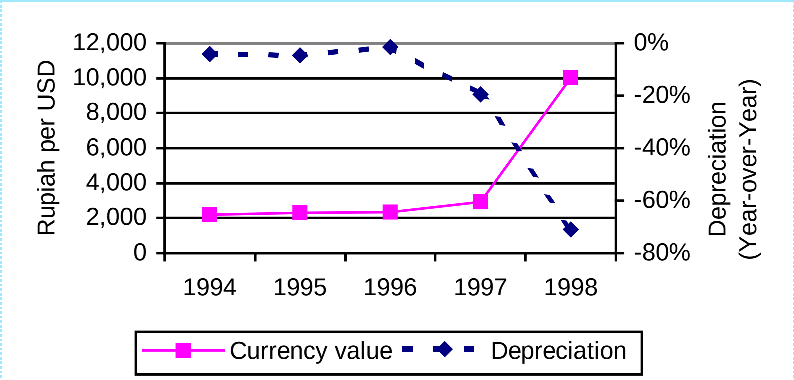
Source: World Development Indicators 1999--World Bank.

Figure 2.2
Agriculture/manufacturing share of Indonesia GDP
(1980/1997)

2.1.1.2 Average currency rate

Indonesia's currency value (Rupiah) sharply weakened in 1998 with the depreciation of about 71% from the 1997 value following the economic crisis which commenced in mid-1997 (see Figure 2.3). However, in 1997, Rupiah, based on average currency rate experienced depreciation of only about 19% from the previous year. In addition, between 1994 and 1998, the depreciation was about 78%. Many analysts discussed that the economic crisis spread was caused by several factors of influence, as Michel Camdesus reported in its Asia-Europe Finance Ministers Meeting in Frankfurt, Germany, January 16, 1999:

> Four influences may explain this phenomenon:
>
> (i) common factors in the external environment, specifically the features in the global financial system that led to the large flows of volatile capital to the region;
>
> (ii) the spillover effects from trade and financial linkages among the countries;
>
> (iii) a true contagion effect, as the crisis in one country caused investors to reassess the fundamentals in other countries; and
>
> (iv) a number of unexpected exogenous factors, including weaker terms of trade and the deepening of the recession in Japan.

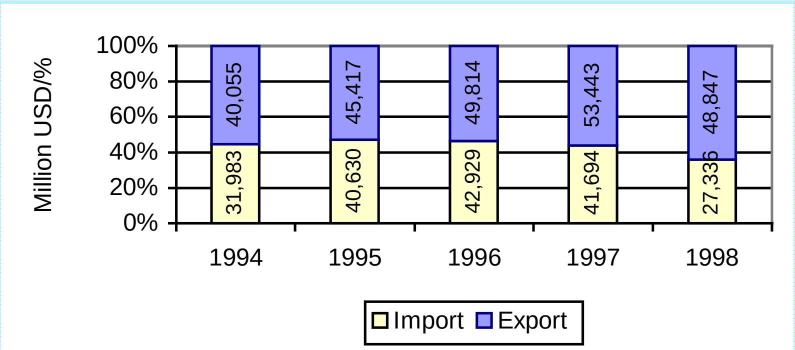


Source: Indonesian Central Bureau of Statistics, Bank Indonesia, Ministry of Finance, World Bank, U.S. Department of Commerce (USDOC).

Figure 2.3
Indonesia currency value and its depreciation
(1994 – 1998)

2.1.2 Trade

Indonesia's trade share between imports and exports between 1994 and 1997 was relatively stable (44% and 56% respectively). But in 1998, the import share was lower (36%) compared with the average share between 1994 and 1997 as the Asian crisis deepened. Exchange rate variations (the value of the Indonesian currency plummeted), which were large in the course of 1998, can have a major impact on the dollar prices of internationally traded goods. The impact is that import goods becomed more expensive and export goods becomed cheaper. That is why the total Indonesia's trade in value fell in 1998, particularly sharply for import trade (see Figure 2.4).



Source: Indonesian Central Bureau of Statistics, Ministry of Finance, Ministry of Industy and Trade.

Figure 2.4
Indonesia merchandise trade in value and its shares
(1994 – 1998)

In terms of value, the import trade growth in 1998 declined to -34% whilst the export trade declined to -9% (see Table 2.1). This import and export trade growth decreased sharply as compared with the average trade growth in 1994-97 (11% and 10% respectively). However, the import value in 1998 was still slightly above the import value in 1992 (i.e. USD 27,279 million).

Tabel 2.1
Indonesia merchandise trade
(1994 – 1998)

Million USD

Descriptions	1994	1995	1996	1997	1998	% Annual Change					1994/97
						1994	1995	1996	1997	1998	Average
Total Trade	72,038	86,047	92,743	95,137	76,183	11%	19%	8%	3%	-20%	10%
Import Trade	31,983	40,630	42,929	41,694	27,336	13%	27%	6%	-3%	-34%	11%
Export Trade	40,055	45,417	49,814	53,443	48,847	9%	13%	10%	7%	-9%	10%

Source: Indonesian Central Bureau of Statistics, Ministry of Finance, Ministry of Industy and Trade.

2.2 Container terminal descriptions

2.2.1 The hinterland and its connections

The terminal is serving the most rapid growing hinterland area of the country from the utmost western side of Java Island until the border of Central Java. Its posistion is very strategic, surrounded by many industrial areas and some plantations. The western part is mainly industrial areas situated in Merak, Cilegon and Tangerang. The central and eastern parts are also industrial areas situated in Jakarta and Bekasi. In the southern part beginning from Cibinong, Bogor, Sukabumi, Cianjur and Bandung, there are some plantation areas that produce tea, rubber, rice, fruit and other commodities (Port of Tanjung Priok, 1997).

The terminal is connected to its hinterland by roads and railway systems as shown in Figure 2.5. The railway connections are dedicated to transport a number of particular commodities between the terminal to the inland port of Gede Bage in Bandung, the capital of West Java. The railway service is provided by a railway state-owned company called PT (Persero) Kereta Api.

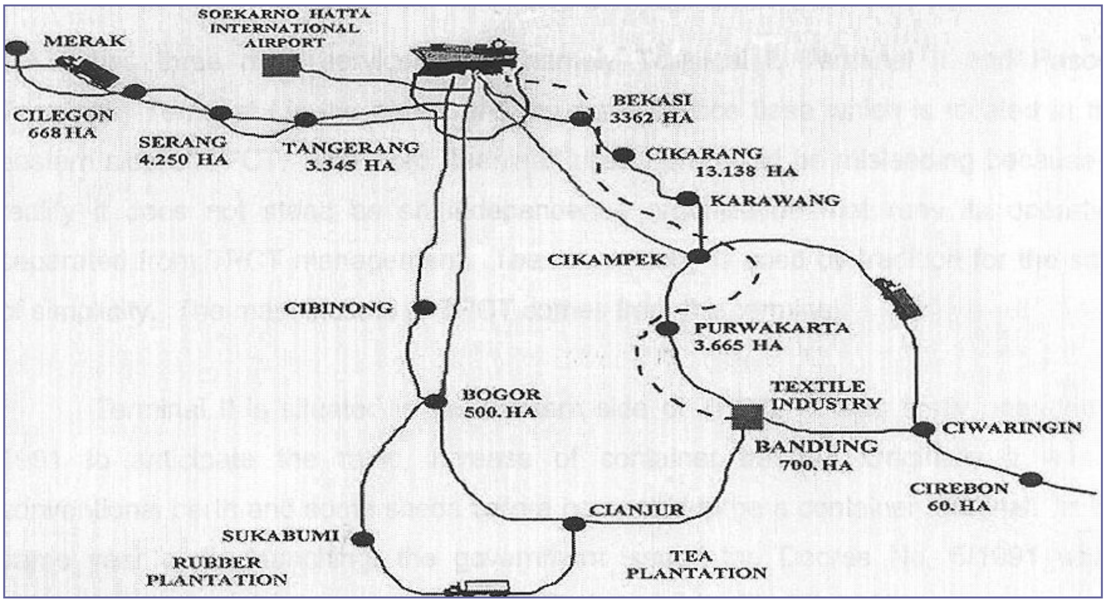


Figure 2.5 Map of hinterland of the container terminal (Port of Tanjung Priok)

2.2.2 Container terminal throughput & ship calls

Container throughput in JICT is always increasing, as the world container market grows continously, except in 1998 and 1999 due to the economic crisis in Indonesia. Between 1994 and 1997, the traffic increased by almost 32% from 1.16 million TEUs to 1.53 million TEUs, while in terms of tons, the traffic increased by 27% from 10.43 to 13.29 million tons. However, because of the economic crisis, the traffic slightly decreased to 1.42 and 1.47 million TEUs or, in terms of tons, decreased to 10.59 and 12.63 million tons in 1998 and 1999 respectively (see Table 2.2).

In 1994, the number of ship calls was about 2,000 calls with an average load of 600 TEUs per ship. Furthermore, between 1995 to 1998, the number of ship calls was decreasing to around 1,600 calls, but the average load was increasing to 900 TEUs per ship. It means that, after 1994, the ship size was increasing as the growth of containerisation continued to increase (see Table 2.2).

Table 2.2
Container traffic in Jakarta International Container Terminal in TEU and Ton
(1994 – 1999)

Descriptions	1994	1995	1996	1997	1998	1999
Shipcalls	1,984	1,492	1,574	1,665	1,580	1,588
% change	-1.05%	-24.80%	5.50%	5.78%	-5.11%	0.51%
TEU Import	564,706	642,788	700,943	755,373	698,474	730,463
TEU Export	599,426	657,338	723,140	777,704	726,473	742,042
In TEU (Total)	1,164,132	1,300,126	1,424,083	1,533,077	1,424,947	1,472,505
% change	18.99%	11.68%	9.53%	7.65%	-7.05%	3.34%
Ton Import	5,851,839	6,855,499	7,236,660	7,481,625	4,112,794	6,093,383
Ton Export	4,576,894	5,329,317	6,201,285	5,807,825	6,472,808	6,536,776
In Ton (Total)	10,428,733	12,184,816	13,437,945	13,289,450	10,585,602	12,630,159
% change	16.39%	16.84%	10.28%	-1.11%	-20.35%	19.31%

Source: Company record.

2.2.3 Container terminal handling system

According to its operational features, JICT is using the *rubber-tyred gantry crane (RTG) system* for its operation. In this system, "the container yard is equipped with rubber-tyred gantry cranes for stacking and unstacking, with tractor-trailer units for quay transfer and other movements" (UNCTAD, 1986a, p. 5). Transfer between shipside and CY is carried out by tractor-trailer sets.

The RTGs pick up the containers from the roadway and move along the row to stack them in the CY while the trucks-trailer sets move off around the CY and back to the quay apron. For receipt/delivery, road vehicles are allowed onto the terminal and along the truck lane to the appropriate row. The RTGs are used solely for stacking/unstacking and moving positions within the row in the block. The terminal is also using Harbour-Mobile Cranes (MHC) to load and unload containers to and from the trucks or trailers on the quay apron, but they are not very much in use.

In the CFS, the equipment used is forklifts with various capacities. After stripped and stuffed in the CFS, forklifts move containers to the tractor-trailers. The tractor-trailers then move them to the CY or out of the terminal. For a particular case, container handling is done by top loader or side loader. This operation is normally done to receive export empty containers from the external trailers.

The terminal is operated 24 hours a day and seven days a week with three shifts. The terminal implemented EDI to improve its services on 15 September 1997. In other cases, for the clients who have not implemented EDI, the terminal also provides a Help Desk to assist them.

2.2.4 Container terminal facilities

In total, the JICT has a total quay length of 1,410 m comprising six berths with alongside depth from –9m to –11m, whilst the seventh berth currently being equipped has a depth of –14 m. The total container yard area is 39.73 ha with an import capacity of 24,556 TEUs and an export capacity of 11,662 TEUs. Although export traffic is higher than import traffic, the import capacity is higher due to the longer dwelling time. The total CFS area is 4,500 sqm. Those figures are shown in Table 2.3.

Table 2.3
Container terminal facilities

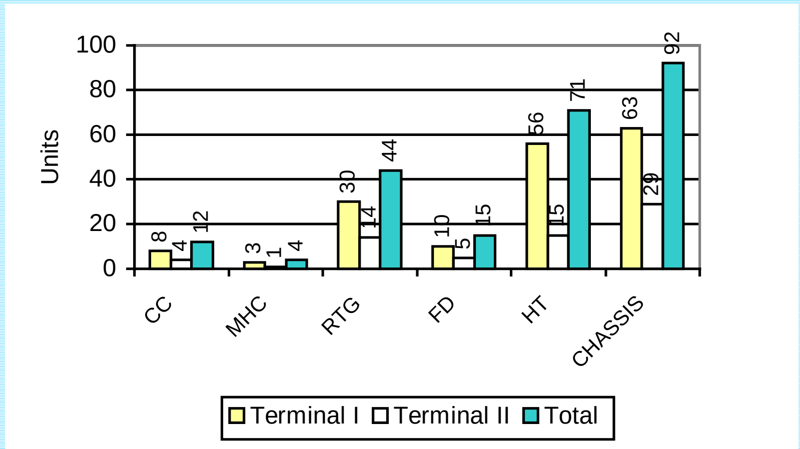
Description	Terminal I	Terminal II	CFS	Total
1. Berth				
Length	900 m	510 m	-	1,410 m
Apron width	27 m	16 m	-	-
Draft	11 m	9 m	-	-
2. Yard				
Land area	31.40 ha	6.83 ha	1.50 ha	39.73 ha
Import capacity	18,900 TEUs	4,999 TEUs	357 TEUs	24,556 TEUs
Export capacity	8,905 TEUs	2,400 TEUs	357 TEUs	11,662 TEUs
Reefer capacity	240 plugs	48 plugs	-	288 plugs
3. CFS				
Area	-	-	4,500 sqm	4,500 sqm

2.2.5 Container terminal equipment

2.2.5.1 Number of equipment

Terminal I is served by 8 container cranes (CCs), 3 mobile harbour cranes (MHCs), 30 rubber-tyred gantry cranes (RTGs), 10 forklift diesel (FDs), 56 head-truck (HTs) and 63 chassis. Terminal II is served by 4 CCs, 1 MHC, 14 RTGs, 3 FDs, 15 HTs and 29 chassis (Unit Terminal Petikemas Tanjung Priok, p. 28). So in total, the JICT is served by 12 CCs and 4 MHCs, 44 RTGs, 17 FDs, 71 HTs and 92 chassis (see Figure 2.6).

Among the cranes there are some leased equipment. For the CC, there are 3 pieces of leased equipment in terminal II. For the MHC, all of the equipment is leased equipment. For the RTG, there are 9 pieces of leased equipment in terminal I and 3 pieces of leased equipment in terminal II.



Source: Jakarta International Container Terminal 1999.

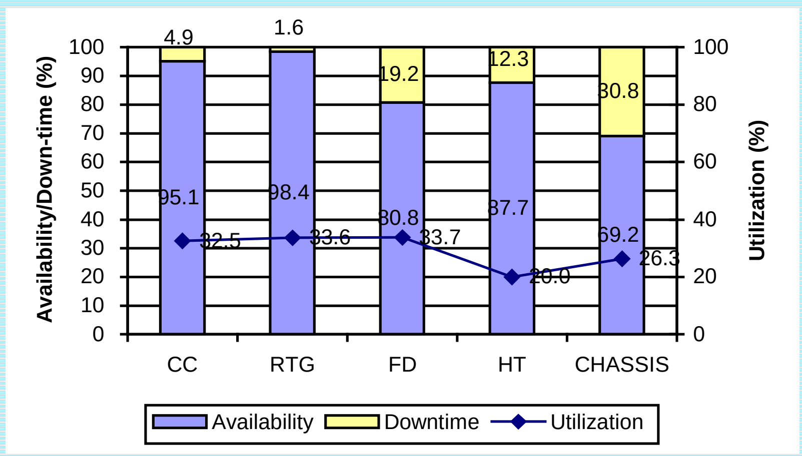
Figure 2.6
The number of equipment in JICT 1999

2.2.5.2 Equipment performance

The JICT measures the performance of equipment by taking into account the achievement of availability, downtime, and utilisation of equipment. UNCTAD also considers these indicators as very important measures for equipment performance.

Although the JICT divides availability of equipment into three different parts, i.e., availability equipment, availability inherent and availability occupied, for the purpose of this study, the performance of equipment is measured according to formulas introduced by UNCTAD (1990, p.3), such as: equipment availability, equipment down-time, and equipment utilisation.

Equipment availability is defined as a measure of proportion of time individual machines or classes of machines, which are accessible to operators. *Equipment downtime* is defined as a measure of the time when equipment is out of service and unavailable for use. *Equipment utilisation* is defined as a measure of proportion of the time that a machine (or category of machines) is performing useful work. The performance of the equipment by category in the JICT is described in Figure 2.7.



Source: Jakarta International Container Terminal 1999 (May – November)

Figure 2.7
Equipment performance in JICT 1999

In general, all the equipment has a very good availability that is about 80 to 98%, except for chassis, which has the availability of 70%. In terms of utilisation, the utilisation of the RTG, head truck and chassis is lower compared with the average utilisation recommended by UNCTAD. However, this does not show the real situation since this data is based on a five-month observation. Since all MHCs are leased equipment, its performance is not shown in Figure 2.7.

2.2.5.3 The age and conditions of equipment

Equipment owned by JICT varies in brand/manufacturer and age due to the different sources of funding. This condition is normal in developing countries because there is lack of money for funding their equipment, which usually needs a huge investment. In the following, the author is trying to explain the age and conditions for each type of equipment in general.

There are three container cranes over 20 years old, one between 11 to 20 years old, and five containers below 10 years old. It can be said that 44% of the CCs are quite old equipment and constitute the main hindrance to its efficiency. In addition, there are seven RTGs over twenty years old, eight RTGs between 11 to 20 years old, and seventeen RTGs below 10 years old. The situation is better where more than 50% of the RTGs are still 'young'.

Furthermore, for forklift diesel, one of them is over 20 years old, seven of them between 11 to 20 years old and nine of them are below 10 years old. Moreover, for the head-truck, thirteen of them are between 11 to 20 years old, forty-eight of them are between 5 to 10 years old and ten of them are below 5 years old. This equipment is quite new, reliable and operational.

Finally, for chassis, fourteen of them are over 20 years old, eighteen of them are between 11 to 20 years old, fifty of them are between 5 to 10 years old, and ten of them are below 5 years old. The age breakdown for each type of the equipment is as follows.

Table 2.4
Age of the equipment (units)

Type of Equipment	< 5 years	5 to 10 years	11 to 20 years	> 20 years	Total
Container Crane	2	3	1	3	9
Transtainer (RTG)	-	17	8	7	33
Fork-lift Diesel	6	3	7	1	17
Head Truck	10	48	13	-	71
Chassis	10	50	18	14	92

Note: For details see Appendix 1.

2.2.5.4 Annual operating (maintenance and running) costs of equipment

For the purpose of the equipment plan model, annual operating costs of equipment are taken only for container cranes. The percentage changes in USD are the same with the changes in Rupiah, that is between 10 to 17% annualy because the exchange rate applied by the company is the same i.e. Rp 8,000 per USD. However, these changes do not really represent the actual increase in annual operating costs because , in facts, the exchange rate is different. The increase in costs is calculated based on the assumption that maintenance cost changes increase as the age of equipment become older. The 1999 operating cost data, as shown in Table 2.5 were used as a base for further calculation. The complete calculation of the economic life or annual costs of the equipment (capital recovery and operating costs) is shown in Appendix 3.

From Table 2.5, it can be concluded that, coincidently, the changes of the operating costs per year of equipment are typical for particular groups of equipment. For example: 1970's Pre-Panamax cranes have annualy operating costs changes of around 10 to 11%. In addition, 1990's Panamax cranes have annual maintenance and running costs changes of around 17%.

Table 2.5
Annual maintenance and running costs of equipment

Equipment Register	Year		Maintenance Costs (in Indonesian Rupiahs)		% change	Maintenance Costs (in USD)		% change
	made	Used	1998	1999		1998	1999	
CC02A (2nd)	1972	1992	209,317,380	233,078,335	11.35%	26,165	29,135	11.35%
CC02	1976	1978	470,814,358	519,972,914	10.44%	58,852	64,997	10.44%
CC03	1976	1978	499,425,532	549,691,727	10.06%	62,428	68,711	10.06%
CC01	1983	1986	314,355,391	386,923,807	23.08%	39,294	48,365	23.08%
CC04	1992	1992	979,252,905	1,145,075,800	16.93%	122,407	143,134	16.93%
CC05	1992	1992	1,096,625,284	1,282,467,582	16.95%	137,078	160,308	16.95%
CC06	1992	1992	1,052,767,288	1,231,087,227	16.94%	131,596	153,886	16.94%
CC07	1997	1997	963,839,304	1,128,202,686	17.05%	120,480	141,025	17.05%
CC08	1997	1997	914,094,454	1,074,667,511	17.57%	114,262	134,333	17.57%
Total			**6,500,491,896**	**7,551,167,589**	**16.16%**	812,561	943,896	16.16%

Source: Company record.
Exchange rate: 1USD = Rp. 8,000,- (1998) and Rp. 8,000,- (1999)

Table 2.5 also shows that the Panamax cranes have higher annual operating costs than the Pre-Panamax cranes, although Panamax cranes are much 'younger' than Pre-Panamax cranes. It can be explained because each piece of equipment has its own specifications e.g. horse power, etc., which affect the increases of the costs. For example: for a particular manufacturer, the machine or drive of the equipment is not 'suitable' in tropical climates, where the machines are often having problems with the engine so spares from the manufacturer country for repairs, are needed, which is expensive. On the other hand, for another particular manufacturer, the drive of the equipment is more reliable and needs less money to maintain. Uitlization of the individual equipment also affects the increase in costs.

2.3 The development of container handling equipment

In general, "the trend will be for container handling equipment to be cheaper to maintain which will increase its economic life but probably no more than 20 per cent" (Crook, 2000). It also means that the price of equipment may be cheaper with higher handling rate per hour. In specific cases, the container crane sizes will be bigger and bigger "dictated by increases in vessel size (notably of beam and freeboard) and container dimensions" (UNCTAD, 1986a, p. 24).

2.4 Other selected profiles

The other selected profiles are considered as other factors influencing the container traffic other than the previous ones. Those factors are container shipping fleet capacity, East Asia trade volume growth, Asia's trade volume change per annum, and GDP development in Asia. The profiles are shown in Appendix 2.

2.5 Summary

This chapter has clearly described the selected country profiles and container terminal descriptions, which are important for this study. The data of selected country profiles, container terminal figures, and other selected profiles are used to forecast the containerised traffic using *econometric approach.* In addition, some container terminal descriptions are used in relation to the equipment planning for the JICT. Those topics are discussed in the next chapter three and chapter four.

CHAPTER 3
Container traffic forecasting

"This chapter describes the container traffic forecasting and discusses the methodology used for its forecast"

3.1 Container traffic forecasting framework

To determine the optimum container handling equipment plan for long-term (i.e. ten years) planning, there has to be the procedure to deal with it. The container handling equipment needs depend on the container traffic. Therefore, a forecasting system to forecast the container traffic is needed in order to determine how much equipment is necessary. The implementation of a forecasting system requires:

(1) identification of key environmental sectors (by correlation analysis);
(2) forecasting of key environmental sectors (by looking at a reliable sources);
(3) conditional forecasting for alternative strategic option (by scenarios)
(Makridakis, Wheelwright, 1987, p.80).

To apply the procedure, it is important to identify the key environmental factors influencing container traffic. There are several causal relationships and factors that affect container traffic. The author identified that transport, trade, and economy is the environmental factors influencing the port (i.e. container traffic). To determine the relationships between container traffic and these environmental factors, an examination of the variables quantifying those environmental factors is required. For the various relationships between the container traffic and its variables, some variables will typically have a more important impact than others. The correlation between the container traffic and its variables will show this. The higher the correlation coefficient, the more important will the impact be.

After examining those variables, a forecasting model of container traffic can be build by using *multiple regression analysis (simultaneous system)*. This model has a major advantage, that is it can explain inter-relationships between dependent variables. This approach is used because the author wants to have explanatory variables influencing the container traffic. The framework for container traffic forecasting is described on Figure 3.1.

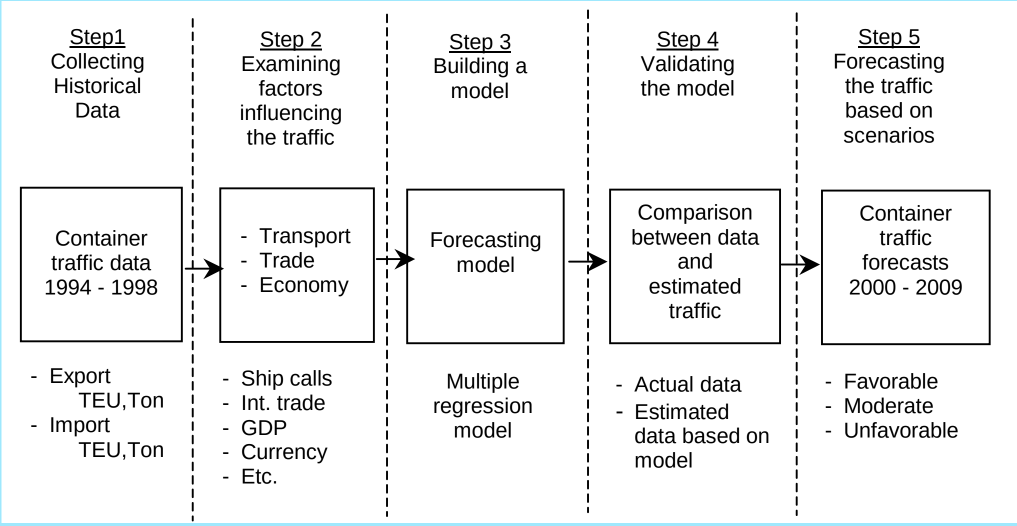
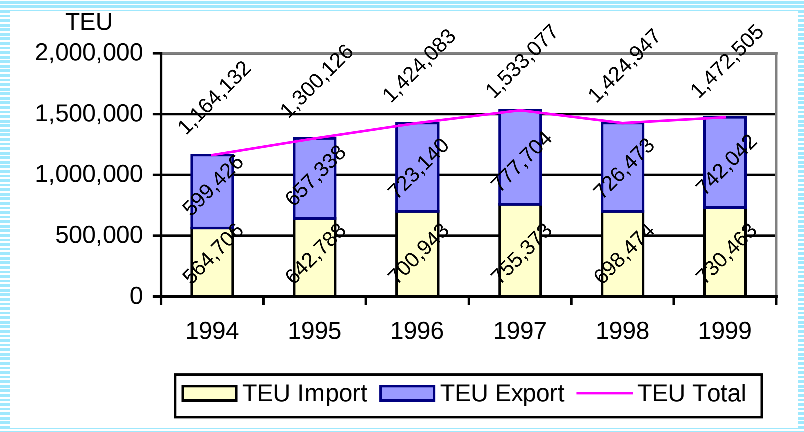


Figure 3.1
Container traffic forecasting framework

3.2 Container traffic

Container traffic in terms of TEU and Ton (see Figures 3.2 and 3.3) in JICT have continuously increased from year to year (except in 1998 as an impact of the economic crisis and it still affected growth in 1999). However, the trends in general are constantly increasing as a result of containerisation.

