Study on Maritime Transportation and Logistics Systems of International Cargo ―Focusing on the Global Wheat Transportation―

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Study on Maritime Transportation and Logistics Systems of International Cargo

—Focusing on the Global Wheat Transportation—

(国際貨物における海洋ロジスティクスシステムに関する研究)

—地球規模の小麦輸送について—

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Research on Maritime Transportation and Logistics Systems of International Cargo

—Focusing on the Global Wheat Transportation—

ABSTRACT

1. Background

Wheat, the principal food of about half of the world's population, is grown in most areas of the world. Even people groups who eat mostly rice also eat some forms of wheat. It is well known that the trade volume of wheat occupies the half of that of grain.

The global population has increased since World War II, and it is anticipated that it will increase rapidly in the 21st century. Currently, about 4.4 billion of the world's 6.3 billion people live in developing countries. The population is increasing most rapidly in developing countries that attained political independence after World War II. In developing countries, about 800 million people do not get enough food or adequate nutrition for daily life. Meanwhile, developed countries are saturated with food. The food-shortage problem is becoming increasingly serious.

Shipping continues to be dominant mode of transportation, accounting for almost two thirds of world trade (metric tons). With the economic globalization, maritime transportation will become more and more important.

In recent years, many countries have been facing a number of pressing system-wide environmental issues related to the combustion of fossil fuels for mechanized applications, including air pollution, heavy reliance on the extraction and processing of petroleum, and emissions of greenhouse gases. The transportation sector is a leading contributor to these problems, and within this sector, freight transportation is a significant contributor especially to energy use and carbon emissions.

2. Purpose

In the 21st century, a steep increase in the global population is expected; mostly will happen in Asia and Africa. According to statistics of FAO, the growing population can be maintained by increased cereal production. But the unbalance between supply and production still exists in the world. The food problem is still serious for people. Firstly, the purpose of this research is to estimate the supply and import/export of wheat on the basis of the continental method. Using the continental method, we can obtain the volumes of wheat shortage and the trade features about the import/export. Secondly, by analyzing the trade flow data, we show a clear situation of wheat trade. Thirdly, we

made an assessment to emissions of CO_2 in the wheat transportation. Finally, considering the cargo creation, we developed an analyzing system of wheat maritime transportation and logistics including transportation tons, ton-miles, valve, number of bulk carriers needed and emissions of CO_2 in the transportation.

3. Contents

This dissertation is organized as follows.

Chapter 1 presents background of the research and purpose. Beside that, chapter 1 also describes the structure of this research.

Chapter 2 reviews the related research from the following viewpoint. They are global model, marketing of grain, time series analyses and mathematical programming. We also explore the positioning of this research from cargo creation and environmental problem.

In chapter 3, we analyze the population predictions, population changes and population growth rate according to the UN's data. The factor of population increasing is clearly shown.

Chapter 4 examines the production, supply of wheat on the basis of the continental method and analyzes the factors that affect the production and supply. Using the continental method, we can obtain the volumes of wheat surplus and shortage. After discussing the relations between the import, shortage and volume of maritime transportation, the requirements for maritime transportation of wheat are investigated and estimated in the future.

Chapter 5 proposes a trade flow analysis of wheat. First of all, we conduct the trade flow data of across section using programming. Secondly, we analyze the Asian wheat's import by panel data. Finally, the share analysis of the international wheat export market is discussed.

In chapter 6, the maritime transportation and logistics systems of wheat are analyzed for Asia. Firstly we analyze the Asian trade condition of wheat. Secondly from the import condition of Asia, we can make a decision which port can be used as importing ports and exporting ports based on investigating wheat exporting ports of others' countries and wheat importing ports of Asian countries. So the navigation distance between the exporting ports and importing ports can be calculated. Finally, we analyze the maritime transportation and logistics systems of wheat in Asia including maritime Ton, Ton-Miles, trade value, necessary number of bulk carriers and emissions of CO_2 in the transportation. In addition, the effect coming from the international price of wheat is analyzed by Cross-correlations.

In chapter 7, we analyze maritime transportation and logistics systems of wheat to Africa from maritime Ton, Ton-Miles, trade value, necessary number of bulk carriers and emissions of CO_2 in the transportation. After an analysis of the wheat transportation, we find that the agricultural policies greatly affect the wheat transportation to Africa. Then, using two scenarios, we predict how many ships are necessary for the maritime transportation of wheat to Africa in the future.

In chapter 8, a comparative study is undertaken on maritime trade of wheat and rice destined for Africa. For comparison, firstly, the feature of production and supply becomes clear. Secondly, trade feature is also discussed. Moreover, we show that agricultural policies significantly affect the transportation of wheat to Africa. On the other hand, we show that the export of rice to Africa is a regular trend. Finally, based on the comparison of trade, we predict the number of maritime bulk carriers of wheat and rice for Africa. In addition, the effect coming from the international price of wheat and rice is also discussed.

Chapter 9 presents the conclusions of this dissertation. It includes a summary of important results and subject of future investigation.

CONTENTS

Chapter 1 Introduction

1.1 Research Background

Wheat, the principal food of about half of the world's population, is grown in most areas of the world. Even people groups who eat mostly rice also eat some forms of wheat. It is well known that the trade volume of wheat occupies the half of that of grain.

The global population has increased since World War II, and it is anticipated that it will increase rapidly in the 21st century (NIRA 1982). Currently, about 4.4 billion of the world's 6.3 billion people live in developing countries. The population is increasing most rapidly in developing countries that attained political independence after World War II. In developing countries, about 800 million people do not get enough food or adequate nutrition for daily life. Meanwhile, developed countries are saturated with food. The food-shortage problem is becoming increasingly serious (FAO, 2001).

Shipping continues to be dominant mode of transportation, accounting for almost two thirds of world trade (metric tons) (UNCTAD, 2001). With the economic globalization, maritime transportation will become more and more important.

In recent years, many countries have been facing a number of pressing system-wide environmental issues related to the combustion of fossil fuels for mechanized applications, including air pollution, heavy reliance on the extraction and processing of petroleum, and emissions of greenhouse gases. The transportation sector is a leading contributor to these problems, and within this sector, freight transportation is a significant contributor especially to energy use and carbon emissions (Schipper et al., 1997).

1.2 Research Purpose

In the 21st century, a steep increase in the global population is expected; mostly will happen in Asia and Africa. According to statistics of FAO, the growing population can be maintained by increased cereal production (Gilland. B., 2002). But the unbalance between supply and production still exists in the world. The food problem is still serious for people. Firstly, the purpose of this research is to estimate the supply and import/export of wheat on the basis of the continental method. Using the continental method, we can obtain the volumes of wheat shortage and the trade features about the import/export. Secondly, by analyzing the trade flow data, we show a clear situation of wheat trade. Thirdly, we made an assessment to emissions of CO_2 in the wheat transportation. Finally, considering the cargo creation, we developed an analyzing system of wheat maritime transportation and logistics including transportation tons, ton-miles, valve, necessary number of bulk carriers and emissions of CO_2 in the transportation.

1.3 Structure of This Research

The flowchart is constructed for this research as shown in Figure 1.1.