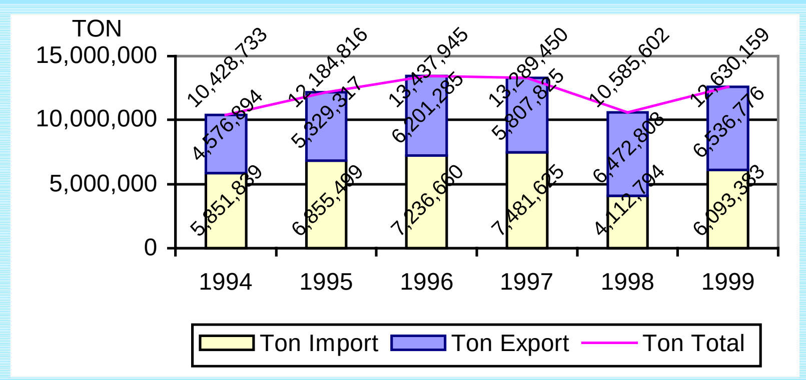
This continued increase in container traffic is widely expected and the port needs to anticipate this increase by planning port expansion i.e. container handling equipment. For this reason, the port has to base its expansion plans of *forecasts* rather than actual throughput figures.



Source: Company Record.

Figure 3.2
Container traffic import and export
(in TEU)

Data for container traffic is taken in terms of TEU and Ton (containerised). It is also divided into imports and exports to see the proportion of this container traffic based on its activity. The figures are based on the container traffic data between 1994 and 1999 (see Table 2.2).



Source: Company Record.

Figure 3.3
Containerised traffic import and export
(in TON)

3.3 Forecasting methodology

The traffic forecasting methodology adopted by the author is based on an *econometric approach*. The inclusion or omission of independent variables follows testing and evaluation of numerous combinations. Generally, the statistical model that best fits historical traffic data is deemed to provide the best explanation of future trends unless otherwise suggested by analysis.

Special emphasis has been placed on monitoring and evaluating the impact on container traffic resulting from economic developments in Asia. For instance, initial predictions about the impact on container traffic to and from JICT have been quite accurate.

The author assumes that the political and general economic climates will remain conducive to growth. No assumptions are made about possible alternative political scenarios, beyond basic GDP growth as adjusted by experts to incorporate known developments such as the Asian currency crisis.

One of the challenges faced when preparing container traffic forecasts involves the availability of reliable data of historical traffic details. The collection of data and the improvement of the traffic statistic database are a continual process at JICT. The JICT draws on various data sources including those, which are available from the operational department and others. While attempts are made to reconcile any material differences between the sources of data, only one source is used on any particular data.

Historical data relating to independent variables are drawn from expert and/or official sources including the national Statistic Bureau, the World Bank, the IMF, the ADB, the ITC, and other agencies. Where the independent variables have been included in forecasting models, projections have been made based on the best judgement, supported by analyses of the relative maturity of the particular market as well as regulatory and other relevant trends.

Based on this condition, the approach used to forecast the container traffic should consider the environment affecting the port, such as: transport, trade, and economy and its variables (see Figure 3.4). Therefore, a multiple regression analysis is used to forecast the containerised traffic. In this approach, forecasts of changes in those variables are used to estimate the corresponding changes in container traffic.

The approach does not directly correspond with containerised traffic in terms of TEU but in ton (containerised) because it concerns about commodities, which are transported by containers. What is imported and exported by people are commodities, where containerisation is one method to transport it. Therefore, the forecast is done on the commodities in tons, which are containerised and then converted in terms of TEU by dividing the container traffic in tons by the average weight of commodities per container.

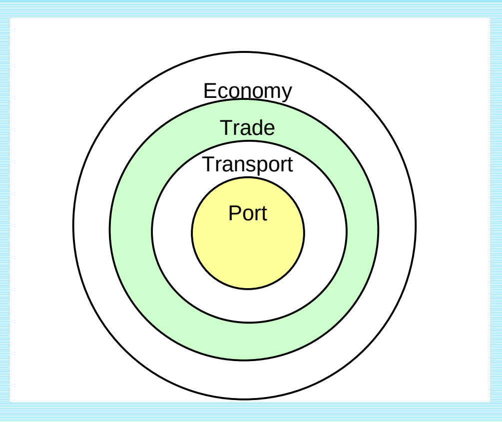


Figure 3.4
Levels of influence to the port

This forecasting method is selected because it is used for long-term forecasts. The forecasting method using *simple growth factor method* for a long-term forecast is not accurate because it does not consider the underlying mechanisms or factors that bring about changes in container traffic. Forecasts of various variables that influence the port (i.e. container terminal) should be used to predict the corresponding changes in container traffic.

3.4 Determinants of container traffic

As mentioned before, three different levels of environment factors influence the port. To know the determinants of containerised traffic, the variables of each sector are examined to both containerised import and export traffic. Furthermore, the variables are also examined in aggregate.

The examination of detail variables for imports and exports is done to know the factors affecting containerised traffic for each segment. Data for container traffic are available for 1994 to 1999 but not for other variables of each sector. They are available for 1994 up to 1998. Therefore, only the data for 1994 – 1998 are used as a base year for creating a model.

This part will be divided into export and import traffic and discusses the factors affecting the volume of containerised traffic for each part, which can be seen from the coefficient of correlation (r) between those variables (For details see Appendix II).

The correlation coefficient, which is symbolised by r, has a range between –1 and 1. If dependent variables increase when independent variables increase, r is positive. If dependent variables decrease when independent variables increase, r is negative. If dependent variables is unaffected by independent variables, then r = 0. When r = -1 or r = 1, a change in the value of independent variables is reflected by a perfectly predictable change in the value of dependent variables, and every point falls on the regression line.

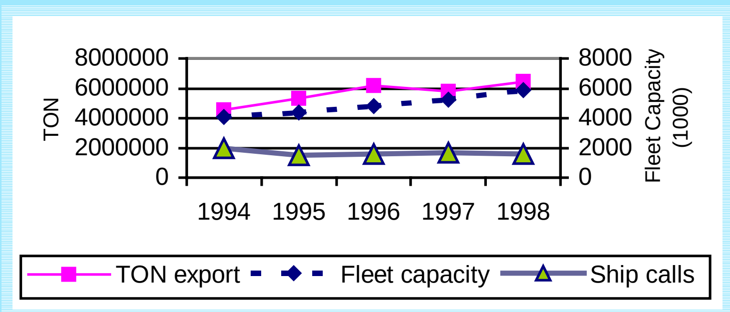
3.4.1 Export traffic

3.4.1.1 Transport sector

Transport is a direct sector influencing a port. The variables examined from the transport sector are ship calls and container shipping fleet capacity. The research identified the strong relationship (see Figure 3.5) between export traffic and the ship calls and the development of container shipping fleet capacity (r=-0.71 and r = 0.87 respectively).

There is a negative relationship between export traffic and the number of ship calls. This implies that the ship coming to the terminal becomes bigger and bigger in its size as ships carry more and more cargo with fewer calls. For the container fleet demands, it can be said that the increase in the container fleet demands reflects the increase of export goods in containers. It also shows that the export goods from the Port of Tanjung Priok (i.e. JICT) are transported more and more in unitised forms such as containers by container vessels. The major part of the export goods, which is containerised, is manufacturing goods. It is true because much of the new manufacturing or industries are located on Java, especially in Jakarta and the surrounding parts of West Java province (see Figure 2.6 Map of the hinterland of the container terminals). Despite Jakarta's congestion and other problems caused by rapid growth, it remains a very attractive location for manufacturers. The city and surrounding villages provide a large supply of labor, and the city roads, airport, and port are the best in the country.

Furthermore, it is believed that the container traffic will always increase in the future as implied from the evolution of world fleet structure where the general cargo ships are declining whilst the container ships are increasing as the demand increases because of the shippers needs. Shippers expect higher quality of services, including guaranteed delivery times, door-to-door services and zero damages. “The world total containerised goods is forecasted in 2001 will be 57.2 million TEUs with the annual forecasted growth rate of 7.1%” (DRI/McGraw-Hill and Mercer Management Consulting, 1997).



Source:
1) Export of Containerised Traffic: Company Record.
2) Fleet Capacity: Ocean Shipping Consultant.

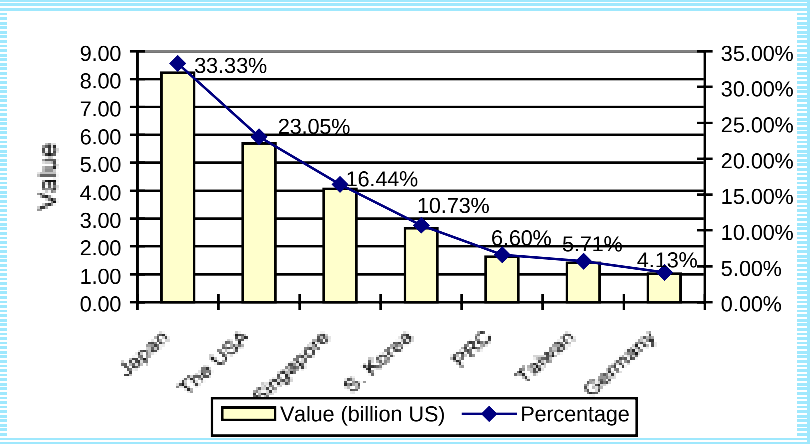
Figure 3.5
Relationship between export of containerised traffic, fleet capacity, & ship calls
(1994 – 1998)

3.4.1.2. Trade sector

Trade is a sector influencing a port beyond the transport sector. The variables examined from the trade sector are foreign trade in value, East Asia trade volume growth, and trade volume change per annum. The research identified a strong relationship between the export traffic and all those variables (r = 0.79; -0.81; -0.72 respectively).

According to a recent publication by ICBS, the export values for the period of January - October 1999, Indonesia has seven main destination countries as follows:

- Japan (USD 8.23 billions)
- The USA (USD 5.69 billions)
- Singapore (USD 4.06 billions)
- South Korea (USD 2.65 billions)
- The People's Republic of China (USD 1.63 billions)
- Taiwan (USD 1.41 billions), and
- Germany (USD 1.02 billions)



Source: Indonesia Central Bureau of Statistics

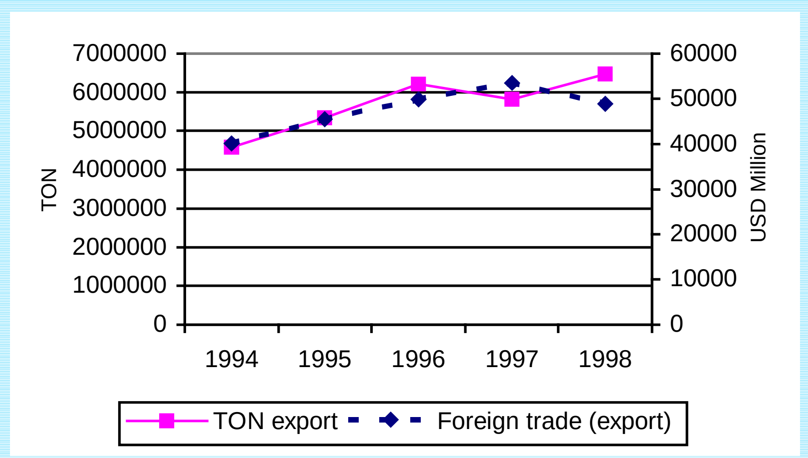
Figure 3.6
Export values and shares of seven main destination countries
(January – October 1999)

Figure 3.6 shows that the market for export goods from Indonesia is mainly to East Asia (72.82% of seven main destination countries).

By commodity groups, the main export goods from Indonesia are manufacturing (USD 21.99 billions), which are mainly transported in containers and primary goods (USD 7.53 billions). It explains why the export of containerised traffic has strong correlation with export value from Indonesia (see Figure 3.7).

As mentioned earlier in Chapter 2, in the 1960s Indonesia manufactured little more than handicrafts and a few textiles, but by the mid-1990s Indonesia was producing manufactured goods that ranged from traditional crafts to aerospace products. Manufacturing in 1997 accounts for 25 percent of the GDP, up from 13 percent in 1980. Labour-intensive consumer exports, such as footwear and glassware, in particular have grown quickly.

Indonesia's main manufactured products include food and beverages, tobacco products, textiles and garments, motor vehicle parts, and electrical appliances. The main manufactured exports include wood products (veneers, plywood, and furniture), textiles, clothing, and footwear. All of these products are transported mainly in containers.

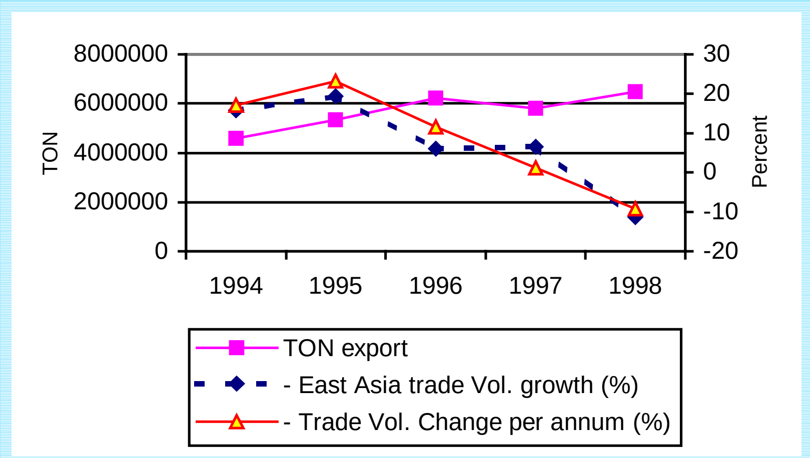


Source:
1) Export of Containerised Traffic: Company Record.
2) Export Trade in Value: Indonesian Central Bureau of Statistics, Ministry of Finance , Ministry of Industy and Trade.

Figure 3.7
Relationships between export of containerised traffic & export trade in values
(1994 – 1998)

Figure 3.7 shows that the traffic is increasing, but in term of value in USD, the trend in 1998 was declining. The only reason is the depreciation in value of local currency (Indonesian Rupiah) to USD where the prices were becoming lower for export goods.

For East Asian trade volume growth and trade volume change per annum, there is a negative correlation with export traffic (see Figure 3.8). It seems that when the East Asian volume growth and trade volume change per annum fell, the export volume from Indonesia was continually increasing. It can be explained that the "Asia's export volume increased marginally, as the strong contraction of intra-Asian trade was only just off-set by a sharp rise in extra-regional flows" (World Bank, 1999). It also shows that probably JICT has performed much better than the other terminals/ports in the region.



Source:
1) Export of Containerised Traffic: Company Record.
2) East Asia Trade Volume Growth and Trade Volume Change per Annum: Ocean Shipping Consultant.

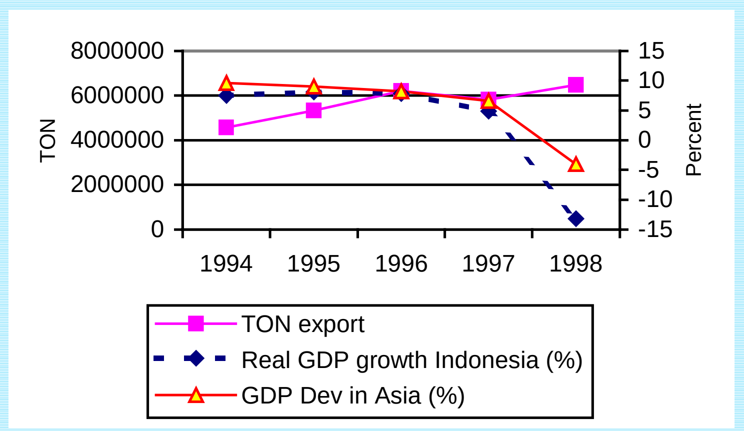
Figure 3.8
Relationships between export of containerised traffic & East Asia trade volume growth and trade volume change per annum
(1994 – 1998)

3.4.1.3 Economy sector

Economy is a sector influencing a port beyond the trade sector. The variables examined from the economy sector are GDP, real GDP growth, average currency rate and GDP development in Asia. The research identified that there are no strong relationships between the export traffic and those variables. However, real GDP growth of the country, average currency rate and GDP development in Asia demonstrate statistical significance (r = -0.61, 0.62, and -0.69 respectively; see Figures 3.9 and 3.10).

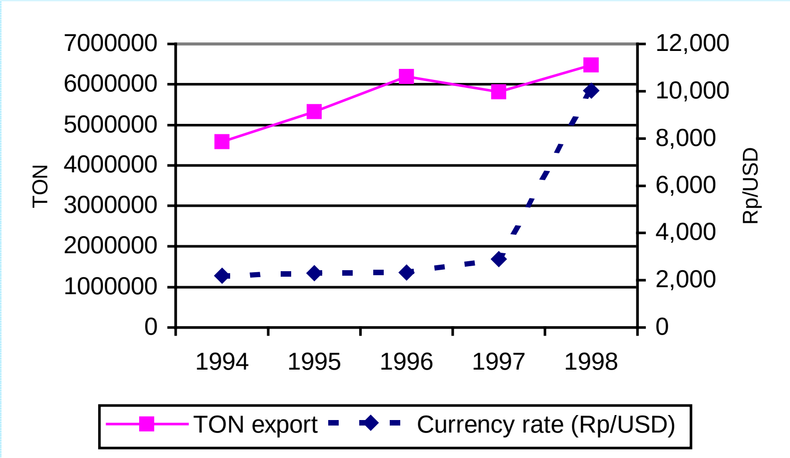
As mentioned in Chapter 2, Indonesia's currency value (Rupiah) sharply weakened in 1998 with a depreciation of about 71% from the 1997 value following the economic crisis, which commenced in mid-1997. As the currency rate fell, Indonesia tried to export as much as possible to increase the GDP of the country.

In addition, between 1991 and 1996, Indonesia experienced the real GDP growth with an average of 8% but in 1997, due to economic crisis in Asia, the growth declined (4.9%) and in 1998 the growth was negative (-13.2%). It shows that when the real GDP growth was lower, Indonesia tried to increase its exports to have higher GDP by increasing the volume of exports. It also indicates that the demand is increasing because the importers from foreign countries benefit from lower prices because of the weakness of the Indonesian currency. They buy products from Indonesia as 'cheap' products.



Source:
1) Export of Containerised Traffic: Company Record.
2) Real GDP Growth: Asian Development Bank
3) GDP Development in Asia: Ocean Shipping Consultant.

Figure 3.9
Relationships between export of containerised traffic & real GDP growth of the country and GDP development in Asia
(1994 – 1998)



Source:
3) Export of Containerised Traffic: Company Record.
4) Currancy rate: Indonesian Central Bureau of Statistics, Bank Indonesia, Ministry of Finance, World Bank, U.S. Department of Commerce (USDOC).

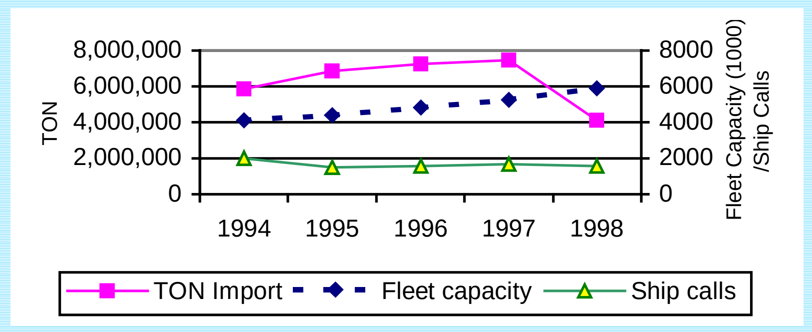
Figure 3.10
Relationships between export of containerised traffic and the value of local currency rate per USD
(1994 – 1998)

3.4.2 Import traffic

3.4.2.1 Transport sector

Transport is a direct sector influencing a port. The variables examined from the transport sector are ship calls and container shipping fleet capacity. The research identified that there is no strong relationship between the import traffic and the number of ship calls and the development of container shipping fleet capacity (r = -0.13 and -0.44 respectively; see Figure 3.11).

It may be concluded that there may be no significant effects between the number of ship calls and the development of container shipping capacity to the import traffic. It implies that probably the import traffic is influenced by other factors such as the economy of the country.

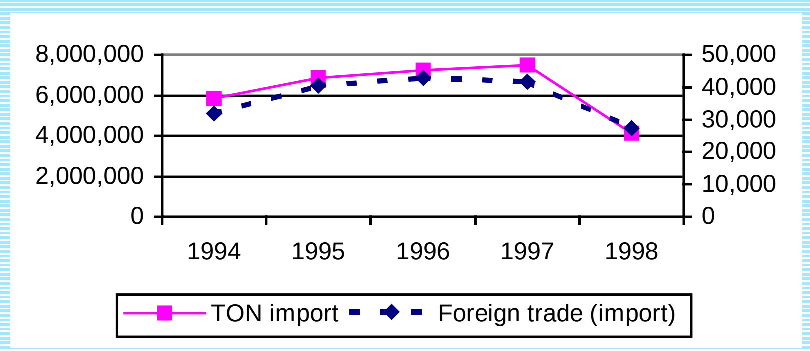


Source:
1) Import of Containerised Traffic & Ship calls: Company Record.
2) Fleet Capacity: Ocean Shipping Consultant.

Figure 3.11
Relationship between import of containerised traffic and fleet capacity and ship calls
(1994 – 1998)

3.4.2.2. Trade sector

Trade is a sector influencing a port beyond the transport sector. The variables examined from the transport sector are foreign trade, East Asian trade volume growth, and trade volume change per annum. The research identified a strong relationship between the import traffic and the import trade in value (r = 0.97; see Figure 3.12) and weak relationships with East Asian trade volume growth and trade volume change per annum (r = -0.39 and 0.42 respectively). It can be said that the decrease or increase of import traffic reflects the decrease or increase of import values.



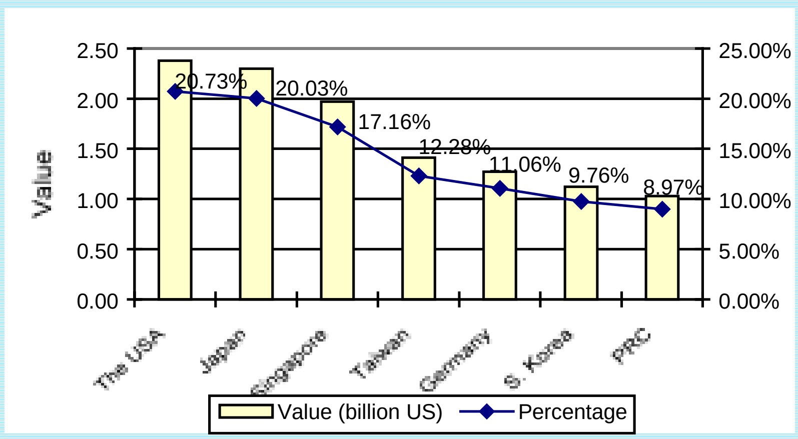
Source:
1) Import of Containerised Traffic: Company Record.
2) Import Trade in Value: Indonesian Central Bureau of Statistics, Ministry of Finance , Ministry of Industy and Trade.

Figure 3.12
Relationships between import of containerised traffic & import trade in value
(1994 – 1998)

According to a recent ICBS publication, for the import values for the period of January - October 1999, Indonesia has seven main countries of origins as follows:

- The USA (USD 2.38 billions)
- Japan (USD 2.30 billions)
- Singapore (USD 1.97 billions)
- Taiwan (USD 1.41 billions)
- Germany (USD 1.27 billions)
- South Korea (USD 1.12 billions)
- The People's Republic of China (USD 1.03 billions)

Figure 3.13 show that the biggest exporter country to Indonesia in terms of import values is the USA. However, the main exporter countries to Indonesia are still from East Asia (68.21% of seven main exporter countries to Indonesia).



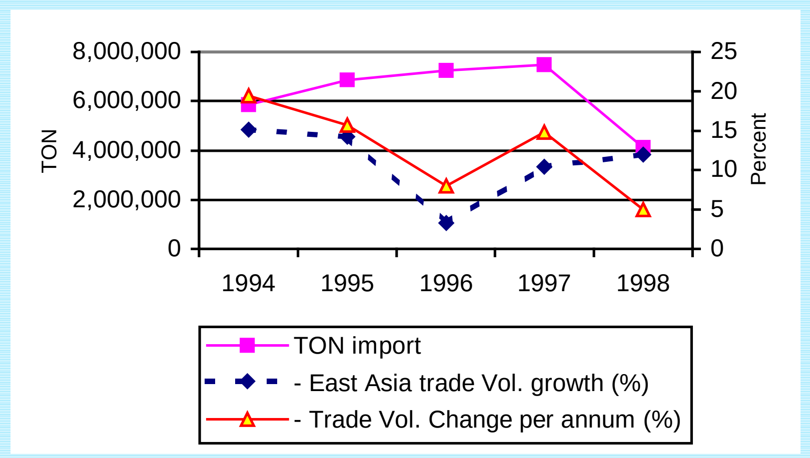
Source: Indonesia Central Bureau of Statistics

Figure 3.13
Import values and percentage of seven main countries of origins
(January – October 1999)

By commodity groups, the most dominant import commodity to Indonesia was manufacturing products (USD 11.75 billions), which are mainly transported in containers. It explains why the import container traffic has a strong correlation with import trade in value from Indonesia. According to the National Trade Data Bank and Economic Bulletin Board-products of STAT-USA, U.S. Department of

Commerce, published in “Indonesia: Economic Trends and Outlook 1999”, the main commodities imported by Indonesia from the USA are: (1) computer systems and peripherals; (2) construction equipment and building materials; (2) franchises; (4) agricultural products, both for consumption and as manufacturing inputs; and (5) electric-power systems.