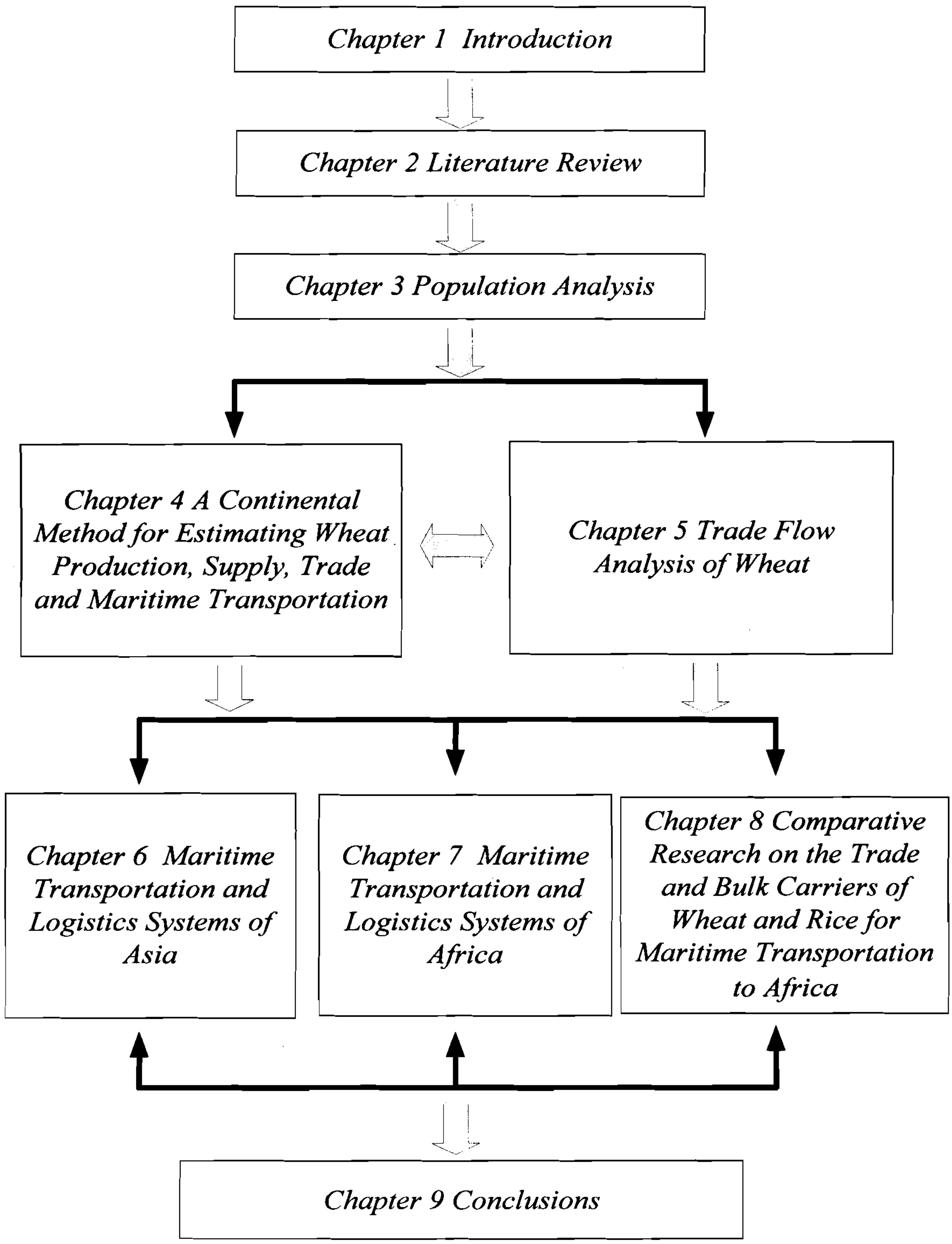

Figure 1.1 Flowchart of This Research

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Chapter 2 Literature Review

2.1 Related Research

2.1.1 Global Models

Across the globe, the issue of human survival facing food and population crises is being discussed actively. Many international organizations, such as the Food and Agriculture Organization of the United Nations (FAO 2002) are attempting to quantify the gap between the food supply and the demand. To evaluate this gap, the FAO used a single equation model until 1970, however, now uses the World Food Model. Based on this model, the following predictions can be made in regard to wheat. By 2010, wheat production will reach 679 million tons; supply, 683 million tons; import, 129 million tons; and export, 128 million tons (Alexandrite et al. 1995). By 2030, wheat production will reach 854.9 million tons, and the supply will reach 851.2 million tons (FAO 2003). The FAO has taken the stance that providing adequate food to developing countries is a duty of the developed world.

The International Food Policy Research Institute (IFPRI 2001) developed the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT 2002) and predicted that by 2020, the worldwide production and supply of wheat would be 760 million tons.

In addition, other models have been developed by the United States Department of Agriculture (USDA 1999) and the Organization for Economic Cooperation and Development (OECD 1976). These agencies have studied the supply and demand of wheat on a global basis. However, little research has been done on the supply, demand, and maritime transportation of wheat in specific regions of the world.

Moreover, some pessimists' researches also happen. Meadows (Meadows, et al, 1973) used the World 3 Dynamics Model to simulate the consequence of interactions between the Earth's and human systems. Five variables were examined in the original model, on the assumption that exponential growth accurately described their patterns of increase. These variables are: world population, industrialization, pollution, food production and resource depletion. The System Dynamics (SD) Model is updated until now (Meadows, et al, 1992, 2004). The other alarming research is conducted by Brown (Brown, L, 1994). He discussed food crisis and warned who could feed China.

Finally, Tongeren (Tongeren, F.V., et al, 2001) reviews the present state of applied modeling in the area of trade and agricultural policies and a comparative assessment of alternative modeling approaches. These models are as follows in the Table 2.1. Since the results of global prediction model are different, Morisima (Morisima, M., 1995) argues that the long-term prediction is more important as the goal or alarm than accurate prognosis. The result of prediction is guided in the desirable direction by performing simulation analysis based on the scenario assumed variously.

Table 2.1 List of Models Reviewed

Model	Initiating bodies (institutions and/or persons)	Key reference	Current Status
Partial models			
AGLINK	Organisation for Economic Co-operation and Development (OECD)	See http://www.oecd.org/agr/ Documents/aglink98.pdf	Used
ESIM (European Simulation Model)	US Department of Agriculture/Economic Research Service, USDA/ERS, and University Gottingen, Germany	Tangermann and Josling (1994)	Used
FAO World Model	Food and Agriculture Organisation of the United Nations (FAO)	FAO (1993) and see http/:www.fao.org/es/esc	Used
FAPRI	Food and Agricultural Policy Research Institute, Iowa State University	Young et al. (1999)	Used
GAPsi (Gemeinsame AgrarPolitik Simulation)	Bundes Forschungsanstalt fur Landwirtschaft (FAL), Germany	Frenz and Manegold (1988)	Used
MISS (Modele International Simplifie de Simulation)	Institut National de la Recherce Agronomique (INRA), France	Mahe and Tavera (1989)	Not used
SWOPSIM (Static World Policy Simulation Model)	US Department of Agriculture/Economic Research Service (USDA/ERS)	Roningen (1986)	Not used
WATSIM (World Agricultural Trade Simulation Model)	University of Bonn, European Commission, Federal Ministry of Agriculture, Germany	Henrichsmeyer et al. (1998)	Used
Economy-wide models			
G-Cubed (Global Computable Genereal Equilibrium Growth Model)	McKibbin and Wilcoxen, US Environmental Protection Agency (EPA)	McKibbin and Wilcoxen (1999), and see http://www.msgpl.com.au/msgpl/msghome.htm	Used
GTAP (Global Trade Analysis project)	Purdue University, GTAP Center and GTAP Consortium	Hertel (1997), and see http://www.agecon.purdue.edu/gtap/	Used
GREEN	Organisation for Economic Co-operation and Development (OECD)	Lee et al. (1994)	Used
INFORUM (Inter-industry Forecasting at the University of Maryland)	University of Maryland	Almon (1991), and see http://www. inform.umd.edu/EdRes/Topic/Economics/ EconData/Intpartn.html	Used
MEGABARE/GTEM	Australian Bureau of Agriculture and Resource Economics	ABARE (1996), and see http://www.abare.gov.au/ Used	
Michigan BDS (Brown-Deardorff-Stern)	University of Michigan	Brown et al. (1992), and see http://www.spp.umich.edu/rsie/model	Used
RUNS (Rural-Urban-North-South)	Organisation for Economic Co-operation and Development (OECD)	Burniaux and van der Mensbrugghe (1990)	Not used
WTO Housemodel	The World Trade Organisation (WTO)	Francois et al. (1995), and see http://www. intereconomics.com/handbook/disk.htm	Used

2.1.2 Marketing of Grain

The world wheat market is characterized by a limited number of major exporting regions, with the United States, Canada, Australia, the European Union (EU) and Argentina accounting for about 83% of total exports (FAPRI 1993). Imports are somewhat less concentrated, although China, the former Soviet Union and North Africa have absorbed almost 40% of total imports in recent years (FAPRI 1993). The implications of this market structure for trade, prices and policies have been widely studied (McCalla 1966; Alaouze et al 1978; Paarlberg and Abbott 1986; Goodwin and Schroeder 1991). Within these studies, export price determination has received special attention because of the small number of major exporting regions as well as the presence of large multinational grain trading companies and the fact that wheat is not an entirely homogeneous product. Several studies have investigated the relationships between export prices for the five principal exporters (Spriggs et al 1982; Perkins et al 1984; Gilmour and Fawcett 1987; Goodwin and Schroeder 1991).

On the other hand, major grain companies (such as ADM, Inc., Cargill, Inc., etc.) are large-scale grain distribution companies who connect producers and consumers, and are the bearers of world market export. These major grain companies bring about a big influence to a world market (Tino, N., 2006).

2.1.3 Time Series Methods

Time series methods are often used to study the dynamics of regional, export-wheat, railroad rates, etc. In USA, railroad wheat transportation markets in the central plains are modeled with error correction and directed graphs (Bessler and Fuller, 2000). Bessler (Bessler et al, 2003) also examine dynamic relationships among wheat prices from five countries for the years 1981–1999. The same method is employed with observational data to sort–out the dynamic causal relationships among prices from major wheat producing regions: Canada, the European Union, Argentina, Australia, and the United States. His results show that Canada and the U.S. are leaders in the pricing of wheat in these markets. The U.S. has a significant effect on three markets excluding Canada.