Regarding East Asian trade volume growth and trade volume change per annum, there are weak relationships with the import traffic (see Figure 3.14).



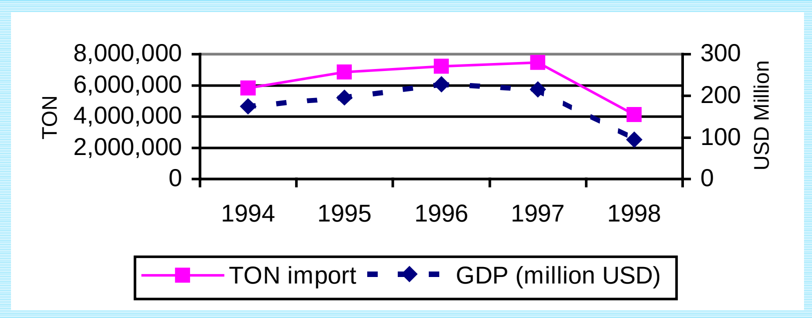
Source:
1) Import of Containerised Traffic: Company Record.
2) East Asia Trade Volume Growth and Trade Volume Change per Annum: Ocean Shipping Consultant.

Figure 3.14
Relationships between import of containerised traffic & East Asia trade volume growth and trade volume change per annum
(1994 – 1998)

3.4.2.3 Economy sector

Economy is a sector influencing a port beyond the trade sector. The variables examined from the economy sector are GDP, real GDP growth, average currency rate and GDP development in Asia. The research identified that there is a strong relationship between the import traffic and those variables (r = 0.98; 0.85; -0.86; and 0.80 respectively).

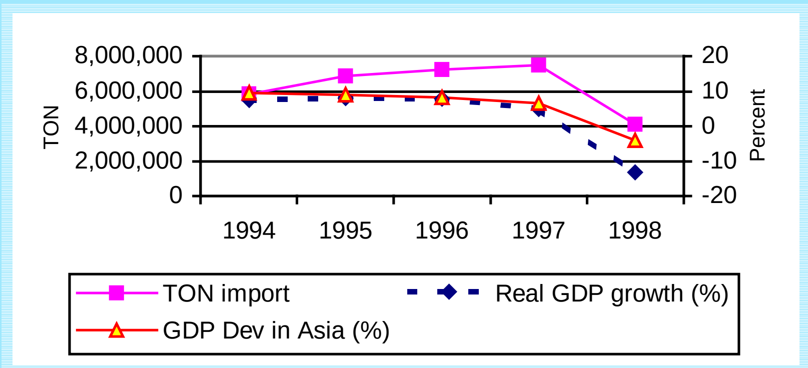
All those variables almost perfectly represent the real mechanism in the economy. For instance, when the GDP of a country is high, people in the country tend to import more from foreign countries and import less when the GDP or their economy is low (see Figure 3.15).



Source:
1) Import of Containerised Traffic: Company Record.
2) GDP: Indonesian Central Bureau of Statistics, Bank Indonesia, Ministry of Finance, World Bank, U.S.Department of Commerce (USDOC).

Figure 3.15
Relationships between import of containerised traffic & GDP of the country
(1994 – 1998)

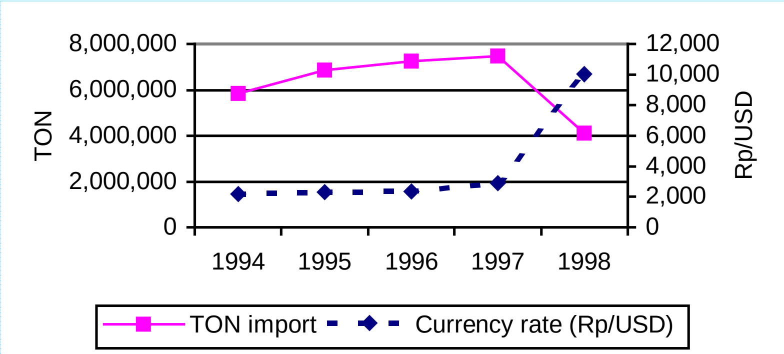
The same mechanism is also true for a wider scope--the GDP development in Asia. The real GDP growth also describes the real mechanism in the economy (see Figure 3.16). For instance, when the real GDP growth is high, the country tends to import more and import less when the growth is low or even negative.



Source:
1) Export of Containerised Traffic: Company Record.
2) Real GDP Growth: Asian Development Bank
3) GDP Development in Asia: Ocean Shipping Consultant.

Figure 3.16
Relationships between import of containerised traffic and real GDP growth of the country and GDP development in Asia
(1994 – 1998)

In addition, it is also true with the currency rate. When the currency rate is weak, the country tends to reduce its imports because the imported goods are too expensive to buy (see Figure 3.17).



Source: Indonesian Central Bureau of Statistics, Bank Indonesia, Ministry of Finance, World Bank, U.S. Department of Commerce (USDOC).

Figure 3.17
Relationships between import of containerised traffic and the value of local currency rate per USD
(1994 – 1998)

3.5 Traffic forecasting model

The traffic forecasting model is built based on aggregate traffic and aggregate variables (not by segments—export and import) because the model gives the best statistical fit to the data (see Table 3.1).

Table 3.1 Regression summary result for the aggregate model*

Regression Summary for Model
03-14-2000 20:43:51 Page: 1 of 1

Variable	Mean	Standard Deviation	Regression Coefficient	Standard Error	t	Prob.> |t|
Traffic	11985309	1434650	Dependent	Variable		
Constant			916889.3	935059.2	.9805682	.430202
Trade	84429.6	10098.65	119.9196	14.77247	8.117775	.014838
GDP	181	52.74941	5214.068	2828.129	1.843646	.2065499

Se = 199047.9 R-square = .99037 R-adjusted = .98075 CPU Seconds = .05468

*) The result is processed by using Quant System 3.0 software.

The author considers variables having medium correlation/stability to be included in the model so it will reduce the bias or increase the validity of the model ($0.35 < r^2 < 0.7$). According to a study by ITC, a variable is considered as having a high trend stability if it has $r^2 > 0.7$, a medium trend stability if it has $0.35 < r^2 < 0.7$, a low trend stability if it has $r^2 < 0.35$.

Having examined those variables, it is clear that variable trade and GDP has a strong correlation with the growth of containerised traffic. To build a model, those strong variables are again examined by multiple regression to see its effects on container traffic simultaneously. The final multiple regression formula is the model for container traffic. In formula, the container traffic model can be written as follows:

Containerised Traffic = 916,889.3 + 119.9196 Trade + 5,214.068 GDP

With r^2 adjusted = 0.98075 (see Table 3.1)

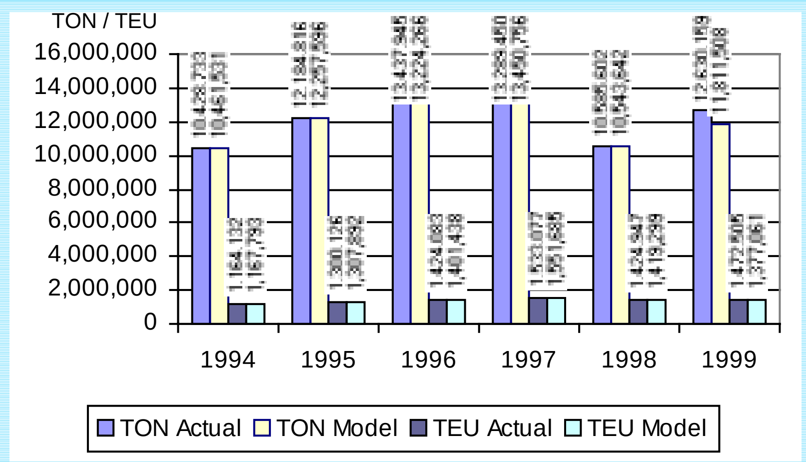
<u>Where:</u>

- Containerised traffic = Total tonnage which is containerised;
- Trade = Total containerised trade in value terms (in million USD);
- GDP = GDP of Indonesia (in billion USD);

Based on the model, the containerised traffic is estimated to be 119.9196 times the total trade (in million USD) plus 5,214.068 times GDP (in billion USD) plus a constant of 916,889.3. This model has a very good explanatory power with an adjusted r^2 of 0.98075. *(*r^2 is the coefficient of determination, a statistical measure of the "explained" variation in the data as a percentage of the total variation in the data. Values for r^2 range from 0 to 1.00 so that for a simple regression model with only one explanatory variable, all the data lie on the regression line when r^2 equals 1.00—that is, there are no unexplained variations in the data. Adjusted r^2 is a measure that takes into account how many explanatory variables are used in the regression model). Based on its high-adjusted r^2, the regression confirms that total trade and GDP of the country is very meaningful to forecast the containerised traffic for the current year.

3.6 Model validation

Model validation is accomplished by comparing base year aggregate containerised traffic and forecasted containerised traffic predicted by the model. From Figure 3.18, it can be said that the model is quite good in representing the real world although in 1999 the result was slightly different. This is due to the 1999 trade and GDP figures, which are still very roughly estimated. It is also true for the containerised traffic in terms of TEU. It can be concluded that the model is ***valid to forecast*** the containerised traffic in the future. Therefore, the author will use this model to forecast the containerised traffic for the next ten years (year 2000 up to 2009) with three scenarios.



Source: Prepared by the author. 1999 trade and GDP figures are derived from internet: http://www.tdctrade.com/mktprof/asia/mpido.htm (24 July 2000)

Figure 3.18
Comparison of containerised traffic (in Ton & TEU) actual v.s. model
(1994 – 1999)

3.7 Scenarios

Any forecast of future trade might be uncertain. It is hoped that the actual traffic level is closer to the central forecast than to the upper or lower forecast. So there is a risk of variation between actual and forecast traffic. To minimise this risk, we sets of different scenarios describing alternatives are needed. The author has taken the scenarios based on the factors composing the containerised traffic model, i.e. the trade and GDP of the country.

For this study, the author will make three economic and trade scenarios based on the historical data. The first scenario is assumed as favourable economic developments (high growth). The second scenario is assumed as moderate economic developments (average growth). Finally, the third scenario is assumed as the unfavourable economic developments (low growth) (see Table 3.2). Those three scenarios are defined as follows:

- *Favourable economy:* The economic situation where the economic growth is assumed to be always increasing as can be seen from the annual GDP growth trends between 1994 and 1996 (see figure 2.1) when the GDP growth was influenced by the growth of manufacturing industries in the country.

> Especially in relation with manufacturing, the role of exports is often in the discussions of Asian economies. As with other countries in the region, the growing exports was an important component of Indonesia's economic success and certainly one reason for the rapid growth of its manufacturing sector (Embassy of the US in Jakarta, 1999).

- *Moderate economy:* The economic situation where the economic growth is assumed to be an average growth before the economic crisis (between year 1994 and 1996) and to continue with the same growth as the average one.

- *Unfavourable economy:* The economic situation where the economic growth is assumed to be a very slow economic growth as an effect of the banking and debt problems continuing. As mentioned in recent economic reports, "there is a little prospect that strong growth will return until there is much progress on resolve the banking and debt problems and other sectors that contributed substantially to growth in the past" (Embassy of the US in Jakarta, 1999).

The annual GDP growth range is between 10% to 16% or, in other words, with the inflation level of 4% to 6%, the annual real GDP growth lies between 6% to 10%.

Table 3.2
Economic scenarios based on historical data

Scenario 1 Favourable Economy	Scenario 2 Moderate Economy	Scenario3 Unfavourable Economy
▪ Annual GDP growth by 15.80% per year ▪ Trade annual growth in value by 18.69%	▪ Annual GDP growth by 13,33% per year ▪ Trade growth in value by 12,60%	▪ Annual GDP growth by 10,86% per year ▪ Trade growth in value by 6,51%

Note: The growth is calculated based on the annual growth before economic crisis (between 1994 and 1996) with 68% confidence.

The growth in the scenario above is based on the statistical calculation with a normal distribution. For examples, the probability of the country having the trade growth of 2.58% as in year 1997 is small (only 5%). Another example, which is extreme, the probability of the country having a trade growth of –19.92% as in 1998 is very small (0.0000047%). In this case, the probability of the country facing economic crisis is very small. It also means that the economic crisis is an unusual or rare event, which happened in the country.

3.8 Container traffic forecasts

Based on the model formed in the previous paragraph, the container traffic forecasts for the next ten years are figured out in Table 3.3 and the comparison between actual and forecasted traffic can be seen in Figure 3.18.

Table 3.3
Container traffic forecasts for year 2000 – 2009

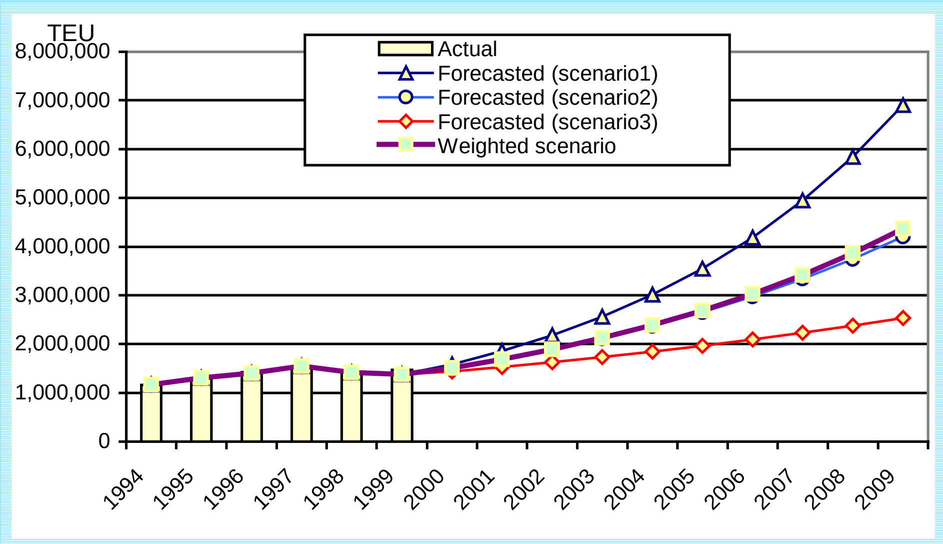
(1000 TEUs)

Container Traffic	2000	2001	2002	2003	2004
Scenario 1	1,581.58	1,854.33	2,177.55	2,560.59	3,014.53
Scenario 2	1,509.16	1,686.90	1,887.14	2,112.73	2,366.88
Scenario 3	1,436.75	1,528.12	1,625.94	1,730.69	1,842.89
Weighted scenario	1,509.16	1,688.29	1,891.81	2,123.26	2,386.66
Container Traffic	**2005**	**2006**	**2007**	**2008**	**2009**
Scenario 1	3,552.52	4,190.14	4,945.86	5,841.60	6,903.33
Scenario 2	2,653.21	2,975.79	3,339.22	3,748.66	4,209.95
Scenario 3	1,963.07	2,091.85	2,229.85	2,377.78	2,536.39
Weighted scenario	2,686.68	3,028.65	3,418.78	3,864.19	4,373.12

Source: Prepared by the author.

In addition, it is necessary to consider the weighted scenario of the forecasted traffic as the data used for further calculation of the equipment plan, so a single figure of forecasted traffic is obtained to calculate the equipment plan.

Based on the normal distribution, the likely outcome (scenario 2) has a probability of 68% and the favourable and unfavourable outcomes (scenario 1 and 3) have the probability of 16% each. Then, those probabilities are used to calculate the weighted scenario of forecasted traffic. The figures are shown in Figure 3.19.



Source: Prepared by the author.

Figure 3.19
Container traffic actual (1994 – 1999) and forecasted (2000 – 2009) in TEU

The figure shows that the weighted scenario is relatively close to or slightly higher than scenario 2. This is clear because the likely outcome (scenario 2) has a much higher probability to happen compared with scenarios 1 and 3. The weighted-scenario seems realistic because it has an average growth of forecasted container traffic of 12.6%. It means that the container traffic forecasts derived from the model follows the actual container traffic growth (i.e. the average growth of 11.9% between 1992 and 1999 or 13.9% between 1991 and 1999).

Finally, to be applied into the mathematical model for optimum equipment plan, this data then is converted to the number of container movements based on the historical data. The number of container movement calculation is figured out in Appendix 3.

3.9 Analysis of the forecast results

The aggregate model of the traffic forecasts has shown a very good representation of the actual aggregate traffic (see Figure 3.17). In practice, it is important to follow the difference between the actual and the forecasted value as to allow the company to adjust its equipment plan. With every additional year of data, new forecasts can be prepared with the existing model or the model can be re-calibrated and then the forecasts can be prepared.

In addition, the accuracy of the forecasts of the model still depends on the accuracy of the economic scenarios. If economic scenarios are assumed to be accurate, the traffic-forecast result is probably accurate because the coefficient of determination (adjusted r^2) is equal 0.98 or nearly 1. It means that 98% of the variation on the total traffic can be explained as a result of the total trade and GDP of the country. However, it is necessary to emphasis that "no matter which forecasting method is employed, the results will always suffer from a high degree of uncertainty" (UNCTAD, 1995, p. 87).

CHAPTER 4
Container handling equipment planning

"This chapter describes process of determining optimum container handling equipment planning, its mathematical model, analyses its results, and discusses them"

4.1 Mathematical modelling framework

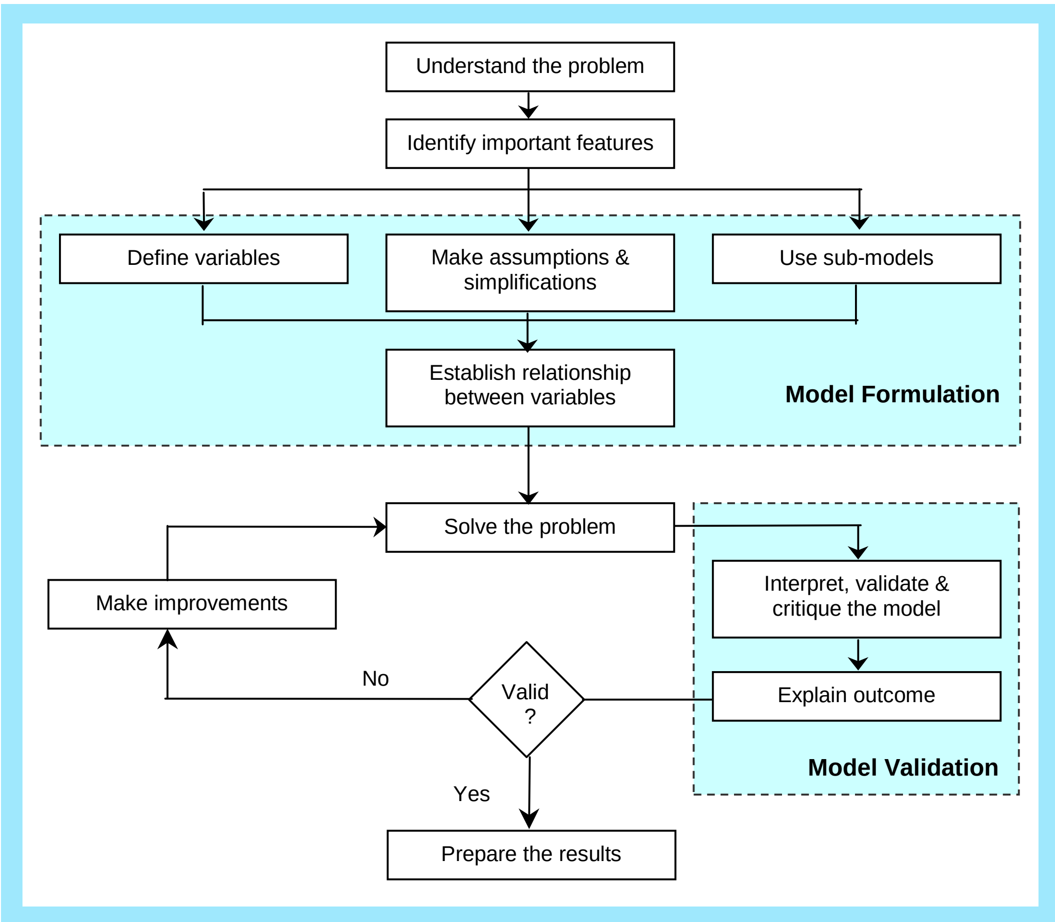


Figure 4.1 The mathematical modeling framework

The mathematical modeling framework is described to show how the model is built to represent the real problem. The model is built based on the real situation and the relationships between variables, which constitute the model. Based on this model, the optimum equipment plan for each year is then derived from the result of the model with different scenarios.

4.2 The problem solving approach

4.2.1 Key concept

Optimal resource allocation is one of the major problems of economics. Given limited resources and virtually unlimited wants, how can resources be optimize by the utility? The technique of linear programming (LP) has made an important contribution towards solving this problem. Slater and Ascroft (1990, p.306), define a linear programming as follows.

> Linear Programming is a mathematical technique which yields the optimum solution to problems defined by a linear objective function subject to a set of linear constraints. Mathematically, the problem of linear programming may be stated as one of the optimizing (maximizing or minimizing) a linear objective function of the following form.

Max (or Min): $Z = C_1X_1 + C_2X_2 + ….. + C_nX_n$

Subject to:

$$a_{11}X_1 + a_{12}X_2 + … + a_{1n}X_n \leq B_1$$
$$a_{21}X_1 + a_{22}X_2 + … + a_{2n}X_n \leq B_2$$
$$…….$$
$$a_{m1}X1 + a_{m2}X_2 + … + a_{mn}X_n \leq B_m$$

and $X_j \geq 0 \ (j = 1, …., n)$

where C_j, a_{ij}, and B_j are all constants.

Proportionality, non-negativity, accountability for resources, and decision criterion are the assumptions behind linear programming. *Integer linear programming (ILP)* may have to be used if divisibility of products and projects, implied by the use of LP, may not be realistic. For example: number of equipment, frequency, and vice versa.

4.2.2 Understanding the problem

Generally speaking, container handling equipment is practically divided into three areas: ship to shore equipment, shore-based handling equipment and handling equipment in the container yard. The problem solved by the model is for ship-to-shore equipment (i.e. container cranes) as a base. For other types of equipment, such as RTGs, tractors/head trucks, they are calculated based on the proportion of the equipment against the container cranes applied by JICT after considering the peak factor that is the ratio of container crane : RTG : tractor/head truck = 1 : 4 : 7. If the result from the model shows that the container cranes needed for a particular year is six units, twenty four units of RTGs and fourty-two units tractors/head trucks are needed. Then, when regarding equipment in the mathematical model, it means the model for calculating the container crane needs.

The equipment decision taken can be investment in a number of new types of equipment, expansion of existing stock of equipment and equipment replacement. This is summarised in Table 4.1.

Table 4.1
Decisions on equipment

Decisions	Variables	Causes
Investment in new types of equipment	Types, units, buy or not, when	Build a new terminal, future traffic demand
Expansion of existing stock of equipment	Types, units, when	Future traffic demand
Equipment replacement	Sale, redeployment, scrapping	Physical failure, reduce efficiency, obsolence

The problem is by the increasing in future container traffic and the existing stock of equipment, how many new types of equipment are needed and when or how many similar pieces of equipment with existing equipment are needed and when or does the existing equipment need to be replaced and when and how many new pieces of equipment are needed. All these possibilities will be tried to be solved by using a mathematical method so the number of equipment needed under those categories can can give a result.

4.3 A mathematical model

4.3.1 Model formulation

A few assumptions are made to formulate this model. The assumptions are:

- spare parts and equipment are available at certain level all the time;
- capital budgets are available all the time;
- maintenance is done properly to provide the availability on average, more than 90%, although as a consequence of the old equipment the maintenance costs will increase considerably;

The limiting factor in this problem is the number of existing equipment, i.e. CCs. For each individual of existing CCs, they can not be more than one each. However, for new equipment, more than one piece of equipment can be purchased.

The company has various options, including retaining existing equipment, whether owned equipment or hire-purchase, purchasing new equipment, whether the same type as the existing equipment or new types, or hire-purchasing new equipment, whether the same type as the existing or new types. What should be done is to present a recommended configuration of the equipment to meet projected handling demands. The decision is *the lowest total annual costs and capital costs configuration*. Any configuration of equipment recommended is capable of meeting the projected daily demand of container movements.

4.3.1.1 Variables

In order to solve this problem, the decision to be made should be related to the following variables:

- *Existing equipment*

  There are 12 container cranes at present, nine of which are owned by JICT and three of them are leased from outside companies. Owned equipment is symbolised as E_1, E_2, ..., E_9 and hire-purchased equipment as E_{10}, ..., E_{12}. Since the existing equipment is still in its economic life (during the planning period up to 2009), it is assumed that all the existing pieces of equipment are retained.

- *New types of equipment*

  It is proposed to have one new type of equipment with different specification compared with the existing equipment to be considered i.e. type A, which is symbolised as E_{13}. Type A is defined as a container crane with outreach 40 m, maximum lift 40 Ton and handling rate of 30 - 36 containers/hour (Post Panamax) with price of US$ 6 million (or 6.78 million US$ including erection and transportation costs).

  Note:

  Prices are compiled by the UNCTAD Secretariat based on 1996 manufacturers prices.

  Type A is considered because JICT has had direct call services for bigger ships such as Grand Alliance ships to Nothern Europe. As stated by Simon Moore, President Director of JICT, "We believe Tanjung Priok and JICT are now ready to handle Grand Alliance vessels and we can promote Jakarta to be the hub to transship from and to other Indonesian ports" (Journal of Commerce, July 2000).

So, in the general model, the equipment is E_i (i = 1, 2, ..., 13).

For every equipment, there are three options: retain, buy new one, or hire-purchase. But since there is no costs data available for hire-purchase equipment of new equipment, this option is eliminated and therefore only two options are used in the model. In such a case, the hire-purchase option will be considered after the optimum result is achieved by knowing the annual total costs of particular new equipment, which is selected. The option hire-purchase is then accepted if the offer is lower or equal to the annual costs of that particular equipment. This will be discussed in Chapter 5.

Next, supposing those options i.e. retain, and buy new one as j = 1, 2, the variables for the model can be simplified by combining them. So, now there is equipment $E_{i,j}$. For example:

- $E_{1,2}$ means buying new equipment with the same type as equipment 1.
- $E_{10,1}$ means retaining the hire-purchase of equipment 10.