In addition, AR and ARIMA model are employed to forecast quarterly railroad grain carloadings (Babcock, 1999). A special type of ARIMAX model in which X is a vector of explanatory dummy variables is used to forecast inland waterway grain traffic (Babcock and Lu 1999).

Only recently, vector autoregressive model (VAR) is popular method of time series and is applied by many researchers. A series of research as follows: multivariate autoregressive time series models are applied to forecast the trade flows of four commodity markets (crude oil, iron ore, grain and coal) on major trade routes (Veenstra and Haralambides, 2001). Relationship between Canada and U.S. wheat prices is examined using cointegration and error correction approach by Mohanty, (Mohanty et al, 1996, Ghoshray, 2007). They also estimate the export price relationships in the international wheat exporters, the United States, Canada, Australia, The European Union and

Argentina using a general error correction approach (Mohanty et al, 1999) developed by Engle and Granger(1987).

Moreover, the effects of U.S. wheat prices, dollar values, and their volatilities on U.S. wheat market shares in 10 Asian countries are analyzed by Jin and Koo (Jin and Koo, 2003). Estimation results show that higher U.S. wheat prices and U.S. dollar appreciation have detrimental effects, while increases in competitors' wheat prices and currency values have cross positive effects on U.S. market shares. The importers are not sensitive to volatility in annual price and exchange rate changes.

2.1.4 Mathematical Programming

Blakeslee (Blakeslee, et al, 1973) developed a LP model in order to minimize the grain transport cost in the world.

Recently, a mixed-integer programming model is designed to minimize the combined costs of delivering wheat to milling sites, milling flour, marketing mill feeds, and shipping flour to end users in Southern Plains of U.S.A. (Tembo et al, 1999).

Little work has been done on maritime shipping problems with focus on the whole supply chain (Christiansen et al., 2004; Bilgen and Ozkarahan, 2004). At this point, it is suitable to mention the literature where maritime shipping is an important issue within supply chain optimization.

Bilgen and Ozkarahan (2007) address a blending and shipping problem faced by a company that manages a wheat supply chain. The problem involves the delivery of bulk products from loading ports to destination ports, which may be served by different vessel types. Since the products demanded by customers are mainly exported in bulk to overseas customers, the shipment planning is of great economic importance. The problem is formulated as a mixed-integer linear programming model (MILP). The objective function seeks to minimize the total cost including the blending, loading, transportation and inventory costs. Constraints on the system include blending and demand requirements, availability of original and blended products; as well as blending, loading, draft and vessel capacity restrictions.

2.2 The Positioning of This Research

2.2.1 Viewpoint of Cargo Creation of Transportation

In this section, we discuss the cargo creation of transportation. Here, the cargo creation can be classified into 3 fields. They are optimum transportation, change of cargo transportation volume and occurrence of new cargo as shown in Figure 2.1.

The optimum transportation is very important in the present transportation. It is often used the result of operation research to conduct the optimum problem. But we recognize the change of cargo transportation volume including future transportation is more important than present transportation. This research is focused on this viewpoint to analyze the trade flow of wheat. Moreover, we also consider that the occurrence of new cargo belongs to the cargo creation because new value and needs exist in the new cargo. But, the problem isn't involved in the study.

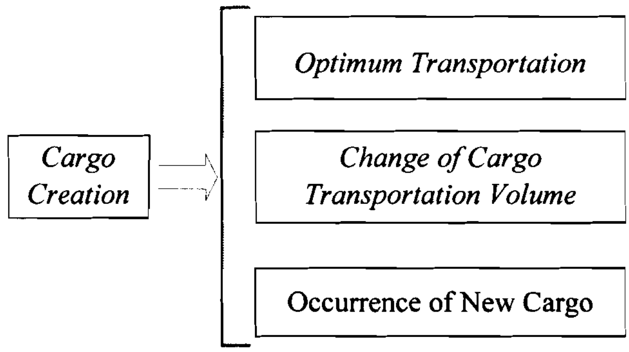

Figure 2.1 Cargo Creation of Transportation

The change of cargo transportation is often occurred by international trade. In the following test, we analyze the change of wheat transportation by partial equilibrium trade model of wheat. Here we use two countries (home country and foreign country) to analyze the change of trade.