The variables focused on achieving the optimum solution are the number of equipment needed for each type or category of equipment. If buying new equipment with the same type of the old equipment (Pre-Panamax cranes) is not considered, then the number of the equipment for that type of equipment is put on the model as zero.

4.3.1.2 Constraints

The constraints considered for the model are as follows:

- *Daily demand of particular year (D)*

  Daily demand is derived from yearly forecasted container movements divided by 365 days. Hence:

$$\sum_{i=1}^{13}\sum_{j=1}^{2} h_{ij} \times \mu \times E_{ij} \leq D$$

  Where:

  h_{ij} = handling rates of equipment *i* options *j* (movements per hour).

  E_{ij} = number of equipment needed for equipment *i* options *j* (units).

- *Utilisation of equipment (μ)*

  Utilisation of the equipment has a limit. It should not exceeds maximum allowed Berth Occupany Ratio (BOR). In this case, the terminals have six berths and, therefore, the maximum BOR is 73.75% (interpolated according to table 3 of UNCTAD publication and maximum acceptable waiting time per service time (Wt/St) = 10%).

  ”The evidence from European operators, most of their cranes record a utilisation of 30–60%” (UNCTAD, 1986a, p.18). However, according to a Containerization International survey, ”a worldwide gantry cranes reveal a utilisation of about 25%” (UNCTAD, 1986a, p.18). This low figure is caused by the peaking factor where on some days, all berths are occupied and all cranes in operation but on other days, the berths may be empty. However, for planning purposes it is necessary to simulate the model by applying the utilisation of 35%, 40%, 45%, and 50% as a reasonable maximum limit.

μ *35%* = 8.4 hours per day or 3,066 hours per year
μ 40%= 9.6 hours per day or 3,504 hours per year
μ 45%= 10.8 hours per day or 3,942 hours per year
μ *50%*= 12 hours per day or 4,380 hours per year

- *Maximum number of equipment*

  As mentioned before, only one piece of equipment is retained for each existing equipment but it can be more than one for buying and hire-purchasing equipment with the same type of the existing equipment. On the other hand, it can be more than one piece of equipment for all options of the new type of equipment.

$$E_{1,1};\ E_{2,1};\ \ldots;\ E_{12,1} = 1$$
$$E_{i,2} \geq 1$$

4.3.1.3 Objective Function

For each equipment there is capital cost and operating costs. Both, existing and new piece of equipment has their own economic life. For new equipment the capital cost is its price in the current situation, while for existing owned-equipment, the capital cost is considered to be the market value of the equipment at the current time.

In addition, for both, operating costs are increasing as time goes by. The performance will probably fall, the machine will become more unreliable, and to provide high availability will be more costly.

To determine the economic life of equipment, the calculation of the discounted value of all future costs associated is needed. The costs to be included are all the costs that depend on the age of the equipment such as maintenance and running costs. Costs do not change with the age of the equipment such as labour costs and power; this, should not be included. The costs are incurred over period of time, and must be discounted to present value.

In this study, the increase in operating costs for new equipment are assumed to be 3% for the first 5 year and increase 1% every 5 years afterwards. The initial operating costs vary based on historical data in the company. This principle is applied both for existing and new equipment. "For economic life calculations the assumptions is made that the costs increase each year for items of equipment that deteriorate because of increased maintenance" (UNCTAD, 1990b, p.9). Furthermore, according to UNCTAD (1990b, p.9),

> the following rules apply for minimizing costs:
>
> - **Rule 1**: If the cost of replacing every *n + 1* years is less than the cost of replacing every *n* years, the item should not be replaced.
> - **Rule 2**: If the cost of replacing every *n + 1* years is greater than the cost of replacing every *n* years, the item should be replaced.

The objective function of the model is based on this principle, i.e. as long as the equipment used is still in its economic life period, the Equivalent Uniform Annual Cost (EUAC) or Capital Recovery Cost or annual total costs (T_{ij}) is uniform at the minimum. It is assumed that the equipment is used until it reaches its economic life. After exceeding its economic life, the EUAC is increased continually. Therefore, to minimise the costs, the objective function is given by :

$$\left\{ \sum_{i=1}^{13}\sum_{j=1}^{2}(T_{ij} \times E_{ij}) + \sum_{i=1}^{13}\sum_{j=1}^{2}(C_{ij} \times E_{ij}) \right\}$$

Where:

T_{ij} = Annual total costs of equipment i option j.

C_{ij} = Capital cost of equipment i option j.

Hence the formulation is complete.

4.3.2 Data needed to use the model

4.3.2.1 Handling rate

The handling rate of container cranes is varied. Logically, for old equipment, the handling rate is lower than the newer equipment.

Table 4.2
Handling rate of equipment (container cranes)

Equipment		Handling Rate (container moves per hour)	
		Standard	**Actual**
Existing	CC-02A	25	20
	CC-02	25	20
	CC-03	25	20
	CC-01	25	20
	CC-04	30	25
	CC-05	30	25
	CC-06	30	25
	CC-07	30	25
	CC-08	30	25
	Hire-purchase 1	N/A	14
	Hire-purchase 2	N/A	22
	Hire-purchase 3	N/A	22
New	Type A	36	30

Source:
- Existing equipment: Data, Information and Marketing Department, Tanjung Priok Branch 1996
- New equipment: UNCTAD

4.3.2.2 Daily demand for handling operations in quay side

The daily demand of handling operations in quay side is derived from annual demand divided by the number of days a year (i.e. 365 days). The daily demand in container moves of the equipment is shown in Table 4.3.

Table 4.3
Daily demand of container moves

Year	Container moves
2000	2,819
2001	3,153
2002	3,534
2003	3,966
2004	4,458
2005	5,018
2006	5,657
2007	6,386
2008	7,218
2009	8,168

Source: Appendix 3

4.3.2.3 Total annual costs

Total annual costs are the sum of annual capital recovery costs and annual operating costs. The costs calculated are the costs for existing equipment, new equipment with the same type of the existing equipment and new equipment of the new type of equipment, and hire-purchase equipment. New equipment with the same type of existing equipment is considered only for the Panamax cranes because, nowadays, Pre-Panamax cranes are out of date with the currrent situation. Therefore, to buy new equipment with the same type as CC-02A, CC-01, CC-02, and CC-03 is not considered anymore.

For hire-purchase equipment, the situation is different. The three hire-purchase pieces of equipment are two Panamax cranes hired for five years starting in 1996 (Hire purchase 2 and 3) and one Pre-Panamax crane hired for five years starting in 1997 (Hire purchase 1). The terminal is not responsible for maintenance and running costs of the equipment. Therefore, after five years they become the possession of the terminal. The hire cost is based on the type and conditions of the containers. The cost for 40' container is 49 USD for full containers and 44 USD for empty containers. Similarly, the cost for 20' container is 31 USD for full containers and 28 USD for empty containers. The total annual costs are calculated based on these figures. However, it is assumed that the cranes are handling these containers with certain proportion of different types of containers (in this case 1999 proportion is used) and the utilisation of 30% or 2,628 hours per year. Then, the total annual costs are calculated by weighted average costs based on the 1999 proportion multiplied by number of moves per year. The calculation of weighted average cost per moves is as follows:

20' container full:	46%	X 31 USD =	14.1 USD
20' container empty:	6%	X 28 USD =	1.7 USD
40' container full:	40%	X 49 USD =	19.6 USD
40' container empty:	8%	X 44 USD =	3.6 USD
Weighted costs per moves	**100%**		**39.1 USD**

For example: The total annual costs for equipment hire purchase 1.

Total annual costs= utilisation hours x handling rate per hour x 39.1 USD

= 2,628 x 14 x 39.1

= 1,434,888 USD per year for 5 years.

The same calculation method is applied for the other two hire purchase equipment. After 5 years, because the equipment is becoming the possession of the terminal, the operating costs become the responsibility of the terminal. Then, the operating costs pattern after the cranes are transferred to the terminal is assumed to be the same as for other cranes (see Appendix 4). The summary of total annual costs of equipment is summarised in Table 4.4.

Table 4.4
Total annual costs

Equipment	Register (variables)	Total Annual Costs**
I. Existing*		
Pre-Panamax	CC-02A ($X_{1,1}$)	334,987
	CC-02 ($X_{2,1}$)	455,010
	CC-03 ($X_{3,1}$)	462,405
	CC-01 ($X_{4,1}$)	411,331
	Hire-purchase 1 ($X_{10,1}$)	786,188
Panamax	CC-04 ($X_{5,1}$)	569,279
	CC-05 ($X_{6,1}$)	619,959
	CC-06 ($X_{7,1}$)	610,064
	CC-07 ($X_{8,1}$)	617,335
	CC-08 ($X_{9,1}$)	616,743
	Hire-purchase 2 ($X_{11,1}$)	1,065,900
	Hire-purchase 3 ($X_{12,1}$)	1,065,900
II. New types		
Post-Panamax	Type A ($X_{13,2}$)	927,320
III. New as existing***		
CC-04, 05, 06	($X_{567,1}$)	599,767
CC-07, 08	($X_{89,1}$)	617,039

Source: Appendix 4
Note:
*) Existing, including retrofit
**) Including maintenance and running costs
***) The average costs of a group of equipment

4.3.2.4 Capital costs of the equipment

Capital costs is the costs for buying one new piece of equipment (i.e. price of the equipment + installment costs). It is assumed that the price of a new Panamax is 5,650,000 USD and that of a Post Panamax is 6,780,000 USD (1996 prices, UNCTAD Secretariat).

4.4 The solution

The solution is derived from the calculation resulting from the Quant System software. The result is the optimum result considering the minimum total annual costs of the equipment combined with minimum capital costs. Following is an example of the mathematical model for calculating the optimum equipment plan with the assumption that the average utilisation of equipment is 35% for year 2000.

Objective function: min: {(Total annual costs) + (capital costs)}

{(334,987$X_{1,1}$ + 455,010$X_{2,1}$ + 462,405$X_{3,1}$ + 411,331$X_{4,1}$ + 569,279$X_{5,1}$ + 619,959$X_{6,1}$ + 610,064$X_{7,1}$ + 617,335$X_{8,1}$ + 616,743$X_{9,1}$ + 786,188$X_{10,1}$ + 1,065,900$X_{11,1}$ + 1,065,900$X_{12,1}$ + 0$X_{13,1}$ + 334,987$X_{1,2}$ + 455,010$X_{2,2}$ + 462,405$X_{3,2}$ + 411,331$X_{4,2}$ + 599,767$X_{567,2}$ + 617,039$X_{89,2}$ + 786,188$X_{10,2}$ + 1,065,900$X_{11,2}$ + 1,065,900$X_{12,2}$ + 927,320$X_{13,2}$) + (0$X_{1,2}$ + 0$X_{2,2}$ + 0$X_{3,2}$ + 0$X_{4,2}$ + 5,650,000$X_{567,2}$ + 5,650,000$X_{89,2}$ +0$X_{10,2}$ + 0$X_{11,2}$ + 0$X_{12,2}$ + 6,780,000$X_{13,2}$)}

Constraints:

Daily demand:

1) 168$X_{1,1}$ + 168$X_{2,1}$ + 168$X_{3,1}$ + 168$X_{4,1}$ + 210$X_{5,1}$ + 210$X_{6,1}$ + 210$X_{7,1}$ + 210$X_{8,1}$ + 210$X_{9,1}$ + 118$X_{10,1}$ + 185$X_{11,1}$ + 185$X_{12,1}$ + 0$X_{13,1}$ + 168$X_{1,2}$ + 168$X_{2,2}$ + 168$X_{3,2}$ + 168$X_{4,2}$ + 210$X_{567,2}$ + 210$X_{89,2}$ + 118$X_{10,2}$ + 185$X_{11,2}$ + 185$X_{12,2}$ + 252$X_{13,2}$ $\geq$ **2,819**

Maximum number of existing equipment:

2) $X_{1,1}$ **= 1**
3) $X_{2,1}$ **= 1**
4) $X_{3,1}$ **= 1**
5) $X_{4,1}$ **= 1**
6) $X_{5,1}$ **= 1**
7) $X_{6,1}$ **= 1**
8) $X_{7,1}$ **= 1**
9) $X_{8,1}$ **= 1**
10) $X_{9,1}$ **= 1**
11) $X_{10,1}$ **= 1**
12) $X_{11,1}$ **= 1**
13) $X_{12,1}$ **= 1**
14) $X_{1,2}$ **= 0** (Buying new equipment is not considered to this option/Pre-Panamax)
15) $X_{2,2}$ **= 0** (Buying new equipment is not considered to this option/Pre-Panamax)
16) $X_{3,2}$ **= 0** (Buying new equipment is not considered to this option/Pre-Panamax)
17) $X_{4,2}$ **= 0** (Buying new equipment is not considered to this option/Pre-Panamax)
18) $X_{10,2}$ **= 0** (New hire-purchase option for this type is not considered anymore)
19) $X_{11,2}$ **= 0** (New hire-purchase option for this type is not considered anymore)
20) $X_{12,2}$ **= 0** (New hire-purchase option for this type is not considered anymore)

This process is then iterated year by year up to the year 2009. The same process is also applied to other utilisation scenarios. The optimum configuration of new container cranes and investments needed are summarised in Table 4.5.

Table 4.5
Number of new container cranes needed and its investments

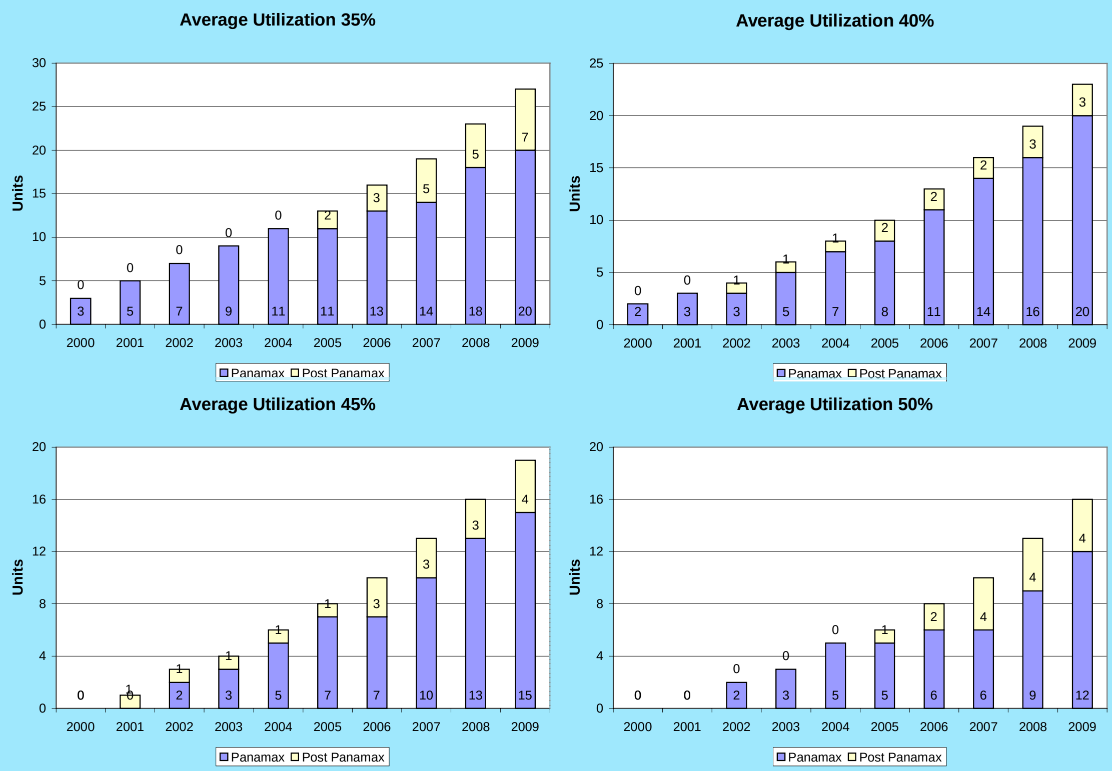
Year	Utilisation Level											
	35%			40%			45%			50%		
	P	PP	Invest.	P	PP	Invest.	P	PP	Invest.	P	PP	Invest.
2000	3	0	16.95	2	0	11.30	0	0	-	0	0	-
2001	5	0	28.25	3	0	16.95	0	1	6.78	0	0	-
2002	7	0	39.55	3	1	23.73	2	1	18.08	2	0	11.30
2003	9	0	50.85	5	1	35.03	3	1	23.73	3	0	16.95
2004	11	0	62.15	7	1	46.33	5	1	35.03	5	0	28.25
2005	11	2	75.71	8	2	58.76	7	1	46.33	5	1	35.03
2006	13	3	93.79	11	2	75.71	7	3	59.89	6	2	47.46
2007	14	5	113.00	14	2	92.66	10	3	76.84	6	4	61.02
2008	18	5	135.60	16	3	110.74	13	3	93.79	9	4	77.97
2009	20	7	160.46	20	3	133.34	15	4	111.87	12	4	94.92

Source: Appendix 5. For investment, prepared by the author (calculated).
Note:
P= Panamax type (Noell manufacturer)
PP= Post-Panamax type
Invest.= Accumulated investment needed (in million USD).

Table 4.5 can be interpreted in various ways:

1. If the container cranes (existing and new) are planned to be utilised by 40%, 2 new Panamax cranes and 11.3 million USD of investment are needed to cope with the traffic in 2000; or
2. If the company has limited resources i.e. a budget of 10 million USD for container cranes in 2001, to be able to cope with the traffic, the company needs to buy one new Post-Panamax crane and all container cranes (existing and new) should be utilised by 45%; or
3. If the company does not have budgets for buying container cranes in 2001, the existing equipment should be utilised by 50% and vice versa.

The comparison of the number of container cranes needed for different utilisation levels is shown in Figure 4.2.



Source: Appendix 5.

Figure 4.2
The comparison of number of container cranes needed with different utilisation scenarios

4.5 The optimum equipment plan and acquisition policy

The completion of the optimum equipment plan is calculated on the basis of the ratio applied by JICT after considering the *Peak Factor* that is CC: RTG: tractor/head truck = 1: 4: 7. This ratio is higher compared with the ratio introduced by UNCTAD that is 2: 3: 10. However, this ratio has not yet been considered the peaking factor. For chassis, as applied in JICT, the ratio between tractor-trailers sets: chassis (single deck) is 1: 1.2. For forklift diesel, which is used to handle the LCL containers in CFS, the ratio used between CC: forklift diesel = 1: 1 (UNCTAD, 1986a, p. 60). This is quite reasonable since the LCL containers are only about 0.2% – 0.3% of the total containers throughput between 1998 and 1999.

The optimum equipment plan has also reviewed the performance, age and condition, to determine which assets should be replaced or disposed during the planning period. As mentioned before, for container cranes, all existing equipment is still in its economic life during the planning period i.e. upto 2009. The economic life of other pieces of equipment is assumed to be 20 years for RTG and 15 years for tractor/head truck, chassis, and forklift diesel. The complete optimum equipment plan and acquisition policy is described in Appendix 6.

4.6 Summary

The equipment plan model (specifically for container cranes) is made as *a tool* for the management to calculate the optimum equipment plan that can meet the cargo handling demands with the lowest total annual costs and capital costs configuration. Compared ith a traditional way of calculating an ipment plan i.e. by dividing the daily handling demand with the average handling rate multiplied utilisation hours per day without considering its costs, the equipment plan model is better, in a way, because it considers the cost factors incorporated into the model. In addition, the model also considers when to purchase the Panamax or Post Panamax and how many according to the demand level with a low cost configuration. The traditional way can not do this. The comparison between calculation using the traditional way and this model is discussed in Chapter 5. It is evident that the model gives a result of the container cranes configuration with the lowest capital costs or investments and lower cost per move compared with the traditional result.

In this study, the optimum equipment plan is made with four utilisation scenarios of container cranes i.e. 35, 40, 45 and 50%. Based on the result derived from the model, the equipment plan for other pieces of equipment is calculated with the ratio applied by JICT. The decision to be made, for which scenario of equipment plan to be selected, depends on the management to decide. If the management believes that the average utilisation of the equipment that can be achieved is 40%, then the management should use the equipment plan with the 40% scenario and vice versa (see Appendix 6).

The optimum equipment plan resulting from this study is made to provide *guidelines* to management for what should be done if they believe a certain utilisation level of container cranes can be achieved. Chapter 5 will try to discuss and analyse the equipment plan model and its results more in depth.

CHAPTER 5
Analysis

"This chapter discusses and analyses the optimum container handling equipment plan model and its results, especially for container cranes and compares the results generated by the traditional way and the equipment plan model"

5.1 Analysis of the equipment plan model

In this study, the equipment plan model is especially made for calculating the optimum number of container cranes, whereas the other pieces of equipment are calculated on the ratio basis applied by JICT. The equipment plan model is a useful tool for equipment planning particularly if the company wants to have cost-effective equipment planning. Not only does it consider the economic life, handling rates, and annual costs of the equipment but also capital costs or investments needed to buy new equipment. By this model, the equipment configuration resulting from the model has the minimum total annual costs and capital costs configuration, and ultimately, it will give lower costs of equipment per move.

In addition, since the author does not have enough data, some assumptions have been made to be able to make the model representative enough to solve the problem. It would be more interesting if there are some data for a group of equipment e.g. Panamax cranes or Post Panamax cranes from different manufacturers with different prices, lifetime costs and options e.g. buying new one or leasing/hire purchase. If so, the model will have more 'life'; in other words, it really represents the real life in doing equipment selection. The author tried to contact some manufacturers about the prices, lifetime costs, and options of the equipment via e-mail, but none of the manufacturers gave the author feedback. Therefore, only the prices provided by UNCTAD are used in the model for new equipment.

In this study, the author only considers Post Panamax cranes as new type of equipment since it is not the right choice to consider Super Post Panamax cranes to be included in the model because of the type of ships calling at the terminal. Most of the ship calls at the terminal are feeder ships and very few Post Panamax ships. Super Post Panamax cranes should be considered if there is a possibility to have big container ships of around 6,000 TEUs capacity or more calling to the terminal.

In addition, it will also be more interesting if there are budget constraints applied into the model. This can not be done because the author does not have any information about the budgets for buying container cranes from the company. If all the data are available, the model can be developed further. This is recommended for further research.

5.2 Analysis of the optimum equipment plan

5.2.1 Container cranes

5.2.1.1 Existing equipment

All the 12 existing container cranes, whether owned or hire-purchased, are still retained because they are still in their economic life during the planning period i.e. up to the year 2009.

For the owned equipment, the economic life of the closest owned container cranes will end in 2020 i.e CC-03 and, then, CC-02, CC-04, CC-05 and CC-06 in 2021 (see Appendix 4 for details). Then, these owned container cranes should be replaced with the same or other types depending on the result of the model if applying such situation into the model with certain traffic levels on that particular year and certain utilisation levels.

It is also observed that for old owned container cranes (Pre-Panamax: CC-02A, CC01), they have longer economic life because their maintenance cost patterns are better than those above. It may happen because probably these old oild pieces of equipment are still more reliable compared with those above although they are older. This can be seen from their operating costs which are lower (see Appendix 4).

For existing hire-purchased equipment, whether Pre-Panamax type or Panamax type, the total annual cost is higher than the similar type owned by the company. For hire-purchased Pre-Panamax cranes, the total annual cost is US$ 786,188, whereas the typical annual total cost for Pre-Panamax cranes is around US$ 350,000 – 460,000. In addition, for hire-purchased Panamax cranes, the total annual cost is US$ 1,065,900 whereas the typical total annual cost for Panamax cranes is around US$ 550,000 – 650,000. This is due to the high capital cost during the first five years for hiring this equipment before it is transferred to JICT.

The capital cost is calculated on the basis of US$ 39.1 per move and a utilisation level of 30% or 2,628 hours per year. In fact, for Panamax container cranes (e.g. hire-purchase 2 and 3) with the utilisation and handling rates remaining the same, the cost per move for hire-purchase should lie between *US$ 18.8 – 22.7* to achieve the annual total costs around US$ 550,000 – 650,000 (assumed the operating costs pattern as it is—see Appendix 4).

Therefore, in the future, when hiring the hire-purchase equipment, the company should consider or calculate the annual total costs or cost per move of the equipment. The annual total costs or cost per move of hire-purchase equipment should be equal or might be slightly higher compared with the typical type of such equipment.

5.2.1.2 New equipment

As mentioned before, buying the new Pre-Panamax cranes is not considered to be used anymore as they have already been 'out of date' to be applied because most of the shipping lines are more interested in the equipment with higher handling rates.

According to the ship type calls at the terminal, the suitable container cranes to serve them are Panamax type and Post Panamax type. Based on the result, for Panamax cranes, the equipment selected is equipment from the **Noell** manufacturer having an average total annual costs of US$ 599,767. This equipment has lower total annual costs compared with the **Guna Nusa** manufacturer having an average annual total costs of US$ 617,039. For Post-Panamax cranes, since there is no data from which manufaturer the equipment is, it is said as a Post Panamax crane (price according to UNCTAD, 1996 price) regardless its manufacturer.

The number of new container cranes needed, depends on management to decide according to their utilisation level that can be achieved (see Appendix 6).

5.2.2 Other container handling equipment

Since other pieces of container handling equipment, such as: RTG, tractor/head truck, chassis, and forklift diesel are calculated on the ratio basis, there is no deep analysis of their total annual costs. What is important is their configuration to the total equipment plan and acquisitions policy to meet container handling demands (see Appendix 6).

5.3 Investments

Investments needed are calculated according to the optimum equipment plan as described in Appendix 6. The calculation is based on the price list prepared by UNCTAD (1996 prices). The prices (including erection and/or transport costs) used are:

- US$ 6.78 million for a Post-Panamax container crane with outreach 40m, maximum lift 40 T and handling rate 30 – 36 boxes/hour;
- US$ 5.65 million for Panamax crane with outreach 25m, maximum lift 40 T and handling rate 18 – 24 boxes/hour;
- US$ 1.92 million for RTG with span 20 – 24 m, maximum lift 40 T and lift height of 1 over 4;
- US$ 0.11 million for Tractor/headtruck;
- US$ 0,0165 million for single chassis with load capacity 45 T;

The calculation of investments needed for different utilisation scenarios for the year 2000 up to 2009 are shown in Table 5.1.