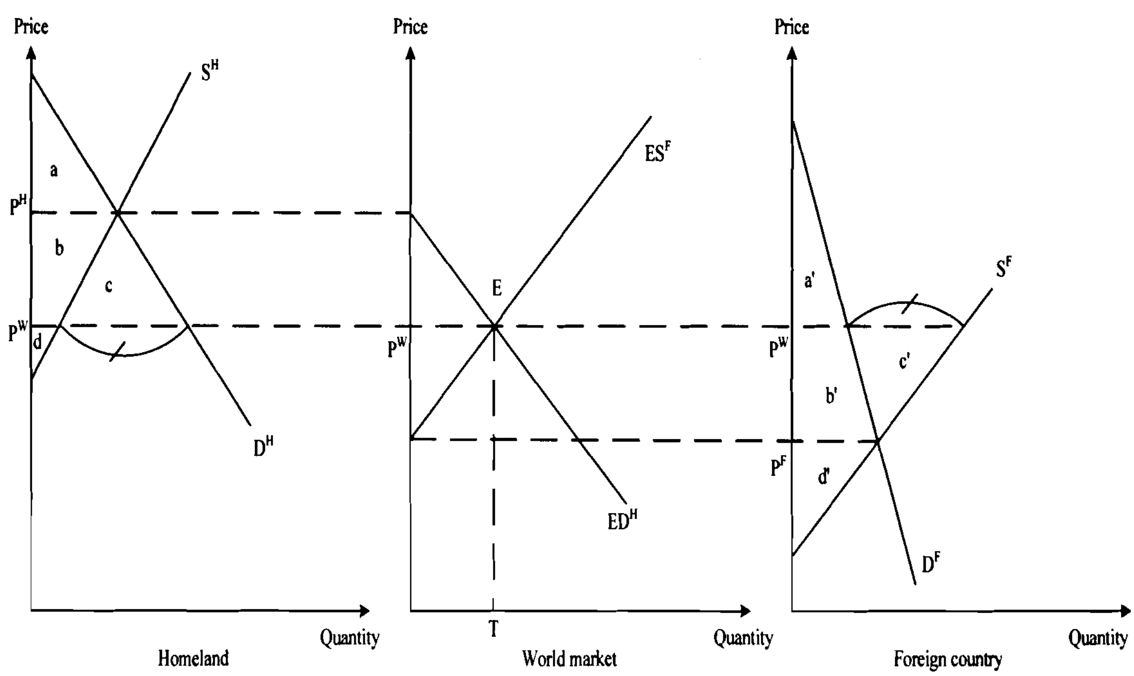

Figure 2.2 International Trade of Wheat

Figure 2.2 shows the change of before and after trade. Before trade, home country and foreign country is independence and equilibrium, respected. Their equilibrium price is P^H and P^F. The surplus is shown in Table 2.2

Table 2.2 Surplus of before Trade

	Home land	Foreign county
Consumer Surplus	a	a'+b'
Producer Surplus	b+d	d'
Social Surplus	a+b+d	a'+b'+d'

After trade, according to the law of one price, the international price of wheat becomes the equilibrium price (P^W). The surplus is shown in Table 2.3.

Table 2.3 Surplus of after Trade

	Home land	Foreign county
Consumer Surplus	a+b+c	a'
Producer Surplus	d	b'+c'+d'
Social Surplus	a+b+c+d	a' +b'+c'+d'

By comparison, as shown in Table 2.4, the social surplus of home country and foreign country will increase c and c', respectively.

Table 2.4 Change of Surplus

	Home land	Foreign county
Consumer Surplus	+ (b + c)	-b'
Producer Surplus	-b	+ (b' + c')
Social Surplus	+c	+c'

Consequently, the production and consumption of wheat become more efficient than before. On the other hand, the economic public welfare of both countries can be raised. Here is the fundamental reason for advocating a free trade. With the development of trade, the change of cargo transportation will happen continuously.

On the other hand, in recent years, container transportation is noted in the maritime transportation. However, bulk transport occupies about 80% on a weight basis and about 40% on a value basis during the international cargo transportation. Energy resources, raw material, and grain are transported by bulker; consumer goods of commercialization are mainly shipped by container. Wheat is usually shipped by dry bulk. Table 2.5 shows the types of dry bulk and important cargo shipped. In the past 30 years, the annual growth rate of dry bulk's shipping tonnage is 3.9% on the average with the increase of cargo movement in the world. Among them, Capesize is 7.1%, Panamax is 6.5%, Handymax is 4.0%, Handysize is 0.7%, respectively. It is clear that the ship size becomes bigger and bigger. The changes of cargo transportation volume will affect the necessary number of bulk carriers. We also discuss the change of number of bulk carriers for wheat in the future.