Table 5.1
Investment in container handling equipment (2000 - 2009)

Unit (US $ million)

Equipment	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Utilisation 35%										
CC	16.95	11.30	11.30	11.30	11.30	13.56	18.08	19.21	22.60	24.86
RTG	44.18	15.37	15.37	15.37	21.13	15.37	23.05	23.05	30.74	36.50
Tractor/HT	3.74	1.54	1.54	1.54	2.97	1.54	2.31	3.08	3.08	3.08
Chassis	0.87	0.84	0.28	0.28	0.49	0.28	0.42	1.24	0.55	0.55
Forklift Diesel	0.33	0.11	0.11	0.11	0.11	0.11	0.17	0.33	0.22	0.22
Total	66.08	29.16	28.60	28.60	36.00	30.86	44.02	46.91	57.19	65.21
Cumulative	66.08	95.23	123.83	152.42	188.43	219.28	263.30	310.22	367.41	432.62
Utilisation 40%										
CC	11.30	5.65	6.78	11.30	11.30	12.43	16.95	16.95	18.08	22.60
RTG	36.50	7.68	7.68	15.37	21.13	15.37	23.05	23.05	23.05	36.50
Tractor/HT	2.97	0.77	0.77	1.54	2.97	1.54	2.31	3.08	2.31	3.08
Chassis	0.74	0.14	0.14	0.28	0.49	0.28	0.42	1.24	0.42	0.55
Forklift Diesel	0.28	0.06	0.06	0.11	0.11	0.11	0.17	0.33	0.17	0.22
Total	51.78	14.30	15.43	28.60	36.00	29.73	42.89	44.65	44.02	62.95
Cumulative	51.78	66.08	81.51	110.10	146.10	175.83	218.72	263.37	307.40	370.35
Utilisation 45%										
CC	-	6.78	11.30	5.65	11.30	11.30	13.56	16.95	16.95	18.08
RTG	21.13	7.68	15.37	7.68	21.13	15.37	15.37	23.05	23.05	28.82
Tractor/HT	1.43	0.77	1.54	0.77	2.97	1.54	1.54	3.08	2.31	2.31
Chassis	0.46	0.14	0.28	0.14	0.49	0.28	0.28	1.24	0.42	0.42
Forklift Diesel	0.17	0.06	0.11	0.06	0.11	0.11	0.11	0.33	0.17	0.17
Total	23.18	15.43	28.60	14.30	36.00	28.60	30.86	44.65	42.89	49.79
Cumulative	23.18	38.61	67.21	81.51	117.51	146.10	176.96	221.61	264.50	314.29
Utilisation 50%										
CC	-	-	11.30	5.65	11.30	6.78	12.43	13.56	16.95	16.95
RTG	21.13	-	15.37	7.68	21.13	7.68	15.37	15.37	23.05	28.82
Tractor/HT	1.43	-	1.54	0.77	2.97	0.77	1.54	2.31	2.31	2.31
Chassis	0.46	-	0.28	0.14	0.49	0.14	0.28	1.10	0.42	0.42
Forklift Diesel	0.17	-	0.11	0.06	0.11	0.06	0.11	0.28	0.17	0.17
Total	23.18	-	28.60	14.30	36.00	15.43	29.73	32.62	42.89	48.66
Cumulative	23.18	23.18	51.78	66.08	102.08	117.51	147.23	179.85	222.74	271.40

Note: Investment is calculated according the optimum number of equipment as on Appendix 6.

Table 5.1 shows that the less the utilisation of the equipment, the higher the investment needed. For example, with a utilisation of 35% the cumulative investment needed up to the year 2009 is US$ 433 million, while if the equipment is utilised by 50%, the cumulative investment needed is only US$ 271 million or 37.4% less.

It shows how important it is to increase the utilisation of assets so as to reduce the costs of equipment. It means that the company needs to increase the utilisation of existing assets to have lower costs and lower capital investments as its strategies. This strategy is recommended by UNCTAD to be able to achieve competitive advantage through the cost leadership strategy (UNCTAD, 1993).

5.4 Cost per move of container cranes

According to the calculation, the average cost per move of container cranes resulting from the model for the planning period up to 2009 is US $ 8.9 for utilisation 35%, US $ 7.9 for utilisation 40%, US $ 7.1 for utilisation 45%, and US $ 6.5 for utilisation 50% (see Appendix 7). This average cost per move is resulted from the use of the combination of existing, new Panamax and new Post Panamax cranes.

The result shows that it is evident that the higher the utilisation of assets, the lower the unity costs or cost per move of the equipment.

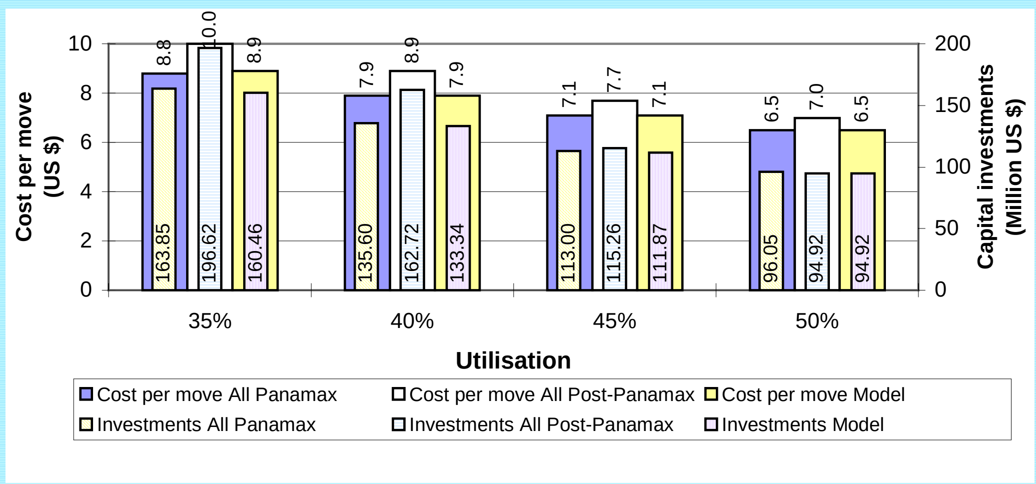
5.5 Comparisons between traditional way and the model

The comparisons between the traditional way of calculating the equipment plan and the model are needed so as to prove whether the equipment plan model is useful or not. Since the model is applied only for calculating the optimum equipment plan for container cranes, the comparisons for other pieces of equipment are not carried out.

In the traditional way, there are two calculations examined for buying new equipment. They are ”all Panamax cranes” and ”all Post-Panamax cranes”. These options are selected because the traditional way can not determine the combination of Panamax cranes and Post-Panamax cranes e.g. when to buy Panamax or Post-Panamax cranes, and how many units are needed on a particular year for Panamax or Post-Panamax cranes. In the ”equipment plan model”, there is one calculation for buying new equipment that is a combination between Panamax and Post-Panamax cranes. This model can also determine when and how many units Panamax and Post-Panamax cranes should be bought with lower total annual costs and capital investments. Therefore, the comparisons are carried out on these three options.

The comparison shows that, for all the utilisation scenarios during the planning period up to 2009, the ”equipment plan model” gives the best solution having equal or lower average cost per move with the lowest capital investments, except cost per move for utilisation scenario of 35%, which is slightly higher. This might be caused by the rounding up of the calculation.

The result shows clearly that the ”equipment plan model” is a useful tool for calculating the optimum equipment plan. It is apparent that the ”model” gives a better solution because the calculation takes into account their handling rates, economic life, total annual costs, and capital investments. For example: on the utilisation scenario of 40%, the ”model” generates an average cost per move of US $ 7.9 with the cumulative capital investments of US $ 133.34 million. For “all Panamax scenario”, although it generates the same average cost per move of US $ 7.9 as the ”model”, it needs higher capital investments, that is US $ 135.60 million. For ”all Post-Panamax scenario”, it generates higher cost per move of US $ 8.9 and capital investments of US $ 162.72 million. This is also true for other utilisation scenarios (see Figure 5.1; see Apendix 7 for details). Therefore, this model is a good tool to help the management in making a decision concerning the container handling equipment plan.



Source: Appendix 7.

Figure 5.1
Comparisons of the results between traditional way and the equipment plan model

Despite of the economic comparisons, following are the other comparisons among the ”equipment plan model”, ”all Panamax” and ”all Post-Panamax”:

<u>”All Panamax”</u>

- Lower unit costs;
- Higher capital costs/investments;
- Not deal with the market developments meaning that it can not serve Post-Panamax ships.

<u>”All Post-Panamax”</u>

- Higher unit costs;
- Higher capital costs/investments;
- Over capacity although it deal with the market developments where the trend is the ships becomes bigger and bigger.

<u>”Model”</u>

- Lower unit costs;
- Optimum capital costs/investments;
- Optimum capacity and, furthermore, it deals with the market developments meaning that it can serve Post-Panamax ships.

5.6 Summary

From the analysis, it can be summarised that the equipment plan model is a useful tool for the company to calculate an optimum container handling equipment plan. In addition, based on the results of the model, it is also useful for the company to prepare annual budgets for the container handling equipment and set up tariffs. The equipment plan which resulted has an economical strength meaning that the company can achieve a competitive advantage through cost leadership because the equipment plan configuration has lower unity costs. Lower unity costs means that the equipment plan also has considered the optimum capacity of the equipment to cope with the demand by minimising the unused capacity while it still has enough inventory to cope with the container handling demands. Chapter 6 will conclude the result of this study and give some recommendations to the management to be able to apply this study in practice and for further research.

CHAPTER 6
Conclusions and Recommendations

"This chapter describes the conclusions and recommendations related with the optimum container handling equipment plan and the equipment plan model"

6.1 Conclusions

From this study, it can be concluded that:

- JICT experienced a dramatic growth in container traffic from 0.18 TEUs in 1986 to 1.53 million TEUs in 1997 or more than eight times in the period of eleven years. This growth is believed to be continued in the future as an impact of the globalisation of the world economy and trade liberalisation.
- To be a world class operator, JICT has to provide high quality services as close as possible to the customers' requirements. One way to do so is to have an adequate or optimum inventory of equipment to meet cargo handling demands along with the growth of the container traffic.
- To have an optimum inventory of equipment, JICT has to provide considerable investments in infrastructure and expensive equipment, which is inherently risky if the proper procedures are not carried out. Therefore, a careful container traffic forecast has been done to minimise the risks of the investments in equipment.
- The container traffic forecast is done by using an *econometric approach* because the containerisation is closely related with the commodity transported in containers. In other words, the trade in commodities depends on the macro economic condition of the country.

- According to the study, container traffic in JICT primarilly depends on the trade and GDP of the country as those variables have an adjusted r^2 or determinants of 0.98 or very close to 1. It means that 98% of the variation of the container traffic can be explained as a result of the variations in trade and GDP of the country. Therefore, the container traffic forecast in JICT is calculated based on this container traffic forecasting model.

- To minimise the risks, the container traffic forecast is done by applying three scenarios on the model. The scenarios are favourable economy, moderate economy and unfavourable economy. For the purpose of calculating the equipment plan, the weighted average scenario is used. The container traffic forecast seems to be realistic because it has the average growth of 12.6%. It means that the weighted scenario follows the average growth of container traffic in JICT, that is the average growth of 11.9% between 1992 and 1999 or 13.9% between 1991 and 1999.

- Although the equipment plan model seems to be theoretical, the optimum equipment plan derived from the equipment plan model using a mathematical model i.e. integer linear programming approach gives a better result compared with the traditional way of calculating it although some assumptions have been made to make the model more realistic. This is becaused the cost-benefit analysis has been incorporated into the model. The results show that the equipment plan model gives **lower costs per move with lowest capital investments**. Therefore, the equipment plan model is **a useful tool** for management to prepare an optimum equipment plan.

- The results also provide **guidelines** to the management regarding the optimum equipment plan, equipment acquisitions, and capital investments needed with different utilisation scenarios, which are useful for the management to make a decision concerning the equipment. The utilisation scenario is used as a base for making a decision. If the management believes that a 45% utilisation scenario is the utilisation level that can be achieved, then the equipment plan, equipment acquisitions, and capital investments should be based on the results of the 45% utilisation scenario. The model also gives a guideline to the management to make a decision concerning hire purchase or lease equipment.

6.2 Recommendations

6.2.1 Recommendations for JICT

To have a better container handling equipment plan by using the equipment plan model, JICT should:

- provide a reliable costs record for the equipment, which is important in order to have cost effectiveness in applying equipment plan policies.
- establish an effective Equipment Management Information System (EMIS) as a part of the Management Information System (MIS), which is a major constraint on port equipment plan and maintenance.
- ask for lifetime costs from the equipment suppliers to have better references about the equipment itself.
- train and involve staff in calculating the optimum equipment plan by following the procedures.
- include the equipment plan in the port's corporate plan.

6.2.2 Recommendations for further research

Because of lack of the data available, such as prices and lease costs of different types of new cranes with different manufacturers and lifetime costs of the existing and new cranes, some limitations have been made into the equipment plan model. So, for example: only type A, in general, of new cranes is considered into the model to represent the Post-Panamax type but no lease option of it because of unavailable data.

Furthermore, for Panamax cranes, only one price (according to UNCTAD) is considered to represent two different manufacturers. In addition, the calculation of the lifetime cost is also made on the assumption that the costs increase by 3% in the first 5 years and will continue to increase by 1 % every 5 years afterwards with the percentage of initial maintenance and running costs varying according to the historical data available in the company. Therefore, if all the data available, following are some recommendations proposed for further research:

- Considering the hire-purchase or lease and buy options of different type of container cranes with different manufacturers to have real choices of various manufacturers available on the market.
- Considering Super Post Panamax cranes into the equipment plan model to see their effects on the equipment configuration and economies of scale, if there is a possibility for JICT to receive Super Post Panamax ships.
- Adding budget or financial constraints to the model to have a more realistic model representing real practices.

References

Au, T. & Au, T. P. (1983). Engineering economics for capital investment analysis. Massachusetts: Allyn and Bacon.

Bangsberg, P. T. (2000, July 20). Grand Alliance launches Indonesia-North Europe service. Journal of Commerce ONLINE. Retrieved July 24, 2000 from the World Wide Web: http://www.joc.com/

Daellenbach, H. G., George, J. A. & McNickle, D. C. (1983). Introduction to operations research techniques (2nd ed.). Massachusetts: Allyn and Bacon.

The United States Embassy, Jakarta, Indonesia (1999, July 30). IMI: Potential sources of growth for Indonesia's economy. Recent economic reports. Retrieved March 22, 2000 from the World Wide Web: http://www.usembassyjakarta.org/econ/imijuly30.html

Indonesia Port Corporation II (IPC II) (1998). Corporate planning 1999 – 2003. [Unpublished], Jakarta: Author.

IPC II (1998). Annual report 1998. Jakarta: Author.

International Monetary Fund (IMF) (1999, January 16). Economic and financial situation in Asia: latest developments. Background paper prepared for presentation by Michel Camdessus, Managing Director of the International Monetary Fund Asia-Europe Finance Ministers Meeting, Frankfurt, Germany. Retrieved April 15, 2000 from the World Wide Web: http://www.imf.org/external/np/speeches/1999/011699.HTM

International Trade Centre (ITC) UNCTAD/WTO (2000, January 24). National export performance. (p.4). Retrieved January 24, 2000 from the World Wide Web: http://www.intracen.org/

Makridakis, S. G. & Wheelwright, S. C. (1987). A handbook of forecasting: a manager's guide (2nd ed.). New York: John Wiley & Sons.

McDonagh, S. (2000, May). The art of traffic forecasting: How to do it and why. Port Development International, 24-25.

Ocean Shipping Consultants (1999). World container port markets to 2012. Chertsey, Surrey, England: Author.

Pelabuhan Tanjung Priok (1999, Desember). Fasilitas pelabuhan Tanjung Priok. Jakarta: Author.

Peters, H. J. F. (2000). The world economy and sea trade. In Baltic and International Maritime Council, BIMCO review 2000, (p.26). London: Author.

Project LINK (2000). Preliminary results from the Project LINK global model. World Economic Outlook, 1998-1999. Retrieved March 7, 2000 from the World Wide Web: http://www.un.org/esa/analysis/link/linkrep1.htm#Table_A_1__LINK _World_Trade_Outlook

Slater, R. & Ascroft, P. (1990). Quantitative techniques in a business context. London: Chapman and Hall Ltd.

Thomas, B. J. & Roach, D. K. (1989). Management of port maintenance. London: Her Majesty's Stationery Office.

United Nations Conference on Trade and Development (UNCTAD) (1986a). Operating and maintenance features of container handling systems, (p.5). Geneva: UNCTAD Secretariat.

UNCTAD (1986b). Improving port performance: container terminal development. Geneva: UNCTAD Secretariat.

UNCTAD (1989). Improving port performance: port equipment management and maintenance. Geneva: UNCTAD Secretariat.

UNCTAD (1990a). Improving port performance: port equipment: policy, management and maintenance. Geneva: UNCTAD Secretariat.

UNCTAD (1990b). UNCTAD Monographs on port management: economic approach to equipment selection and replacement. New York: United Nations.

UNCTAD (1993). Strategic planning for port authorities. (p.38). Geneva: UNCTAD Secretariat.

UNCTAD (1995). Multimodal transport handbook, 5th ed., (p.87). Geneva: UNCTAD Secretariat.

United Nations Statistics Divisions (UNSD) (2000, February). Monthly bulletin of statistics online. Retrieved March 7, 2000 from the World Wide Web: http://esa.un.org/unsd/mbs/mbslist.asp

World Bank (2000, March). Economy: structure of output. 1999 World Development Indicators, (p.193). Retrieved March 7, 2000 from the World Wide Web: http://www.worldbank.org/data/wdi2000/economy.htm

Appendix 1

The age and conditions of the equipment (September 1999)

No.	Equipment Type	Register	Capacity	Manufacturer	Year	Age	Hp	Remarks
				CONTAINER CRANE				
1	Container Crane	CC.02A	30.5	Mitsui	1972	28	-	
2	Container Crane	CC.02	50	Sumitomo	1976	24	830	Retrofit 98
3	Container Crane	CC.03	50	Sumitomo	1976	24	830	Retrofit 97
4	Container Crane	CC.01	35.5	Sumitomo	1983	17	830	Retrofit 98
5	Container Crane	CC.04	40	Noell	1992	8	1379	
6	Container Crane	CC.05	40	Noell	1992	8	1379	Retrofit 97
7	Container Crane	CC.06	40	Noell	1992	8	1379	Retrofit 97
8	Container Crane	CC.07	35	Guna Nusa	1997	3	2095	
9	Container Crane	CC.08	35	Guna Nusa	1997	3	2095	
				TRANSTAINER (RTG)				
1	Transtainer	TT.05A	30,5	Paceco	1976	24	175	Retrofit 96
2	Transtainer	TT.01A	30,5	Paceco	1979	21	175	Retrofit 95
3	Transtainer	TT.02A	30,5	Paceco	1979	21	175	Retrofit 96
4	Transtainer	TT.03A	30,5	Paceco	1979	21	175	
5	Transtainer	TT.04A	30,5	Paceco	1979	21	175	
6	Transtainer	TT.06A	30,5	Paceco	1979	21	175	
7	Transtainer	TT.07A	30,5	Paceco	1979	21	175	
8	Transtainer	TT.03	35	Hitachi	1983	17	400	Retrofit 97
9	Transtainer	TT.04	35	Hitachi	1983	17	400	Retrofit 97
10	Transtainer	TT.05	35	Hitachi	1983	17	400	Retrofit 97
11	Transtainer	TT.08A	30,5	Hyundai	1988	12	540	Retrofit 96
12	Transtainer	TT.09A	30,5	Hyundai	1988	12	540	Retrofit 96
13	Transtainer	TT.10A	30,5	Hyundai	1988	12	540	Retrofit 96
14	Transtainer	TT.16	35	Hyundai	1989	11	540	Retrofit 96
15	Transtainer	TT.17	35	Hyundai	1989	11	540	Retrofit 97
16	Transtainer	TT.18	35	Hyundai	1990	10	540	Retrofit 97
17	Transtainer	TT.19	35	Hyundai	1990	10	540	Retrofit 97
18	Transtainer	TT.20	35	Mitsui	1991	9	400	
19	Transtainer	TT.21	35	Mitsui	1991	9	400	
20	Transtainer	TT.22	35	Mitsui	1991	9	400	
21	Transtainer	TT.23	35	Mitsui	1991	9	400	
22	Transtainer	TT.24	35	Mitsui	1991	9	400	
23	Transtainer	TT.25	35	Mitsui	1991	9	400	
24	Transtainer	TT.26	35	Mitsui	1991	9	400	
25	Transtainer	TT.27	35	Mitsui	1991	9	400	
26	Transtainer	TT.28	35	Mitsui	1991	9	400	
27	Transtainer	TT.29	35	Mitsui	1991	9	400	
28	Transtainer	TT.30	35	Mitsui	1991	9	400	
29	Transtainer	TT.31	35	Mitsui	1991	9	400	
30	Transtainer	TT.32	35	Mitsui	1991	9	400	
31	Transtainer	TT.33	35	Mitsui	1991	9	400	
32	Transtainer	TT.34	35	Mitsui	1991	9	400	

No.	Equipment Type	Register	Capacity	Manufacturer	Year	Age	Hp	Remarks
				FORK LIFT DIESEL				
1	Forklift Diesel	FD. 04	25/20	Mitsubhisi	1979	21	-	
2	Forklift Diesel	FD. 02	36/32	Toyo Umpachi	1983	17	-	
3	Forklift Diesel	FD. 16	2	Datsun	1983	17	-	
4	Forklift Diesel	FD. 18	2	Datsun	1983	17	-	
5	Forklift Diesel	FD. 19	2	Datsun	1983	17	-	
6	Forklift Diesel	FD.09A	2	Datsun	1983	17	-	
7	Forklift Diesel	FD. 11A	10	Toyo Umpachi	1983	17	-	
8	Forklift Diesel	FD.16A	36	Toyo Umpachi	1983	17	-	
9	Forklift Diesel	FD. 29	2	Nissan	1991	9	-	
10	Forklift Diesel	FD. 03A	2	Nissan	1991	9	-	
11	Forklift Diesel	FD.08A	2	Nissan	1991	9	-	
12	Forklift Diesel	FD.01	42	Fantuzzi	1996	4		
13	Forklift Diesel	FD.08	15	Fantuzzi	1996	4	-	
14	Forklift Diesel	FD.09	15	Fantuzzi	1996	4	-	
15	Forklift Diesel	FD 20	3,5	Komatsu	1996	4	64	
16	Forklift Diesel	FD. 04A	42	Fantuzzi	1996	4	-	
17	Forklift Diesel	FD. 05A	15	Fantuzzi	1996	4	-	
				TRACTOR-TRAILER SETS/HEAD-TRUCK				
1	Head Truck	HT. 23	40	Ottawa	1988	12	175	
2	Head Truck	HT. 25	40	Ottawa	1988	12	175	
3	Head Truck	HT. 26	40	Ottawa	1988	12	175	
4	Head Truck	HT. 28	40	Ottawa	1988	12	175	
5	Head Truck	HT. 29	40	Ottawa	1988	12	175	
6	Head Truck	HT. 30	40	Ottawa	1988	12	175	
7	Head Truck	HT. 31	40	Ottawa	1988	12	175	
8	Head Truck	HT. 32	40	Ottawa	1988	12	175	
9	Head Truck	HT. 33	40	Ottawa	1988	12	175	
10	Head Truck	HT. 34	40	Ottawa	1988	12	175	
11	Head Truck	HT. 35	40	Ottawa	1988	12	175	
12	Head Truck	HT. 36	40	Ottawa	1988	12	175	
13	Head Truck	HT. 37	40	Ottawa	1988	12	175	
14	Head Truck	HT. 38	40	Ottawa	1991	9	175	
15	Head Truck	HT. 40	40	Ottawa	1991	9	175	
16	Head Truck	HT. 41	40	Ottawa	1991	9	175	
17	Head Truck	HT. 42	40	Ottawa	1991	9	175	
18	Head Truck	HT. 43	40	Ottawa	1991	9	175	
19	Head Truck	HT. 44	40	Ottawa	1991	9	175	
20	Head Truck	HT. 45	40	Ottawa	1991	9	175	
21	Head Truck	HT. 46	40	Ottawa	1991	9	175	
22	Head Truck	HT. 47	40	Ottawa	1991	9	175	
23	Head Truck	HT. 48	40	Ottawa	1991	9	175	
24	Head Truck	HT. 49	40	Ottawa	1991	9	175	
25	Head Truck	HT. 50	40	Ottawa	1991	9	175	
26	Head Truck	HT. 51	40	Ottawa	1991	9	175	
27	Head Truck	HT. 52	40	Ottawa	1991	9	175	
28	Head Truck	HT. 53	40	Ottawa	1991	9	175	
29	Head Truck	HT. 55	40	Ottawa	1991	9	175	
30	Head Truck	HT. 56	40	Ottawa	1991	9	175	
31	Head Truck	HT. 57	40	Ottawa	1991	9	175	
32	Head Truck	HT.01A.	40	Ottawa	1991	9	175	
33	Head Truck	HT.02A.	40	Ottawa	1991	9	175	
34	Head Truck	HT.03A.	40	Ottawa	1991	9	175	
35	Head Truck	HT.04A.	40	Ottawa	1991	9	175	