Table 2.5 The Types of Dry Bulk and Important Cargo Shipped

	Type	Deadweight (DWT)	Important Cargo
Dry bulk	Capesize	Over 80,000	Iron ore, Coal
	Panamax	60,000-80,000	Coal, Grain, Iron ore, Coke
	Handymax	40,000-60,000	Grain, Coal, Coke
	Handysize	10,000-40,000	Grain, Wood, Steel, Scrap

2.2.2 Viewpoint of Environmental Problem

The distance between producers and consumers becomes longer than before in accordance with the expansion of international food trade. As a result, distribution channels are becoming complicated, and consumers do not know where food comes from and how it is produced. Algela Paxton (Algela 1994) argues about the danger of the long-distance transportation of food. In this study, it is important that how wheat transportation affect environment of earth. In order to deal with the problem, by predicting the maritime ton-miles, we can make an assessment on the emissions of CO_2 in the maritime transportation and logistics of wheat.

On the other hand, changes in climate can have dramatic effects on food systems. Climatic variation triggers starvation, migration, economic disruption, and land use change, for the climate food link is one of the most ancient, critical, and persistent problems of the physical environment (Liverman, D.M., 1987). With the climate change of the earth, the production region of wheat will also become an alteration. As the result, wheat transportation should be changed.

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Chapter 3 Population Analysis

Population has more than doubled since 1960. Even if the global supply of food calories per capita rose from 2420 kcal per day in 1958 (Pawley, 1963) to 2808 kcal in 1999 (FAOSTAT, 2001), the undernourished population still existed in the world, especially the percent of total population in Africa and Asia is higher than the other regions (FAO, 2004) as shown in Figure 3.1.

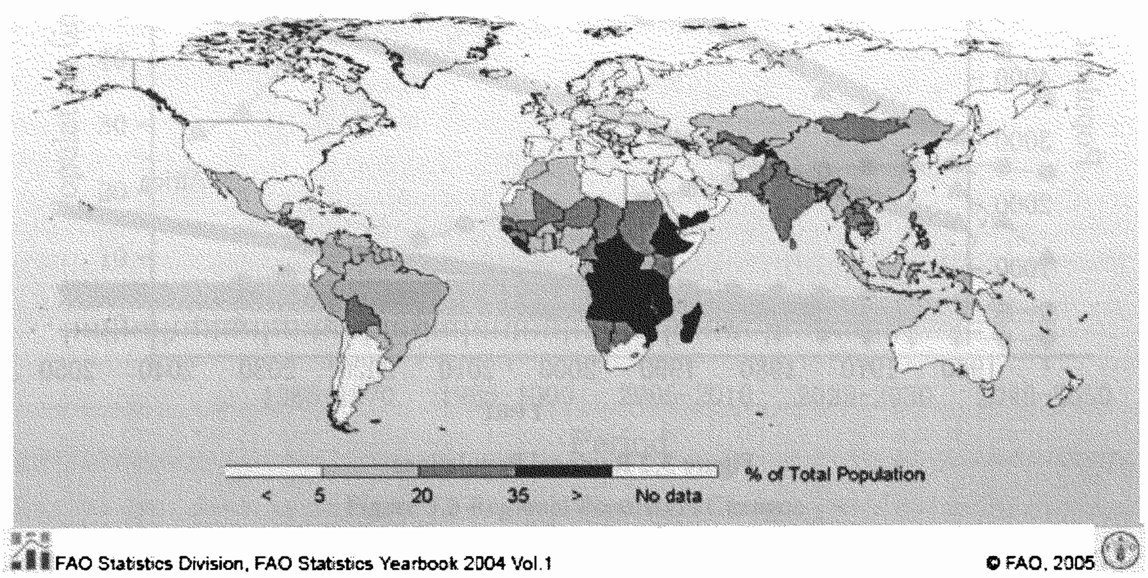

Figure 3.1 Undernourished Population (2000 - 2002)

3.1 Population Predictions

World population increased with a rapid speed in the later half of the 20th century. The situation of population is expressed as "population explosion". The tendency of population development in 21st century is analyzed as follows. Among the three cases of their prediction, which are high, middle and low rank, we focused on the middle one. As shown in Figure 3.2, the world population doubled from 3,023.81 million in 1960 to 6,085.57 million in 2000. According to the U.N.'s "World Population Prospects" (UN, 2004), the world population will increase to 7,905.24 million by 2025 and to 9,075.9 million by 2050. These mid-range estimates show a 1.50-fold increase in 50 years, with the largest increases in Asia and Africa.