No.	Equipment Type	Register	Capacity	Manufacturer	Year	Age	Hp	Remarks
36	Head Truck	HT.05A.	40	Ottawa	1991	9	175	
37	Head Truck	HT.06A.	40	Ottawa	1991	9	175	
38	Head Truck	HT.07A.	40	Ottawa	1991	9	175	
39	Head Truck	HT.08A.	40	Ottawa	1991	9	175	
40	Head Truck	HT.09A.	40	Ottawa	1991	9	175	
41	Head Truck	HT.010A.	40	Ottawa	1991	9	175	
42	Head Truck	HT. 58	40	Capacity	1995	5	210	
43	Head Truck	HT. 59	40	Capacity	1995	5	210	
44	Head Truck	HT. 60	40	Capacity	1995	5	210	
45	Head Truck	HT. 61	40	Capacity	1995	5	210	
46	Head Truck	HT. 62	40	Capacity	1995	5	210	
47	Head Truck	HT. 63	40	Capacity	1995	5	210	
48	Head Truck	HT. 64	40	Capacity	1995	5	210	
49	Head Truck	HT. 65	40	Capacity	1995	5	210	
50	Head Truck	HT. 66	40	Capacity	1995	5	210	
51	Head Truck	HT. 67	40	Capacity	1995	5	210	
52	Head Truck	HT. 68	40	Capacity	1995	5	210	
53	Head Truck	HT. 69	40	Capacity	1995	5	210	
54	Head Truck	HT. 70	40	Capacity	1995	5	210	
55	Head Truck	HT. 71	40	Capacity	1995	5	210	
56	Head Truck	HT. 72	40	Capacity	1995	5	210	
57	Head Truck	HT. 73	40	Capacity	1995	5	210	
58	Head Truck	HT. 74	40	Capacity	1995	5	210	
59	Head Truck	HT. 75	40	Capacity	1995	5	210	
60	Head Truck	HT. 76	40	Capacity	1995	5	210	
61	Head Truck	HT. 77	40	Capacity	1995	5	210	
62	Head Truck	HT. 78	40	Ottawa	1996	4	210	
63	Head Truck	HT. 79	40	Ottawa	1996	4	210	
64	Head Truck	HT. 80	40	Ottawa	1996	4	210	
65	Head Truck	HT. 81	40	Ottawa	1996	4	210	
66	Head Truck	HT. 82	40	Ottawa	1996	4	210	
67	Head Truck	HT.011A.	40	Ottawa	1996	4	210	
68	Head Truck	HT.012A.	40	Ottawa	1996	4	210	
69	Head Truck	HT.013A.	40	Ottawa	1996	4	210	
70	Head Truck	HT.014A.	40	Ottawa	1996	4	210	
71	Head Truck	HT.015A.	40	Ottawa	1996	4	210	
				CHASSIS				
1	Chassis	CHS. 01	40	Hargill-Co	1978	22	-	
2	Chassis	CHS. 03	40	Hargill-Co	1978	22	-	
3	Chassis	CHS. 04	40	Hargill-Co	1978	22	-	
4	Chassis	CHS. 05	40	Hargill-Co	1978	22	-	
5	Chassis	CHS. 06	40	Hargill-Co	1978	22	-	
6	Chassis	CHS. 07	40	Hargill-Co	1978	22	-	
7	Chassis	CHS. 10	40	Hargill-Co	1978	22	-	
8	Chassis	CHS. 11	40	Hargill-Co	1978	22	-	
9	Chassis	CHS. 12	40	Hargill-Co	1978	22	-	
10	Chassis	CHS. 13	40	Hargill-Co	1978	22	-	
11	Chassis	CHS. 14	40	Hargill-Co	1978	22	-	
12	Chassis	CHS. 15	40	Hargill-Co	1978	22	-	
13	Chassis	CHS. 24A	40	Hargill-Co	1978	22	-	
14	Chassis	CHS. 29A	40	Hargill-Co	1978	22	-	
15	Chassis	CHS. 17	40	PT. Bukaka	1983	17	-	
16	Chassis	CHS. 25/36	40	PT. Bukaka	1983	17	-	
17	Chassis	CHS. 27	40	PT. Bukaka	1983	17	-	
18	Chassis	CHS. 30	40	PT. Bukaka	1983	17	-	
19	Chassis	CHS. 34	40	PT. Bukaka	1983	17	-	
20	Chassis	CHS. 48	40	Mandiri	1988	12	-	

No.	Equipment Type	Register	Capacity	Manufacturer	Year	Age	Hp	Remarks
21	Chassis	CHS. 49	40	Mandiri	1988	12	-	
22	Chassis	CHS. 50	40	Mandiri	1988	12	-	
23	Chassis	CHS. 51	40	Mandiri	1988	12	-	
24	Chassis	CHS. 52	40	Mandiri	1988	12	-	
25	Chassis	CHS. 54	40	Mandiri	1988	12	-	Spreader
26	Chassis	CHS. 55	40	Mandiri	1988	12	-	
27	Chassis	CHS. 56	40	Mandiri	1988	12	-	
28	Chassis	CHS. 57	40	Mandiri	1988	12	-	
29	Chassis	CHS. 58	40	Mandiri	1988	12	-	
30	Chassis	CHS. 59	40	Mandiri	1988	12	-	
31	Chassis	CHS. 61	40	Mandiri	1988	12	-	
32	Chassis	CHS. 62	40	Mandiri	1988	12	-	
33	Chassis	CHS. 64	40	PT. Gemala	1991	9	-	
34	Chassis	CHS. 65	40	PT. Gemala	1991	9	-	
35	Chassis	CHS. 66	40	PT. Gemala	1991	9	-	
36	Chassis	CHS. 46/67	40	PT. Gemala	1991	9	-	
37	Chassis	CHS. 68	40	PT. Gemala	1991	9	-	
38	Chassis	CHS. 69	40	PT. Gemala	1991	9	-	
39	Chassis	CHS. 47/70	40	PT. Gemala	1991	9	-	
40	Chassis	CHS. 72	40	PT. Gemala	1991	9	-	
41	Chassis	CHS. 73	40	PT. Gemala	1991	9	-	
42	Chassis	CHS. 74	40	PT. Gemala	1991	9	-	
43	Chassis	CHS. 76	40	PT. Gemala	1991	9	-	
44	Chassis	CHS. 77	40	PT. Gemala	1991	9	-	
45	Chassis	CHS. 78	40	PT. Gemala	1991	9	-	
46	Chassis	CHS. 79	40	PT. Gemala	1991	9	-	
47	Chassis	CHS. 80	40	PT. Gemala	1991	9	-	
48	Chassis	CHS. 81	40	PT. Gemala	1991	9	-	
49	Chassis	CHS. 82	40	PT. Gemala	1991	9	-	
50	Chassis	CHS. 83	40	PT. Gemala	1991	9	-	
51	Chassis	CHS. 84	40	PT. Gemala	1991	9	-	
52	Chassis	CHS. 85	40	PT. Gemala	1991	9	-	
53	Chassis	CHS. 86	40	PT. Gemala	1991	9	-	
54	Chassis	CHS. 87	40	PT. Gemala	1991	9	-	
55	Chassis	CHS. 88	40	PT. Gemala	1991	9	-	
56	Chassis	CHS. 89	40	PT. Gemala	1991	9	-	
57	Chassis	CHS. 90	40	PT. Gemala	1991	9	-	
58	Chassis	CHS. 91	40	PT. Gemala	1991	9	-	
59	Chassis	CHS. 53/92	40	PT. Gemala	1991	9	-	
60	Chassis	CHS. 93	40	PT. Gemala	1991	9	-	
61	Chassis	CHS. 01A	40	PT. Gemala	1991	9	-	
62	Chassis	CHS. 02A	40	PT. Gemala	1991	9	-	
63	Chassis	CHS. 03A	40	PT. Gemala	1991	9	-	
64	Chassis	CHS. 04A	40	PT. Gemala	1991	9	-	
65	Chassis	CHS. 04A	40	PT. Gemala	1991	9	-	
66	Chassis	CHS. 05A	40	PT. Gemala	1991	9	-	
67	Chassis	CHS. 06A	40	PT. Gemala	1991	9	-	
68	Chassis	CHS. 07A	40	PT. Gemala	1991	9	-	
69	Chassis	CHS. 08A	40	PT. Gemala	1991	9	-	
70	Chassis	CHS.09A	40	PT. Gemala	1991	9	-	Spreader
71	Chassis	CHS. 10A	40	PT. Gemala	1991	9	-	
72	Chassis	CHS. 11A	40	PT. Gemala	1991	9	-	
73	Chassis	CHS. 11A	40	PT. Gemala	1991	9	-	
74	Chassis	CHS. 12A	40	PT. Gemala	1991	9	-	
75	Chassis	CHS. 13A	40	PT. Gemala	1991	9	-	
76	Chassis	CHS. 13A	40	PT. Gemala	1991	9	-	
77	Chassis	CHS. 14A	40	PT. Gemala	1991	9	-	

No.	Equipment Type	Register	Capacity	Manufacturer	Year	Age	Hp	Remarks
78	Chassis	CHS. 15A	40	PT. Gemala	1991	9	-	
79	Chassis	CHS. 16A	40	PT. Gemala	1991	9	-	
80	Chassis	CHS. 17A	40	PT. Gemala	1991	9	-	
81	Chassis	CHS. 18A	40	PT. Gemala	1991	9	-	
82	Chassis	CHS. 19A	40	PT. Gemala	1991	9	-	Spreader
83	Chassis	CHS. 20A	40	Mandiri	1997	3	-	
84	Chassis	CHS. 21A	40	Mandiri	1997	3	-	
85	Chassis	CHS. 22A	40	Mandiri	1997	3	-	
86	Chassis	CHS. 23A	40	Mandiri	1997	3	-	
87	Chassis	CHS. 24A	40	Mandiri	1997	3	-	
88	Chassis	CHS. 25A	40	Mandiri	1997	3	-	
89	Chassis	CHS. 26A	40	Mandiri	1997	3	-	
90	Chassis	CHS. 27A	40	Mandiri	1997	3	-	
91	Chassis	CHS. 28A	40	Mandiri	1997	3	-	
92	Chassis	CHS. 29A	40	Mandiri	1997	3	-	

Source:
Company record.

Appendix 2

Correlation between container traffic and other related data (base year: 1994 – 1998)

Descriptions	Model Var.	1994	1995	1996	1997	1998	r	r^2
Part 1: Export								
A. Dependent Variable								
- Export (Ton)	EX	4,576,894	5,329,317	6,201,285	5,807,825	6,472,808	1.00	**1.00**
B. Independent Variables								
1. Transport								
- Ship calls	SC	1,984	1,492	1,574	1,665	1,580	-0.71	**0.50**
- Cont. Shipping fleet cap (000TEU)	CSF	4,102	4,408	4,834	5,266	5,880	0.87	**0.76**
2. Trade								
- Foreign trade (Million US$)	IT	40,055	45,417	49,814	53,443	48,847	0.79	**0.62**
- East Asia trade Vol. Growth (%)	EAT	15.70	19.40	6.00	6.60	-11.30	-0.81	**0.66**
- Trade Vol. Change per annum (%)	TVA	17.10	23.20	11.60	1.20	-9.20	-0.72	**0.52**
3. Economy								
- GDP (Billion USD)	GDP	173.74	196.01	227.40	215.78	94.15	-0.24	0.06
- Real GDP growth (%)	GDR	7.50	8.10	7.80	4.90	-13.20	-0.61	**0.38**
- Average Currency rate (Rp/US $)	CR	2,200	2,308	2,342	2,909	10,014	0.62	**0.39**
- GDP Dev in Asia (%)	GDD	9.60	9.00	8.20	6.60	-4.00	-0.69	**0.48**
Part 2: Import								
A. Dependent Variable								
- Import (Ton)	IM	5,851,839	6,855,499	7,236,660	7,481,625	4,112,794	1.00	**1.00**
B. Independent Variables								
1. Transport								
- Ship calls	SC	1,984	1,492	1,574	1,665	1,580	-0.13	0.02
- Cont. Shipping fleet cap (000TEU)	CSF	4,102	4,408	4,834	5,266	5,880	-0.44	0.19
2. Trade								
- Foreign trade (Million US$)	IT	31,983	40,630	42,929	41,694	27,336	0.97	**0.93**
- East Asia trade Vol. Growth (%)	EAT	15.10	14.20	3.30	10.40	12.00	-0.39	0.16
- Trade Vol. Change per annum (%)	TVA	19.40	15.70	8.00	14.80	5.00	0.42	0.17
3. Economy								
- GDP (Billion USD)	GDP	173.74	196.01	227.40	215.78	94.15	0.98	**0.97**
- Real GDP growth (%)	GDR	7.50	8.10	7.80	4.90	-13.20	0.85	**0.73**
- Average Currency rate (Rp/US $)	CR	2,200	2,308	2,342	2,909	10,014	-0.86	**0.74**
- GDP Dev in Asia (%)	GDD	9.60	9.00	8.20	6.60	-4.00	0.80	**0.63**

Appendix 3

Number of container movements for forecasted container traffic (2000 – 2009)

Year	TEU per year	Moves per year	Daily moves
2000	1,509,165	1,029,322	2,819
2001	1,688,285	1,151,491	3,153
2002	1,891,814	1,290,307	3,534
2003	2,123,260	1,448,165	3,966
2004	2,386,664	1,627,819	4,458
2005	2,686,675	1,832,441	5,018
2006	3,028,654	2,065,687	5,657
2007	3,418,782	2,331,772	6,386
2008	3,864,191	2,635,562	7,218
2009	4,373,121	2,982,677	8,168

Note:

Daily container movements for container traffic can be calculated by dividing the total number of TEU per year by average TEU per container for the last four year (i.e. 1.47 see the table below) multiply 365 (number of days per year). In fomula:

Daily moves = Total number of TEU per year/(TEU per container x 365)

Year	Total		Container	TEU	TEU per Container
	20'	40'			
1990	230,614	123,433	354,047	477,480	1.35
1991	289,860	165,854	455,714	621,568	1.36
1992	386,985	214,333	601,318	815,651	1.36
1993	437,297	270,504	707,801	978,305	1.38
1994	494,480	334,851	829,331	1,164,132	1.40
1995	533,614	383,256	916,870	1,300,126	1.42
1996	546,401	435,478	981,879	1,421,693	1.45
1997	562,850	485,127	1,047,977	1,533,104	1.46
1998	511,151	456,905	968,056	1,424,961	1.47
1999	514,865	478,820	993,685	1,472,504	1.48

Appendix 4

Economic life calculations of equipment (container cranes)

Container Crane 02A: Mitsui: 30.5T: 1992: Made 1972
(Used/secondhand equipment)
(Assuming no residual value and a 12% discount rate)

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	2,312,800	31,466	1.000	2,344,266	2,344,266	1.000	2,344,266
2	-	33,983	0.893	30,342	2,374,608	0.528	1,254,510
3	-	37,042	0.797	29,529	2,404,137	0.372	893,714
4	-	40,375	0.712	28,738	2,432,875	0.294	715,166
5	-	44,009	0.636	27,969	2,460,844	0.248	609,520
6	-	47,970	0.567	27,219	2,488,063	0.217	540,322
7	-	52,287	0.507	26,490	2,514,554	0.196	491,949
8	-	57,516	0.452	26,017	2,540,571	0.180	456,629
9	-	63,267	0.404	25,553	2,566,124	0.168	430,006
10	-	69,594	0.361	25,096	2,591,220	0.158	409,469
11	-	76,554	0.322	24,648	2,615,868	0.150	393,350
12	-	84,209	0.287	24,208	2,640,076	0.144	380,541
13	-	93,472	0.257	23,992	2,664,068	0.139	370,299
14	-	103,754	0.229	23,778	2,687,846	0.135	362,070
15	-	115,167	0.205	23,565	2,711,411	0.131	355,447
16	-	127,835	0.183	23,355	2,734,766	0.128	350,123
17	-	141,897	0.163	23,146	2,757,913	0.125	345,864
18	-	158,925	0.146	23,146	2,781,059	0.123	342,511
19	-	177,996	0.130	23,146	2,804,206	0.121	339,917
20	-	199,355	0.116	23,146	2,827,352	0.120	337,966
21	-	223,278	0.104	23,146	2,850,499	0.118	336,563
22	-	250,071	0.093	23,146	2,873,645	0.117	335,628
23	-	282,580	0.083	23,353	2,896,998	0.116	335,121
24	-	319,316	0.074	23,562	2,920,560	0.115	334,987
25	-	360,827	0.066	23,772	2,944,332	0.114	335,181
26	-	407,734	0.059	23,984	2,968,316	0.113	335,663
27	-	460,740	0.053	24,198	2,992,515	0.112	336,402
28	-	525,243	0.047	24,631	3,017,145	0.112	337,392
29	-	598,777	0.042	25,070	3,042,216	0.111	338,610
30	-	682,606	0.037	25,518	3,067,734	0.111	340,035
31	-	778,171	0.033	25,974	3,093,707	0.110	341,650
32	-	887,115	0.030	26,438	3,120,145	0.110	343,440
33	-	1,020,182	0.027	27,146	3,147,291	0.110	345,416
34	-	1,173,210	0.024	27,873	3,175,164	0.109	347,569
35	-	1,349,191	0.021	28,619	3,203,783	0.109	349,889
36	-	1,551,570	0.019	29,386	3,233,169	0.109	352,370
37	-	1,784,305	0.017	30,173	3,263,342	0.109	355,004
38	-	2,069,794	0.015	31,251	3,294,593	0.109	357,816
39	-	2,400,961	0.013	32,367	3,326,960	0.108	360,803
40	-	2,785,115	0.012	33,523	3,360,482	0.108	363,963

Note:
*) Maintenance and running costs, including all attachments and year's supply of spareparts.

- Year 1= year 2000; Economic life end at 2023.
- The first 2-year the costs increase by 8% and continue to increase by 1% every 5 year afterwards.

Container Crane 02: Sumitomo: 50T: 1978: Retrofit 1998: Made 1976
(Assuming no residual value and a 12% discount rate)

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	2,783,200	69,547	1.000	2,852,747	2,852,747	1.000	2,852,747
2	-	74,415	0.893	66,442	2,919,189	0.528	1,542,213
3	-	79,624	0.797	63,476	2,982,665	0.372	1,108,776
4	-	85,994	0.712	61,209	3,043,874	0.294	894,775
5	-	92,874	0.636	59,023	3,102,896	0.248	768,548
6	-	100,303	0.567	56,915	3,159,811	0.217	686,203
7	-	108,328	0.507	54,882	3,214,693	0.196	628,925
8	-	116,994	0.452	52,922	3,267,616	0.180	587,304
9	-	127,523	0.404	51,505	3,319,120	0.168	556,186
10	-	139,001	0.361	50,125	3,369,245	0.158	532,413
11	-	151,511	0.322	48,782	3,418,027	0.150	513,972
12	-	165,147	0.287	47,476	3,465,503	0.144	499,518
13	-	180,010	0.257	46,204	3,511,707	0.139	488,118
14	-	198,011	0.229	45,379	3,557,086	0.135	479,163
15	-	217,812	0.205	44,569	3,601,655	0.131	472,152
16	-	239,593	0.183	43,773	3,645,427	0.128	466,712
17	-	263,552	0.163	42,991	3,688,418	0.125	462,556
18	-	289,907	0.146	42,223	3,730,642	0.123	459,460
19	-	321,797	0.130	41,846	3,772,488	0.121	457,290
20	-	357,195	0.116	41,473	3,813,961	0.120	455,900
21	-	396,486	0.104	41,102	3,855,063	0.118	455,173
22	-	440,100	0.093	40,735	3,895,799	0.117	455,010
23	-	488,511	0.083	40,372	3,936,171	0.116	455,330
24	-	547,132	0.074	40,372	3,976,542	0.115	456,107
25	-	612,788	0.066	40,372	4,016,914	0.114	457,283
26	-	686,323	0.059	40,372	4,057,286	0.113	458,806
27	-	768,681	0.053	40,372	4,097,658	0.112	460,636
28	-	860,923	0.047	40,372	4,138,030	0.112	462,735
29	-	972,843	0.042	40,732	4,178,762	0.111	465,112
30	-	1,099,313	0.037	41,096	4,219,858	0.111	467,740
31	-	1,242,223	0.033	41,463	4,261,320	0.110	470,595
32	-	1,403,712	0.030	41,833	4,303,154	0.110	473,656
33	-	1,586,195	0.027	42,207	4,345,360	0.110	476,904
34	-	1,808,262	0.024	42,960	4,388,320	0.109	480,367
35	-	2,061,419	0.021	43,727	4,432,048	0.109	484,030
36	-	2,350,018	0.019	44,508	4,476,556	0.109	487,881
37	-	2,679,020	0.017	45,303	4,521,859	0.109	491,912
38	-	3,054,083	0.015	46,112	4,567,971	0.109	496,113
39	-	3,512,195	0.013	47,347	4,615,318	0.108	500,523
40	-	4,039,025	0.012	48,615	4,663,933	0.108	505,136

Note:
*) Maintenance and running costs, including all attachments and year's supply of spareparts.
- Year 1= year 2000; Economic life end at 2021.
- The first 3-year the costs increase by 7% and continue to increase by 1% every 5 year afterwards.

Container Crane 03: Sumitomo: 50T: 1978: Retrofit 1997: Made 1976
(Assuming no residual value and a 12% discount rate)

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	2,783,200	73,521	1.000	2,856,721	2,856,721	1.000	2,856,721
2	-	78,667	0.893	70,239	2,926,959	0.528	1,546,318
3	-	84,174	0.797	67,103	2,994,062	0.372	1,113,013
4	-	90,908	0.712	64,706	3,058,769	0.294	899,154
5	-	98,180	0.636	62,395	3,121,164	0.248	773,073
6	-	106,035	0.567	60,167	3,181,331	0.217	690,876
7	-	114,518	0.507	58,018	3,239,349	0.196	633,749
8	-	123,679	0.452	55,946	3,295,296	0.180	592,279
9	-	134,810	0.404	54,448	3,349,743	0.168	561,318
10	-	146,943	0.361	52,989	3,402,732	0.158	537,705
11	-	160,168	0.322	51,570	3,454,302	0.150	519,427
12	-	174,583	0.287	50,188	3,504,491	0.144	505,137
13	-	190,296	0.257	48,844	3,553,335	0.139	493,905
14	-	209,325	0.229	47,972	3,601,307	0.135	485,119
15	-	230,258	0.205	47,115	3,648,422	0.131	478,283
16	-	253,284	0.183	46,274	3,694,696	0.128	473,020
17	-	278,612	0.163	45,448	3,740,144	0.125	469,043
18	-	306,473	0.146	44,636	3,784,780	0.123	466,127
19	-	340,185	0.130	44,238	3,829,017	0.121	464,142
20	-	377,605	0.116	43,843	3,872,860	0.120	462,941
21	-	419,142	0.104	43,451	3,916,311	0.118	462,405
22	-	465,248	0.093	43,063	3,959,374	0.117	462,435
23	-	516,425	0.083	42,679	4,002,053	0.116	462,952
24	-	578,396	0.074	42,679	4,044,731	0.115	463,929
25	-	647,803	0.066	42,679	4,087,410	0.114	465,308
26	-	725,540	0.059	42,679	4,130,089	0.113	467,039
27	-	812,605	0.053	42,679	4,172,767	0.112	469,079
28	-	910,117	0.047	42,679	4,215,446	0.112	471,392
29	-	1,028,432	0.042	43,060	4,258,506	0.111	473,988
30	-	1,162,129	0.037	43,444	4,301,950	0.111	476,839
31	-	1,313,205	0.033	43,832	4,345,782	0.110	479,922
32	-	1,483,922	0.030	44,223	4,390,005	0.110	483,215
33	-	1,676,832	0.027	44,618	4,434,624	0.110	486,701
34	-	1,911,588	0.024	45,415	4,480,039	0.109	490,407
35	-	2,179,211	0.021	46,226	4,526,265	0.109	494,319
36	-	2,484,300	0.019	47,051	4,573,316	0.109	498,427
37	-	2,832,102	0.017	47,892	4,621,208	0.109	502,720
38	-	3,228,597	0.015	48,747	4,669,955	0.109	507,190
39	-	3,712,886	0.013	50,053	4,720,007	0.108	511,876
40	-	4,269,819	0.012	51,393	4,771,401	0.108	516,775

Note:

*) Maintenance and running costs, including all attachments and year's supply of spareparts.

- Year 1= year 2000; Economic life end at 2020.
- The first 3-year the costs increase by 7% and continue to increase by 1% every 5 year afterwards.

Container Crane 01: Sumitomo: 35.5 T: 1986: Retrofit 1998: Made 1983
(Assuming no residual value and a 12% discount rate)

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	2,861,600	50,783	1.000	2,912,383	2,912,383	1.000	2,912,383
2	-	53,322	0.893	47,609	2,959,993	0.528	1,563,770
3	-	56,522	0.797	45,059	3,005,051	0.372	1,117,098
4	-	59,913	0.712	42,645	3,047,696	0.294	895,899
5	-	63,508	0.636	40,360	3,088,057	0.248	764,872
6	-	67,318	0.567	38,198	3,126,255	0.217	678,916
7	-	71,357	0.507	36,152	3,162,407	0.196	618,696
8	-	76,352	0.452	34,538	3,196,945	0.180	574,602
9	-	81,697	0.404	32,996	3,229,941	0.168	541,243
10	-	87,416	0.361	31,523	3,261,464	0.158	515,382
11	-	93,535	0.322	30,116	3,291,580	0.150	494,958
12	-	100,082	0.287	28,771	3,320,351	0.144	478,595
13	-	108,089	0.257	27,744	3,348,095	0.139	465,377
14	-	116,736	0.229	26,753	3,374,848	0.135	454,614
15	-	126,075	0.205	25,797	3,400,645	0.131	445,801
16	-	136,161	0.183	24,876	3,425,521	0.128	438,559
17	-	147,054	0.163	23,988	3,449,509	0.125	432,595
18	-	160,289	0.146	23,345	3,472,854	0.123	427,711
19	-	174,715	0.130	22,720	3,495,574	0.121	423,723
20	-	190,439	0.116	22,111	3,517,685	0.120	420,485
21	-	207,579	0.104	21,519	3,539,204	0.118	417,879
22	-	226,261	0.093	20,943	3,560,147	0.117	415,808
23	-	248,887	0.083	20,569	3,580,715	0.116	414,212
24	-	273,776	0.074	20,201	3,600,917	0.115	413,023
25	-	301,153	0.066	19,841	3,620,757	0.114	412,184
26	-	331,268	0.059	19,486	3,640,244	0.113	411,646
27	-	364,395	0.053	19,138	3,659,382	0.112	411,367
28	-	404,479	0.047	18,967	3,678,350	0.112	411,331
29	-	448,971	0.042	18,798	3,697,148	0.111	411,506
30	-	498,358	0.037	18,630	3,715,778	0.111	411,866
31	-	553,178	0.033	18,464	3,734,242	0.110	412,387
32	-	614,027	0.030	18,299	3,752,541	0.110	413,049
33	-	687,710	0.027	18,299	3,770,840	0.110	413,851
34	-	770,236	0.024	18,299	3,789,139	0.109	414,778
35	-	862,664	0.021	18,299	3,807,438	0.109	415,815
36	-	966,184	0.019	18,299	3,825,737	0.109	416,951
37	-	1,082,126	0.017	18,299	3,844,036	0.109	418,175
38	-	1,222,802	0.015	18,462	3,862,499	0.109	419,494
39	-	1,381,766	0.013	18,627	3,881,126	0.108	420,901
40	-	1,561,396	0.012	18,794	3,899,920	0.108	422,388

Note:
*) Maintenance and running costs, including all attachments and year's supply of spareparts.
- Year 1= year 2000; Economic life end at 2027.
- The first 2-year the costs increase by 5% and continue to increase by 1% every 5 year afterwards.

Container Crane Hire-purchase 1: Hitachi (Pre-Panamax): Made 1976
(Assuming no residual value and a 12% discount rate)

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	1,434,888	-	1.000	1,434,888	1,434,888	1.000	1,434,888
2	1,434,888	-	0.893	1,281,150	2,716,038	0.528	1,434,888
3	1,434,888	-	0.797	1,143,884	3,859,922	0.372	1,434,888
4	1,434,888	-	0.712	1,021,325	4,881,247	0.294	1,434,888
5	1,434,888	-	0.636	911,897	5,793,144	0.248	1,434,888
6	-	125,000	0.567	70,928	5,864,072	0.217	1,273,476
7	-	135,000	0.507	68,395	5,932,468	0.196	1,160,633
8	-	145,800	0.452	65,953	5,998,420	0.180	1,078,124
9	-	157,464	0.404	63,597	6,062,017	0.168	1,015,815
10	-	170,061	0.361	61,326	6,123,343	0.158	967,620
11	-	185,367	0.322	59,683	6,183,026	0.150	929,747
12	-	202,050	0.287	58,084	6,241,111	0.144	899,594
13	-	220,234	0.257	56,529	6,297,639	0.139	875,356
14	-	240,055	0.229	55,014	6,352,654	0.135	855,744
15	-	264,061	0.205	54,032	6,406,686	0.131	839,872
16	-	290,467	0.183	53,067	6,459,753	0.128	827,021
17	-	319,513	0.163	52,120	6,511,872	0.125	816,640
18	-	351,465	0.146	51,189	6,563,061	0.123	808,296
19	-	386,611	0.130	50,275	6,613,336	0.121	801,649
20	-	429,138	0.116	49,826	6,663,162	0.120	796,479
21	-	476,344	0.104	49,381	6,712,543	0.118	792,560
22	-	528,741	0.093	48,940	6,761,483	0.117	789,708
23	-	586,903	0.083	48,503	6,809,986	0.116	787,769
24	-	651,462	0.074	48,070	6,858,056	0.115	786,616
25	-	729,638	0.066	48,070	6,906,126	0.114	786,188
26	-	817,194	0.059	48,070	6,954,196	0.113	786,395
27	-	915,258	0.053	48,070	7,002,266	0.112	787,155
28	-	1,025,089	0.047	48,070	7,050,337	0.112	788,403
29	-	1,148,099	0.042	48,070	7,098,407	0.111	790,079
30	-	1,297,352	0.037	48,499	7,146,906	0.111	792,181
31	-	1,466,008	0.033	48,932	7,195,838	0.110	794,665
32	-	1,656,589	0.030	49,369	7,245,207	0.110	797,492
33	-	1,871,946	0.027	49,810	7,295,017	0.110	800,630
34	-	2,115,299	0.024	50,255	7,345,272	0.109	804,049
35	-	2,411,440	0.021	51,152	7,396,424	0.109	807,773
36	-	2,749,042	0.019	52,066	7,448,490	0.109	811,780
37	-	3,133,908	0.017	52,995	7,501,485	0.109	816,052
38	-	3,572,655	0.015	53,942	7,555,427	0.109	820,572
39	-	4,072,827	0.013	54,905	7,610,332	0.108	825,327
40	-	4,683,751	0.012	56,376	7,666,707	0.108	830,357

Note:

*) Maintenance and running costs, including all attachments and year's supply of spareparts.

- Year 1= year 1997; Economic life end at 2021.
- The first 5-year the costs increase by 8% and continue to increase by 1% every 5 year afterwards.

Container Crane 04: Noell: 40T: 1992: Made 1992
(Assuming no residual value and a 12% discount rate)

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	2,985,980	148,859	1.000	3,134,839	3,134,839	1.000	3,134,839
2	-	154,814	0.893	138,227	3,273,066	0.528	1,729,167
3	-	162,554	0.797	129,587	3,402,653	0.372	1,264,903
4	-	170,682	0.712	121,488	3,524,141	0.294	1,035,954
5	-	179,216	0.636	113,895	3,638,037	0.248	901,095
6	-	188,177	0.567	106,777	3,744,813	0.217	813,245
7	-	197,586	0.507	100,103	3,844,917	0.196	752,223
8	-	209,441	0.452	94,741	3,939,657	0.180	708,093
9	-	222,008	0.404	89,665	4,029,322	0.168	675,195
10	-	235,328	0.361	84,862	4,114,184	0.158	650,130
11	-	249,448	0.322	80,315	4,194,499	0.150	630,731
12	-	264,415	0.287	76,013	4,270,512	0.144	615,552
13	-	282,924	0.257	72,619	4,343,132	0.139	603,684
14	-	302,728	0.229	69,377	4,412,509	0.135	594,394
15	-	323,919	0.205	66,280	4,478,789	0.131	587,138
16	-	346,594	0.183	63,321	4,542,111	0.128	581,512
17	-	370,855	0.163	60,494	4,602,605	0.125	577,203
18	-	400,523	0.146	58,334	4,660,939	0.123	574,033
19	-	432,565	0.130	56,251	4,717,190	0.121	571,803
20	-	467,171	0.116	54,242	4,771,431	0.120	570,351
21	-	504,544	0.104	52,304	4,823,736	0.118	569,546
22	-	544,908	0.093	50,436	4,874,172	0.117	569,279
23	-	593,949	0.083	49,085	4,923,258	0.116	569,515
24	-	647,405	0.074	47,771	4,971,028	0.115	570,174
25	-	705,671	0.066	46,491	5,017,520	0.114	571,191
26	-	769,182	0.059	45,246	5,062,765	0.113	572,508
27	-	838,408	0.053	44,034	5,106,799	0.112	574,078
28	-	922,249	0.047	43,248	5,150,047	0.112	575,903
29	-	1,014,474	0.042	42,475	5,192,522	0.111	577,947
30	-	1,115,921	0.037	41,717	5,234,239	0.111	580,176
31	-	1,227,513	0.033	40,972	5,275,211	0.110	582,563
32	-	1,350,265	0.030	40,240	5,315,451	0.110	585,081
33	-	1,498,794	0.027	39,881	5,355,332	0.110	587,749
34	-	1,663,661	0.024	39,525	5,394,857	0.109	590,547
35	-	1,846,664	0.021	39,172	5,434,029	0.109	593,457
36	-	2,049,797	0.019	38,822	5,472,851	0.109	596,463
37	-	2,275,274	0.017	38,476	5,511,326	0.109	599,552
38	-	2,548,307	0.015	38,476	5,549,802	0.109	602,747
39	-	2,854,104	0.013	38,476	5,588,277	0.108	606,039
40	-	3,196,597	0.012	38,476	5,626,753	0.108	609,416

Note:
*) Maintenance and running costs, including all attachments and year's supply of spareparts.
- Year 1= year 2000; Economic life end at 2021.
- The first 2-year the costs increase by 4% and continue to increase by 1% every 5 year afterwards.

Container Crane 05: Noell: 40T: 1992: Retrofit 1997: Made 1992
(Assuming no residual value and a 12% discount rate)

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	3,193,340	166,720	1.000	3,360,060	3,360,060	1.000	3,360,060
2	-	173,389	0.893	154,812	3,514,872	0.528	1,856,914
3	-	182,059	0.797	145,136	3,660,008	0.372	1,360,572
4	-	191,162	0.712	136,065	3,796,073	0.294	1,115,891
5	-	200,720	0.636	127,561	3,923,634	0.248	971,834
6	-	210,756	0.567	119,588	4,043,222	0.217	878,050
7	-	221,293	0.507	112,114	4,155,336	0.196	812,953
8	-	234,571	0.452	106,108	4,261,444	0.180	765,929
9	-	248,645	0.404	100,424	4,361,868	0.168	730,920
10	-	263,564	0.361	95,044	4,456,912	0.158	704,288
11	-	279,378	0.322	89,952	4,546,864	0.150	683,716
12	-	296,140	0.287	85,133	4,631,997	0.144	667,656
13	-	316,870	0.257	81,333	4,713,330	0.139	655,141
14	-	339,051	0.229	77,702	4,791,032	0.135	645,383
15	-	362,785	0.205	74,233	4,865,265	0.131	637,802
16	-	388,180	0.183	70,919	4,936,184	0.128	631,964
17	-	415,352	0.163	67,753	5,003,937	0.125	627,533
18	-	448,580	0.146	65,333	5,069,270	0.123	624,323
19	-	484,467	0.130	63,000	5,132,270	0.121	622,118
20	-	523,224	0.116	60,750	5,193,020	0.120	620,746
21	-	565,082	0.104	58,580	5,251,600	0.118	620,064
22	-	610,289	0.093	56,488	5,308,088	0.117	619,959
23	-	665,215	0.083	54,975	5,363,063	0.116	620,391
24	-	725,084	0.074	53,502	5,416,565	0.115	621,277
25	-	790,342	0.066	52,069	5,468,635	0.114	622,545
26	-	861,472	0.059	50,675	5,519,309	0.113	624,135
27	-	939,005	0.053	49,317	5,568,627	0.112	625,994
28	-	1,032,905	0.047	48,437	5,617,063	0.112	628,127
29	-	1,136,196	0.042	47,572	5,664,635	0.111	630,495
30	-	1,249,816	0.037	46,722	5,711,357	0.111	633,061
31	-	1,374,797	0.033	45,888	5,757,245	0.110	635,795
32	-	1,512,277	0.030	45,068	5,802,314	0.110	638,671
33	-	1,678,627	0.027	44,666	5,846,980	0.110	641,708
34	-	1,863,276	0.024	44,267	5,891,247	0.109	644,884
35	-	2,068,237	0.021	43,872	5,935,119	0.109	648,182
36	-	2,295,743	0.019	43,480	5,978,599	0.109	651,583
37	-	2,548,274	0.017	43,092	6,021,691	0.109	655,072
38	-	2,854,067	0.015	43,092	6,064,783	0.109	658,678
39	-	3,196,555	0.013	43,092	6,107,875	0.108	662,388
40	-	3,580,142	0.012	43,092	6,150,967	0.108	666,192

Note:
*) Maintenance and running costs, including all attachments and year's supply of spareparts.
- Year 1= year 2000; Economic life end at 2021.
- The first 2-year the costs increase by 4% and continue to increase by 1% every 5 year afterwards.

Container Crane 06: Noell: 40T: 1992: Retrofit 1997: Made 1992
(Assuming no residual value and a 12% discount rate)

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	3,193,340	160,041	1.000	3,353,381	3,353,381	1.000	3,353,381
2	-	166,443	0.893	148,610	3,501,991	0.528	1,850,109
3	-	174,765	0.797	139,322	3,641,313	0.372	1,353,622
4	-	183,504	0.712	130,614	3,771,927	0.294	1,108,793
5	-	192,679	0.636	122,451	3,894,378	0.248	964,588
6	-	202,313	0.567	114,798	4,009,176	0.217	870,656
7	-	212,428	0.507	107,623	4,116,798	0.196	805,414
8	-	225,174	0.452	101,857	4,218,656	0.180	758,239
9	-	238,684	0.404	96,401	4,315,056	0.168	723,076
10	-	253,005	0.361	91,236	4,406,293	0.158	696,289
11	-	268,186	0.322	86,349	4,492,641	0.150	675,563
12	-	284,277	0.287	81,723	4,574,364	0.144	659,349
13	-	304,176	0.257	78,074	4,652,439	0.139	646,677
14	-	325,469	0.229	74,589	4,727,028	0.135	636,761
15	-	348,251	0.205	71,259	4,798,287	0.131	629,022
16	-	372,629	0.183	68,078	4,866,365	0.128	623,025
17	-	398,713	0.163	65,039	4,931,403	0.125	618,436
18	-	430,610	0.146	62,716	4,994,119	0.123	615,067
19	-	465,059	0.130	60,476	5,054,595	0.121	612,703
20	-	502,264	0.116	58,316	5,112,912	0.120	611,170
21	-	542,445	0.104	56,233	5,169,145	0.118	610,329
22	-	585,840	0.093	54,225	5,223,370	0.117	610,064
23	-	638,566	0.083	52,773	5,276,143	0.116	610,337
24	-	696,037	0.074	51,359	5,327,502	0.115	611,062
25	-	758,680	0.066	49,983	5,377,486	0.114	612,169
26	-	826,961	0.059	48,645	5,426,130	0.113	613,598
27	-	901,388	0.053	47,342	5,473,472	0.112	615,297
28	-	991,527	0.047	46,496	5,519,968	0.112	617,270
29	-	1,090,679	0.042	45,666	5,565,634	0.111	619,476
30	-	1,199,747	0.037	44,850	5,610,485	0.111	621,880
31	-	1,319,722	0.033	44,050	5,654,534	0.110	624,453
32	-	1,451,694	0.030	43,263	5,697,797	0.110	627,166
33	-	1,611,381	0.027	42,877	5,740,674	0.110	630,041
34	-	1,788,633	0.024	42,494	5,783,168	0.109	633,054
35	-	1,985,382	0.021	42,114	5,825,282	0.109	636,186
36	-	2,203,774	0.019	41,738	5,867,021	0.109	639,422
37	-	2,446,189	0.017	41,366	5,908,386	0.109	642,746
38	-	2,739,732	0.015	41,366	5,949,752	0.109	646,185
39	-	3,068,500	0.013	41,366	5,991,118	0.108	649,726
40	-	3,436,720	0.012	41,366	6,032,484	0.108	653,359

Note:
*) Maintenance and running costs, including all attachments and year's supply of spareparts.

- Year 1= year 2000; Economic life end at 2023.
- The first 2-year the costs increase by 4% and continue to increase by 1% every 5 year afterwards.

Container Crane 07: Gunanusa: 35T: 1997: Made 1997
(Assuming no residual value and a 12% discount rate)

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	3,608,060	145,256	1.000	3,753,316	3,753,316	1.000	3,753,316
2	-	149,613	0.893	133,583	3,886,899	0.528	2,053,456
3	-	155,598	0.797	124,042	4,010,941	0.372	1,491,028
4	-	161,822	0.712	115,182	4,126,123	0.294	1,212,912
5	-	168,295	0.636	106,954	4,233,077	0.248	1,048,479
6	-	175,027	0.567	99,315	4,332,392	0.217	940,847
7	-	182,028	0.507	92,221	4,424,612	0.196	865,635
8	-	191,129	0.452	86,457	4,511,070	0.180	810,796
9	-	200,685	0.404	81,053	4,592,123	0.168	769,504
10	-	210,720	0.361	75,988	4,668,111	0.158	737,662
11	-	221,256	0.322	71,238	4,739,349	0.150	712,660
12	-	232,318	0.287	66,786	4,806,135	0.144	692,756
13	-	246,258	0.257	63,208	4,869,343	0.139	676,827
14	-	261,033	0.229	59,822	4,929,165	0.135	663,990
15	-	276,695	0.205	56,617	4,985,783	0.131	653,602
16	-	293,297	0.183	53,584	5,039,367	0.128	645,174
17	-	310,895	0.163	50,714	5,090,080	0.125	638,336
18	-	332,657	0.146	48,450	5,138,530	0.123	632,853
19	-	355,943	0.130	46,287	5,184,817	0.121	628,488
20	-	380,859	0.116	44,220	5,229,037	0.120	625,051
21	-	407,519	0.104	42,246	5,271,283	0.118	622,388
22	-	436,046	0.093	40,360	5,311,644	0.117	620,374
23	-	470,929	0.083	38,919	5,350,562	0.116	618,945
24	-	508,604	0.074	37,529	5,388,091	0.115	618,011
25	-	549,292	0.066	36,189	5,424,280	0.114	617,496
26	-	593,235	0.059	34,896	5,459,176	0.113	617,335
27	-	640,694	0.053	33,650	5,492,825	0.112	617,473
28	-	698,357	0.047	32,748	5,525,574	0.112	617,897
29	-	761,209	0.042	31,871	5,557,445	0.111	618,565
30	-	829,717	0.037	31,018	5,588,463	0.111	619,439
31	-	904,392	0.033	30,187	5,618,649	0.110	620,490
32	-	985,787	0.030	29,378	5,648,028	0.110	621,688
33	-	1,084,366	0.027	28,854	5,676,881	0.110	623,039
34	-	1,192,803	0.024	28,338	5,705,219	0.109	624,521
35	-	1,312,083	0.021	27,832	5,733,052	0.109	626,114
36	-	1,443,291	0.019	27,335	5,760,387	0.109	627,801
37	-	1,587,620	0.017	26,847	5,787,234	0.109	629,566
38	-	1,762,259	0.015	26,607	5,813,842	0.109	631,424
39	-	1,956,107	0.013	26,370	5,840,211	0.108	633,360
40	-	2,171,279	0.012	26,134	5,866,346	0.108	635,365

Note:

*) Maintenance and running costs, including all attachments and year's supply of spareparts.

- Year 1= year 2000; Economic life end at 2025.
- The first 2-year the costs increase by 3% and continue to increase by 1% every 5 year afterwards.

Container Crane 08: Gunanusa: 35T: 1997:Made 1997
(Assuming no residual value and a 12% discount rate)

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	3,691,010	138,363	1.000	3,829,373	3,829,373	1.000	3,829,373
2	-	142,514	0.893	127,245	3,956,618	0.528	2,090,289
3	-	148,214	0.797	118,156	4,074,773	0.372	1,514,757
4	-	154,143	0.712	109,716	4,184,489	0.294	1,230,070
5	-	160,309	0.636	101,879	4,286,368	0.248	1,061,679
6	-	166,721	0.567	94,602	4,380,970	0.217	951,397
7	-	173,390	0.507	87,845	4,468,815	0.196	874,283
8	-	182,059	0.452	82,354	4,551,169	0.180	818,003
9	-	191,162	0.404	77,207	4,628,377	0.168	775,579
10	-	200,721	0.361	72,382	4,700,759	0.158	742,821
11	-	210,757	0.322	67,858	4,768,616	0.150	717,061
12	-	221,294	0.287	63,617	4,832,233	0.144	696,518
13	-	234,572	0.257	60,209	4,892,442	0.139	680,037
14	-	248,646	0.229	56,983	4,949,425	0.135	666,720
15	-	263,565	0.205	53,931	5,003,356	0.131	655,905
16	-	279,379	0.183	51,042	5,054,398	0.128	647,098
17	-	296,142	0.163	48,307	5,102,705	0.125	639,919
18	-	316,872	0.146	46,151	5,148,855	0.123	634,124
19	-	339,053	0.130	44,090	5,192,946	0.121	629,473
20	-	362,786	0.116	42,122	5,235,068	0.120	625,772
21	-	388,181	0.104	40,242	5,275,309	0.118	622,864
22	-	415,354	0.093	38,445	5,313,754	0.117	620,620
23	-	448,582	0.083	37,072	5,350,826	0.116	618,976
24	-	484,469	0.074	35,748	5,386,574	0.115	617,837
25	-	523,227	0.066	34,471	5,421,045	0.114	617,128
26	-	565,085	0.059	33,240	5,454,285	0.113	616,782
27	-	610,292	0.053	32,053	5,486,338	0.112	616,743
28	-	665,218	0.047	31,194	5,517,533	0.112	616,997
29	-	725,087	0.042	30,359	5,547,892	0.111	617,501
30	-	790,345	0.037	29,546	5,577,437	0.111	618,217
31	-	861,476	0.033	28,754	5,606,192	0.110	619,114
32	-	939,009	0.030	27,984	5,634,176	0.110	620,163
33	-	1,032,910	0.027	27,484	5,661,660	0.110	621,369
34	-	1,136,201	0.024	26,994	5,688,654	0.109	622,708
35	-	1,249,821	0.021	26,512	5,715,165	0.109	624,160
36	-	1,374,803	0.019	26,038	5,741,203	0.109	625,710
37	-	1,512,284	0.017	25,573	5,766,777	0.109	627,341
38	-	1,678,635	0.015	25,345	5,792,121	0.109	629,065
39	-	1,863,285	0.013	25,119	5,817,240	0.108	630,869
40	-	2,068,246	0.012	24,894	5,842,134	0.108	632,743

Note:
*) Maintenance and running costs, including all attachments and year's supply of spareparts.
- Year 1= year 2000; Economic life end at 2026.
- The first 2-year the costs increase by 3% and continue to increase by 1% every 5 year afterwards.

Container Crane Hire-purchase 2: Mitsui: Panamax: Made 1983
(Assuming no residual value and a 12% discount rate)
Leased: 1996; Transferred: 2001

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	2,254,824	-	1.000	2,254,824	2,254,824	1.000	2,254,824
2	2,254,824	-	0.893	2,013,236	4,268,060	0.528	2,254,824
3	2,254,824	-	0.797	1,797,532	6,065,592	0.372	2,254,824
4	2,254,824	-	0.712	1,604,939	7,670,531	0.294	2,254,824
5	2,254,824	-	0.636	1,432,981	9,103,512	0.248	2,254,824
6	-	63,508	0.567	36,036	9,139,548	0.217	1,984,797
7	-	67,318	0.507	34,106	9,173,654	0.196	1,794,741
8	-	71,357	0.452	32,278	9,205,932	0.180	1,654,625
9	-	76,352	0.404	30,837	9,236,770	0.168	1,547,810
10	-	81,697	0.361	29,461	9,266,231	0.158	1,464,264
11	-	87,416	0.322	28,146	9,294,376	0.150	1,397,604
12	-	93,535	0.287	26,889	9,321,265	0.144	1,343,567
13	-	100,082	0.257	25,689	9,346,954	0.139	1,299,203
14	-	108,089	0.229	24,771	9,371,725	0.135	1,262,432
15	-	116,736	0.205	23,887	9,395,612	0.131	1,231,700
16	-	126,075	0.183	23,033	9,418,645	0.128	1,205,839
17	-	136,161	0.163	22,211	9,440,856	0.125	1,183,957
18	-	147,054	0.146	21,418	9,462,274	0.123	1,165,358
19	-	160,289	0.130	20,844	9,483,117	0.121	1,149,515
20	-	174,715	0.116	20,286	9,503,403	0.120	1,135,986
21	-	190,439	0.104	19,742	9,523,145	0.118	1,124,412
22	-	207,579	0.093	19,213	9,542,359	0.117	1,114,501
23	-	226,261	0.083	18,699	9,561,057	0.116	1,106,009
24	-	248,887	0.074	18,365	9,579,422	0.115	1,098,755
25	-	273,776	0.066	18,037	9,597,459	0.114	1,092,568
26	-	301,153	0.059	17,715	9,615,174	0.113	1,087,303
27	-	331,268	0.053	17,398	9,632,572	0.112	1,082,840
28	-	364,395	0.047	17,088	9,649,660	0.112	1,079,072
29	-	404,479	0.042	16,935	9,666,595	0.111	1,075,928
30	-	448,971	0.037	16,784	9,683,379	0.111	1,073,330
31	-	498,358	0.033	16,634	9,700,014	0.110	1,071,211
32	-	553,178	0.030	16,486	9,716,499	0.110	1,069,512
33	-	614,027	0.027	16,338	9,732,838	0.110	1,068,182
34	-	687,710	0.024	16,338	9,749,176	0.109	1,067,192
35	-	770,236	0.021	16,338	9,765,515	0.109	1,066,504
36	-	862,664	0.019	16,338	9,781,853	0.109	1,066,083
37	-	966,184	0.017	16,338	9,798,192	0.109	1,065,900
38	-	1,082,126	0.015	16,338	9,814,530	0.109	1,065,926
39	-	1,222,802	0.013	16,484	9,831,014	0.108	1,066,156
40	-	1,345,082	0.012	16,190	9,847,204	0.108	1,066,519

Note:
*) Maintenance and running costs, including all attachments and year's supply of spareparts.

- Year 1= year 1996; Economic life end at 2032.
- The first 3-year the costs increase by 6% and continue to increase by 1% every 5 year afterwards.

Container Crane Hire-purchase 3: Mitsui: Panamax
(Assuming no residual value and a 12% discount rate)

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	2,254,824	-	1.000	2,254,824	2,254,824	1.000	2,254,824
2	2,254,824	-	0.893	2,013,236	4,268,060	0.528	2,254,824
3	2,254,824	-	0.797	1,797,532	6,065,592	0.372	2,254,824
4	2,254,824	-	0.712	1,604,939	7,670,531	0.294	2,254,824
5	2,254,824	-	0.636	1,432,981	9,103,512	0.248	2,254,824
6	-	63,508	0.567	36,036	9,139,548	0.217	1,984,797
7	-	67,318	0.507	34,106	9,173,654	0.196	1,794,741
8	-	71,357	0.452	32,278	9,205,932	0.180	1,654,625
9	-	76,352	0.404	30,837	9,236,770	0.168	1,547,810
10	-	81,697	0.361	29,461	9,266,231	0.158	1,464,264
11	-	87,416	0.322	28,146	9,294,376	0.150	1,397,604
12	-	93,535	0.287	26,889	9,321,265	0.144	1,343,567
13	-	100,082	0.257	25,689	9,346,954	0.139	1,299,203
14	-	108,089	0.229	24,771	9,371,725	0.135	1,262,432
15	-	116,736	0.205	23,887	9,395,612	0.131	1,231,700
16	-	126,075	0.183	23,033	9,418,645	0.128	1,205,839
17	-	136,161	0.163	22,211	9,440,856	0.125	1,183,957
18	-	147,054	0.146	21,418	9,462,274	0.123	1,165,358
19	-	160,289	0.130	20,844	9,483,117	0.121	1,149,515
20	-	174,715	0.116	20,286	9,503,403	0.120	1,135,986
21	-	190,439	0.104	19,742	9,523,145	0.118	1,124,412
22	-	207,579	0.093	19,213	9,542,359	0.117	1,114,501
23	-	226,261	0.083	18,699	9,561,057	0.116	1,106,009
24	-	248,887	0.074	18,365	9,579,422	0.115	1,098,755
25	-	273,776	0.066	18,037	9,597,459	0.114	1,092,568
26	-	301,153	0.059	17,715	9,615,174	0.113	1,087,303
27	-	331,268	0.053	17,398	9,632,572	0.112	1,082,840
28	-	364,395	0.047	17,088	9,649,660	0.112	1,079,072
29	-	404,479	0.042	16,935	9,666,595	0.111	1,075,928
30	-	448,971	0.037	16,784	9,683,379	0.111	1,073,330
31	-	498,358	0.033	16,634	9,700,014	0.110	1,071,211
32	-	553,178	0.030	16,486	9,716,499	0.110	1,069,512
33	-	614,027	0.027	16,338	9,732,838	0.110	1,068,182
34	-	687,710	0.024	16,338	9,749,176	0.109	1,067,192
35	-	770,236	0.021	16,338	9,765,515	0.109	1,066,504
36	-	862,664	0.019	16,338	9,781,853	0.109	1,066,083
37	-	966,184	0.017	16,338	9,798,192	0.109	1,065,900
38	-	1,082,126	0.015	16,338	9,814,530	0.109	1,065,926
39	-	1,222,802	0.013	16,484	9,831,014	0.108	1,066,156
40	-	1,345,082	0.012	16,190	9,847,204	0.108	1,066,519

Note:
*) Maintenance and running costs, including all attachments and year's supply of spareparts.
- Year 1= year 1996; Economic life end at 2032.
- The first 3-year the costs increase by 6% and continue to increase by 1% every 5 year afterwards.

Container Crane Type A
(Assuming no residual value and a 12% discount rate)

Unit: $ US

Year	Capital Cost	Annual Maintenance Cost*	Discount Factor 12%	Present Value of Annual Total Cost	Accumulated Present Value Total Cost	Capital Recovery Factor	Equivalent Av. Annual Total Cost
1	6,780,000	125,000	1.000	6,905,000	6,905,000	1.000	6,905,000
2		128,750	0.893	114,955	7,019,955	0.528	3,708,656
3		132,613	0.797	105,718	7,125,673	0.372	2,648,899
4		136,591	0.712	97,223	7,222,896	0.294	2,123,238
5		140,689	0.636	89,410	7,312,306	0.248	1,811,165
6		146,316	0.567	83,024	7,395,330	0.217	1,606,013
7		152,169	0.507	77,093	7,472,423	0.196	1,461,911
8		158,256	0.452	71,587	7,544,010	0.180	1,355,920
9		164,586	0.404	66,473	7,610,483	0.168	1,275,292
10		171,169	0.361	61,725	7,672,209	0.158	1,212,375
11		179,728	0.322	57,867	7,730,076	0.150	1,162,378
12		188,714	0.287	54,251	7,784,327	0.144	1,122,033
13		198,150	0.257	50,860	7,835,187	0.139	1,089,071
14		208,057	0.229	47,681	7,882,868	0.135	1,061,873
15		218,460	0.205	44,701	7,927,570	0.131	1,039,249
16		231,568	0.183	42,307	7,969,876	0.128	1,020,358
17		245,462	0.163	40,040	8,009,916	0.125	1,004,506
18		260,189	0.146	37,895	8,047,812	0.123	991,155
19		275,801	0.130	35,865	8,083,677	0.121	979,879
20		292,349	0.116	33,944	8,117,620	0.120	970,337
21		312,813	0.104	32,428	8,150,049	0.118	962,289
22		334,710	0.093	30,981	8,181,029	0.117	955,504
23		358,140	0.083	29,598	8,210,627	0.116	949,793
24		383,210	0.074	28,276	8,238,903	0.115	944,998
25		410,034	0.066	27,014	8,265,917	0.114	940,986
26		442,837	0.059	26,049	8,291,966	0.113	937,672
27		478,264	0.053	25,119	8,317,085	0.112	934,960
28		516,525	0.047	24,222	8,341,307	0.112	932,766
29		557,847	0.042	23,357	8,364,663	0.111	931,018
30		602,475	0.037	22,522	8,387,186	0.111	929,657
31		656,698	0.033	21,919	8,409,105	0.110	928,651
32		715,801	0.030	21,332	8,430,437	0.110	927,953
33		780,223	0.027	20,761	8,451,198	0.110	927,521
34		850,443	0.024	20,205	8,471,402	0.109	927,321
35		926,983	0.021	19,663	8,491,066	0.109	927,320
36		1,019,681	0.019	19,312	8,510,378	0.109	927,511
37		1,121,649	0.017	18,967	8,529,346	0.109	927,868
38		1,233,814	0.015	18,629	8,547,974	0.109	928,370
39		1,357,195	0.013	18,296	8,566,270	0.108	928,996
40	-	1,492,915	0.012	17,969	8,584,240	0.108	929,732

Note:
*) Maintenance and running costs, including all attachments and year's supply of spareparts.

- Year 1= year when the equipment is purchased; Economic life end after 35 years.
- The first 5-year the costs increase by 3% and continue to increase by 1% every 5 year afterwards.

Appendix 5
Summary of optimal solutions using Quant System 3.0 software

UTILISATION 35%

Solution Summary for 2000 UTILISATION 35

08-07-2000 01:17:37 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	3	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	0	7707320

Minimized OBJ = 26364402 Iteration = 31 Elapsed CPU seconds = 3.24023
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 4

Solution Summary for 2001 UTILISATION 35

08-07-2000 01:19:45 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	5	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	0	7707320

Minimized OBJ = 38863936 Iteration = 17 Elapsed CPU seconds = 1.96972
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2002 UTILISATION 35

08-07-2000 01:22:05 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	7	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	0	7707320

Minimized OBJ = 51363472 Iteration = 17 Elapsed CPU seconds = 1.97998
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2003 UTILISATION 35

08-07-2000 01:23:37 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	9	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	0	7707320

Minimized OBJ = 63863004 Iteration = 17 Elapsed CPU seconds = 1.97998
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2004 UTILISATION 35

08-07-2000 01:25:33 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	11	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	0	7707320

Minimized OBJ = 76362536 Iteration = 17 Elapsed CPU seconds = 1.97998
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2005 UTILISATION 35

08-07-2000 01:26:58 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	11	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	2	7707320

Minimized OBJ = 91777176 Iteration = 27 Elapsed CPU seconds = 3.12988
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 4

Solution Summary for 2006 UTILISATION 35

08-07-2000 01:29:28 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	13	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	3	7707320

Minimized OBJ = 111984032 Iteration = 37 Elapsed CPU seconds = 4.66992
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 5

Solution Summary for 2007 UTILISATION 35

08-07-2000 01:31:14 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	14	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	5	7707320

Minimized OBJ = 133648440 Iteration = 41 Elapsed CPU seconds = 5.16015
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 5

Solution Summary for 2008 UTILISATION 35

08-07-2000 01:32:56 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	18	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	5	7707320

Minimized OBJ = 158647504 Iteration = 49 Elapsed CPU seconds = 6.14990
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 5

Solution Summary for 2009 UTILISATION 35

08-07-2000 01:34:43 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	20	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	7	7707320

Minimized OBJ = 186561680 Iteration = 55 Elapsed CPU seconds = 9.56005
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 6

UTILISATION 40%

Solution Summary for 2000 UTILISATION 40

08-07-2000 00:50:17 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	2	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	0	7707320

Minimized OBJ = 20114636 Iteration = 17 Elapsed CPU seconds = 1.81005
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2001 UTILISATION 40

08-07-2000 00:52:28 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	3	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	0	7707320

Minimized OBJ = 26364402 Iteration = 7 Elapsed CPU seconds = .820068
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 2

Solution Summary for 2002 UTILISATION 40

08-07-2000 00:54:38 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	3	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	1	7707320

Minimized OBJ = 34123804 Iteration = 13 Elapsed CPU seconds = 1.53002
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2003 UTILISATION 40

08-07-2000 00:57:02 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	5	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	1	7707320

Minimized OBJ = 46571256 Iteration = 17 Elapsed CPU seconds = 2.15014
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2004 UTILISATION 40

08-07-2000 00:58:39 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	7	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	1	7707320

Minimized OBJ = 59070792 Iteration = 17 Elapsed CPU seconds = 2.19995
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2005 UTILISATION 40

08-07-2000 01:00:22 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	8	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	2	7707320

Minimized OBJ = 72975792 Iteration = 19 Elapsed CPU seconds = 2.46997
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 4

Solution Summary for 2006 UTILISATION 40

08-07-2000 01:02:11 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	11	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	2	7707320

Minimized OBJ = 91777176 Iteration = 31 Elapsed CPU seconds = 3.89990
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 4

Solution Summary for 2007 UTILISATION 40

08-07-2000 01:03:45 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	14	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	2	7707320

Minimized OBJ = 110526480 Iteration = 31 Elapsed CPU seconds = 3.90014
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 4

Solution Summary for 2008 UTILISATION 40

08-07-2000 01:05:51 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	16	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	3	7707320

Minimized OBJ = 130733336 Iteration = 35 Elapsed CPU seconds = 4.55981
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 5

Solution Summary for 2009 UTILISATION 40

08-07-2000 01:07:40 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	20	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	3	7707320

Minimized OBJ = 155732400 Iteration = 43 Elapsed CPU seconds = 5.42993
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 5

UTILISATION 45%

Solution Summary for 2000 UTILISATION 45

08-06-2000 23:35:49 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	0	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	0	7707320

Solution Summary for 2001 UTILISATION 45

08-06-2000 23:39:42 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	0	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	1	7707320

Minimized OBJ = 15322421 Iteration = 13 Elapsed CPU seconds = 1.36718
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2002 UTILISATION 45

08-07-2000 00:03:27 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	2	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	1	7707320

Minimized OBJ = 27821956 Iteration = 17 Elapsed CPU seconds = 1.97999
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2003 UTILISATION 45

08-07-2000 00:09:07 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	3	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	1	7707320

Minimized OBJ = 34071720 Iteration = 7 Elapsed CPU seconds = .930053
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 2

Solution Summary for 2004 UTILISATION 45

08-07-2000 00:10:33 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	5	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	1	7707320

Minimized OBJ = 46571256 Iteration = 17 Elapsed CPU seconds = 2.14996
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2005 UTILISATION 45

08-07-2000 00:12:21 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	7	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	1	7707320

Minimized OBJ = 59070792 Iteration = 17 Elapsed CPU seconds = 2.14001
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2006 UTILISATION 45

08-07-2000 00:15:12 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	7	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	3	7707320

Minimized OBJ = 74485432 Iteration = 27 Elapsed CPU seconds = 3.46002
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 4

Solution Summary for 2007 UTILISATION 45

08-07-2000 00:17:22 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	10	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	3	7707320

Minimized OBJ = 93234728 Iteration = 31 Elapsed CPU seconds = 3.90002
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 4

Solution Summary for 2008 UTILISATION 45

08-07-2000 00:19:14 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	13	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	3	7707320

Minimized OBJ = 111984032 Iteration = 31 Elapsed CPU seconds = 3.90002
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 4

Solution Summary for 2009 UTILISATION 45

08-07-2000 00:20:57 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	15	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	4	7707320

Minimized OBJ = 132190888 Iteration = 37 Elapsed CPU seconds = 4.66992
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 5

UTILISATION 50%

Solution Summary for 2000 UTILISATION 50

08-06-2000 22:35:50 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	0	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	0	7707320

Minimized OBJ = 7615101 Iteration = 1 Elapsed CPU seconds = .109375
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 0

Solution Summary for 2001 UTILISATION 50

08-06-2000 22:37:10 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	0	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	0	7707320

Minimized OBJ = 7615101 Iteration = 1 Elapsed CPU seconds = .109375
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 0

Solution Summary for 2002 UTILISATION 50

08-06-2000 22:50:55 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	2	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	x12,2	0	1065900
X11,1	1	1065900	x13,2	0	7707320

Minimized OBJ = 20114636 Iteration = 17 Elapsed CPU seconds = 1.81005
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2003 UTILISATION 50

08-06-2000 22:53:16 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	3	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	x12,2	0	1065900
X11,1	1	1065900	x13,2	0	7707320

Minimized OBJ = 26364402 Iteration = 7 Elapsed CPU seconds = .820312
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 2

Solution Summary for 2004 UTILISATION 50

08-06-2000 22:54:05 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	5	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	x12,2	0	1065900
X11,1	1	1065900	x13,2	0	7707320

Minimized OBJ = 38863936 Iteration = 17 Elapsed CPU seconds = 1.97998
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2005 UTILISATION 50

08-06-2000 22:56:52 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	5	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	x12,2	0	1065900
X11,1	1	1065900	x13,2	1	7707320

Minimized OBJ = 46612920 Iteration = 13 Elapsed CPU seconds = 1.47998
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 3

Solution Summary for 2006 UTILISATION 50

08-06-2000 23:17:41 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	6	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	x12,2	0	1065900
X11,1	1	1065900	x13,2	2	7707320

Minimized OBJ = 60528344 Iteration = 23 Elapsed CPU seconds = 2.90966
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 4

Solution Summary for 2007 UTILISATION 50

08-06-2000 23:21:20 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	6	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	4	7707320

Minimized OBJ = 75942984 Iteration = 27 Elapsed CPU seconds = 3.41406
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 4

Solution Summary for 2008 UTILISATION 50

08-06-2000 23:22:56 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	9	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	4	7707320

Minimized OBJ = 94692288 Iteration = 31 Elapsed CPU seconds = 3.90625
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 4

Solution Summary for 2009 UTILISATION 50

08-06-2000 23:24:47 Page: 1 of 1

Variable	Solution	Objective Coefficient	Variable	Solution	Objective Coefficient
X1,1	1	334987	X12,1	1	1065900
X2,1	1	455010	X1,2	0	334987
X3,1	1	462405	X2,2	0	455010
X4,1	1	411331	X3,2	0	462405
X5,1	1	569279	X4,2	0	411331
X6,1	1	619959	X567,2	12	6249767
X7,1	1	610064	X89,2	0	6267039
X8,1	1	617335	X10,2	0	786188
X9,1	1	616743	X11,2	0	1065900
X10,1	1	786188	X12,2	0	1065900
X11,1	1	1065900	X13,2	4	7707320

Minimized OBJ = 113441584 Iteration = 31 Elapsed CPU seconds = 3.90625
Branch selection: Newest problem Integer tolerance = .01 Max. #node = 4

Appendix 6
Optimum container handling equipment plan (2000 - 2009)

Utilisation level: 35%

Container cranes	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	12	15	17	19	21	23	25	28	31	35
Units to be disposed of in year	0	0	0	0	0	0	0	0	0	0
Number of units remaining	12	15	17	19	21	23	25	28	31	35
Inventory level required	15	17	19	21	23	25	28	31	35	39
Number to be purchased	3	2	2	2	2	2	3	3	4	4
Panamax	3	2	2	2	2	0	2	1	4	2
Post-Panamax	0	0	0	0	0	2	1	2	0	2

Rubber-Tyred Gantry Cranes	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	44	60	68	76	84	92	100	112	124	140
Units to be disposed of in year	7	0	0	0	3	0	0	0	0	3
Number of units remaining	37	60	68	76	81	92	100	112	124	137
Inventory level required	60	68	76	84	92	100	112	124	140	156
Number to be purchased	23	8	8	8	11	8	12	12	16	19

Tractors/Head trucks	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	71	105	119	133	147	161	175	196	217	245
Units to be disposed of in year	0	0	0	0	13	0	0	7	0	0
Number of units remaining	71	105	119	133	134	161	175	189	217	245
Inventory level required	105	119	133	147	161	175	196	217	245	273
Number to be purchased	34	14	14	14	27	14	21	28	28	28

Chassis	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	92	92	143	160	176	193	210	235	260	294
Units to be disposed of in year	19	0	0	0	13	0	0	50	0	0
Number of units remaining	73	92	143	160	163	193	210	185	260	294
Inventory level required	126	143	160	176	193	210	235	260	294	328
Number to be purchased	53	51	17	17	30	17	25	75	34	34

Forklift Diesel	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	17	15	17	19	21	23	25	28	31	35
Units to be disposed of in year	8	0	0	0	0	0	0	3	0	0
Number of units remaining	9	15	17	19	21	23	25	25	31	35
Inventory level required	15	17	19	21	23	25	28	31	35	39
Number to be purchased	6	2	2	2	2	2	3	6	4	4

Utilisation level: 40%

Container cranes	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	12	14	15	16	18	20	22	25	28	31
Units to be disposed of in year	0	0	0	0	0	0	0	0	0	0
Number of units remaining	12	14	15	16	18	20	22	25	28	31
Inventory level required	14	15	16	18	20	22	25	28	31	35
Number to be purchased	2	1	1	2	2	2	3	3	3	4
Panamax	2	1	0	2	2	1	3	3	2	4
Post-Panamax	0	0	1	0	0	1	0	0	1	0

Rubber-Tyred Gantry Cranes	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	44	56	60	64	72	80	88	100	112	124
Units to be disposed of in year	7	0	0	0	3	0	0	0	0	3
Number of units remaining	37	56	60	64	69	80	88	100	112	121
Inventory level required	56	60	64	72	80	88	100	112	124	140
Number to be purchased	19	4	4	8	11	8	12	12	12	19

Tractors/Head trucks	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	71	98	105	112	126	140	154	175	196	217
Units to be disposed of in year	0	0	0	0	13	0	0	7	0	0
Number of units remaining	71	98	105	112	113	140	154	168	196	217
Inventory level required	98	105	112	126	140	154	175	196	217	245
Number to be purchased	27	7	7	14	27	14	21	28	21	28

Chassis	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	92	118	126	134	151	168	185	210	235	260
Units to be disposed of in year	19	0	0	0	13	0	0	50	0	0
Number of units remaining	73	118	126	134	138	168	185	160	235	260
Inventory level required	118	126	134	151	168	185	210	235	260	294
Number to be purchased	45	8	8	17	30	17	25	75	25	34

Forklift Diesel	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	17	14	15	16	18	20	22	25	28	31
Units to be disposed of in year	8	0	0	0	0	0	0	3	0	0
Number of units remaining	9	14	15	16	18	20	22	22	28	31
Inventory level required	14	15	16	18	20	22	25	28	31	35
Number to be purchased	5	1	1	2	2	2	3	6	3	4

Utilisation level: 45%

Container cranes	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	12	12	13	15	16	18	20	22	25	28
Units to be disposed of in year	0	0	0	0	0	0	0	0	0	0
Number of units remaining	12	12	13	15	16	18	20	22	25	28
Inventory level required	12	13	15	16	18	20	22	25	28	31
Number to be purchased	0	1	2	1	2	2	2	3	3	3
Panamax	0	0	2	1	2	2	0	3	3	2
Post-Panamax	0	1	0	0	0	0	2	0	0	1

Rubber-Tyred Gantry Cranes	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	44	48	48	56	56	60	68	80	88	100
Units to be disposed of in year	7	0	0	0	3	0	0	0	0	3
Number of units remaining	37	48	48	56	53	60	68	80	88	97
Inventory level required	48	48	56	56	60	68	80	88	100	112
Number to be purchased	11	0	8	0	7	8	12	8	12	15

Tractors/Head trucks	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	71	84	84	98	98	105	119	140	154	175
Units to be disposed of in year	0	0	0	0	13	0	0	7	0	0
Number of units remaining	71	84	84	98	85	105	119	133	154	175
Inventory level required	84	84	98	98	105	119	140	154	175	196
Number to be purchased	13	0	14	0	20	14	21	21	21	21

Chassis	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	92	101	109	126	134	151	168	185	210	235
Units to be disposed of in year	19	0	0	0	13	0	0	50	0	0
Number of units remaining	73	101	109	126	121	151	168	135	210	235
Inventory level required	101	109	126	134	151	168	185	210	235	260
Number to be purchased	28	8	17	8	30	17	17	75	25	25

Forklift Diesel	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	17	12	13	15	16	18	20	22	25	28
Units to be disposed of in year	8	0	0	0	0	0	0	3	0	0
Number of units remaining	9	12	13	15	16	18	20	19	25	28
Inventory level required	12	13	15	16	18	20	22	25	28	31
Number to be purchased	3	1	2	1	2	2	2	6	3	3

Utilisation level: 50%

Container cranes	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	12	12	12	14	15	17	18	20	22	25
Units to be disposed of in year	0	0	0	0	0	0	0	0	0	0
Number of units remaining	12	12	12	14	15	17	18	20	22	25
Inventory level required	12	12	14	15	17	18	20	22	25	28
Number to be purchased	0	0	2	1	2	1	2	2	3	3
Panamax	0	0	2	1	2	0	1	0	3	3
Post-Panamax	0	0	0	0	0	1	1	2	0	0

Rubber-Tyred Gantry Cranes	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	44	48	48	56	60	68	72	80	88	100
Units to be disposed of in year	7	0	0	0	3	0	0	0	0	3
Number of units remaining	37	48	48	56	57	68	72	80	88	97
Inventory level required	48	48	56	60	68	72	80	88	100	112
Number to be purchased	11	0	8	4	11	4	8	8	12	15

Tractors/Head trucks	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	71	84	84	98	105	119	126	140	154	175
Units to be disposed of in year	0	0	0	0	13	0	0	7	0	0
Number of units remaining	71	84	84	98	92	119	126	133	154	175
Inventory level required	84	84	98	105	119	126	140	154	175	196
Number to be purchased	13	0	14	7	27	7	14	21	21	21

Chassis	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	92	101	101	118	126	143	151	168	185	210
Units to be disposed of in year	19	0	0	0	13	0	0	50	0	0
Number of units remaining	73	101	101	118	113	143	151	118	185	210
Inventory level required	101	101	118	126	143	151	168	185	210	235
Number to be purchased	28	0	17	8	30	8	17	67	25	25

Forklift Diesel	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inventory at start of year	17	12	12	14	15	17	18	20	22	25
Units to be disposed of in year	8	0	0	0	0	0	0	3	0	0
Number of units remaining	9	12	12	14	15	17	18	17	22	25
Inventory level required	12	12	14	15	17	18	20	22	25	28
Number to be purchased	3	0	2	1	2	1	2	5	3	3

Appendix 7

The comparison of the number of container cranes needed, cost per move, and capital investment needed between the traditional way and the equipment plan model

Utilisation 35%

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
Units needed											
All Panamax	3	5	7	9	11	14	17	20	24	29	
All Post Panamax	3	4	6	7	9	12	14	17	20	24	
Optimum Model											
- Panamax	3	5	7	9	11	11	13	14	18	20	
- Post Panamax	0	0	0	0	0	2	3	5	5	7	
Cost per move ($/move)											**Ave.**
All Panamax	9.1	9.2	9.2	9.0	8.7	8.7	8.6	8.4	8.4	8.4	8.8
All Post Panamax	10.1	9.8	10.2	9.7	9.8	10.2	10.0	10.0	9.9	10.0	10.0
Optimum Model	9.1	9.2	9.2	9.0	8.7	8.8	8.8	8.9	8.7	8.8	8.9
Investment needed (million $)											
All Panamax	16.95	28.25	39.55	50.85	62.15	79.10	96.05	113.00	135.60	163.85	
All Post Panamax	20.34	33.90	47.46	61.02	74.58	94.92	115.26	135.60	162.72	196.62	
Optimum Model	16.95	28.25	39.55	50.85	62.15	75.71	93.79	113.00	135.60	160.46	

Utilisation 40%

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
Units needed											
All Panamax	2	3	5	7	9	11	14	17	20	24	
All Post Panamax	2	3	4	6	7	9	11	14	17	20	
Optimum Model											
- Panamax	2	3	3	5	7	8	11	14	16	20	
- Post Panamax	0	0	1	1	1	2	2	2	3	3	
Cost per move ($/move)											**Ave.**
All Panamax	8.6	8.2	8.2	8.2	8.0	7.8	7.8	7.6	7.4	7.4	7.9
All Post Panamax	9.2	9.0	8.8	9.1	8.7	8.7	8.6	8.8	8.9	8.8	8.9
Optimum Model	8.6	8.2	8.0	8.0	7.8	7.8	7.8	7.7	7.6	7.5	7.9
Investment needed (million $)											
All Panamax	11.30	16.95	28.25	39.55	50.85	62.15	79.10	96.05	113.00	135.60	
All Post Panamax	13.56	20.34	33.90	47.46	61.02	74.58	94.92	115.26	135.60	162.72	
Optimum Model	11.30	16.95	23.73	35.03	46.33	58.76	75.71	92.66	110.74	133.34	

Note:

- Investment for a Panamax crane= US $ 5.65 million.
- Investment for a Post Panamax crane= US $ 6.78 million.

Utilisation 45%

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
Units needed											
All Panamax	0	2	3	5	6	9	11	14	17	20	
All Post Panamax	0	1	3	4	5	7	9	11	14	17	
Optimum Model											
- Panamax	0	0	2	3	5	7	7	10	13	15	
- Post Panamax	0	1	1	1	1	1	3	3	3	4	
Cost per move ($/move)											**Ave.**
All Panamax	7.4	7.7	7.3	7.3	6.9	7.1	6.9	6.9	6.8	6.6	7.1
All Post Panamax	7.4	7.4	8.1	7.8	7.5	7.7	7.7	7.6	7.8	7.8	7.7
Optimum Model	7.4	7.4	7.6	7.1	7.1	7.0	7.1	7.0	6.9	6.8	7.1
Investment needed (million $)											
All Panamax	-	11.30	16.95	28.25	33.90	50.85	62.15	79.10	96.05	113.00	
All Post Panamax	-	6.78	20.34	27.12	33.90	47.46	61.02	74.58	94.92	115.26	
Optimum Model	-	6.78	18.08	23.73	35.03	46.33	59.89	76.84	93.79	111.87	

Utilisation 50%

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
Units needed											
All Panamax	0	0	2	3	5	7	9	11	14	17	
All Post Panamax	0	0	2	3	4	6	7	9	12	14	
Optimum Model											
- Panamax	0	0	2	3	5	5	6	6	9	12	
- Post Panamax	0	0	0	0	0	1	2	4	4	4	
Cost per move ($/move)											**Ave.**
All Panamax	7.4	6.6	6.8	6.5	6.5	6.4	6.3	6.1	6.1	6.0	6.5
All Post Panamax	7.4	6.6	7.3	7.2	7.0	7.2	6.8	6.8	7.1	6.9	7.0
Optimum Model	7.4	6.6	6.8	6.5	6.5	6.3	6.3	6.4	6.3	6.2	6.5
Investment needed (million $)											
All Panamax	-	-	11.30	16.95	28.25	39.55	50.85	62.15	79.10	96.05	
All Post Panamax	-	-	13.56	20.34	27.12	40.68	47.46	61.02	81.36	94.92	
Optimum Model	-	-	11.30	16.95	28.25	35.03	47.46	61.02	77.97	94.92	

Note:
- Investment for a Panamax crane= US $ 5.65 million.
- Investment for a Post Panamax crane= US $ 6.78 million.