Five-year population estimations were examined for developed and developing countries. In developed countries, the population is projected to increase 2.3%, from 1,191.43 million in 2000 to 1,218.83 million in 2025. However, the population in these countries will decrease by 0.9%, to 1,181.11 million, by 2050. On the other hand, the population of developing countries will increase from 4,865.29 million in 2000 to 6,717.91 million in 2025. Moreover, it is estimated that the population in these countries will reach 8,141.14 million in 2050, for a 50-year increase of 1.67%.

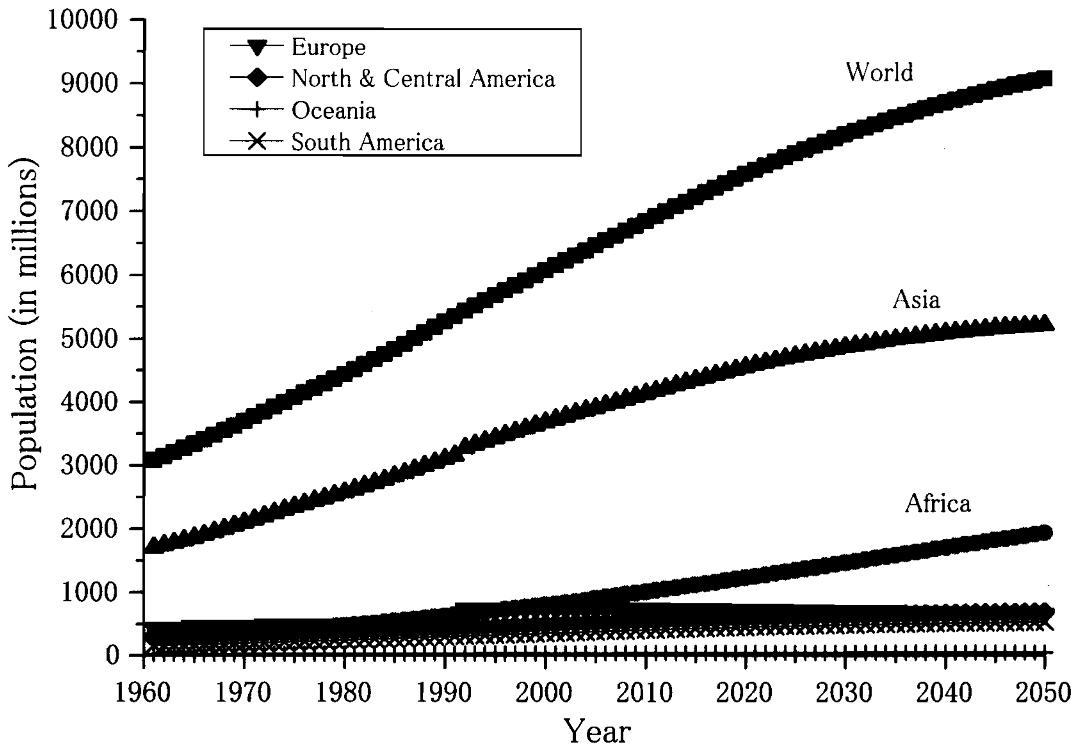

Figure 3.2 Regional Populations

The food shortage is aggravated by the rapid increase in the world's population. In some countries, the population growth rate is higher than the increase in food production. From 1985 to 1995, food production did not catch up with the population growth rate in 64 of 105 developing countries. The worst situation was in Africa. In order to feed a projected population of 8 billion people in 2025, it is necessary to double the present level of food production.

3.2 Population Changes

As shown in Figure 3.3, worldwide population change declined briefly in the late 1980s. However, even if the population change falls further, the population will continue to increase. It is clear that Asia influences the world population because the population change of Asia is most in the world. In the case of Africa, the change of population is projected to increase annually till 2030 and decrease after that. An important point is that the change of population will exceed the change of Asia and become No.1 after 2030.

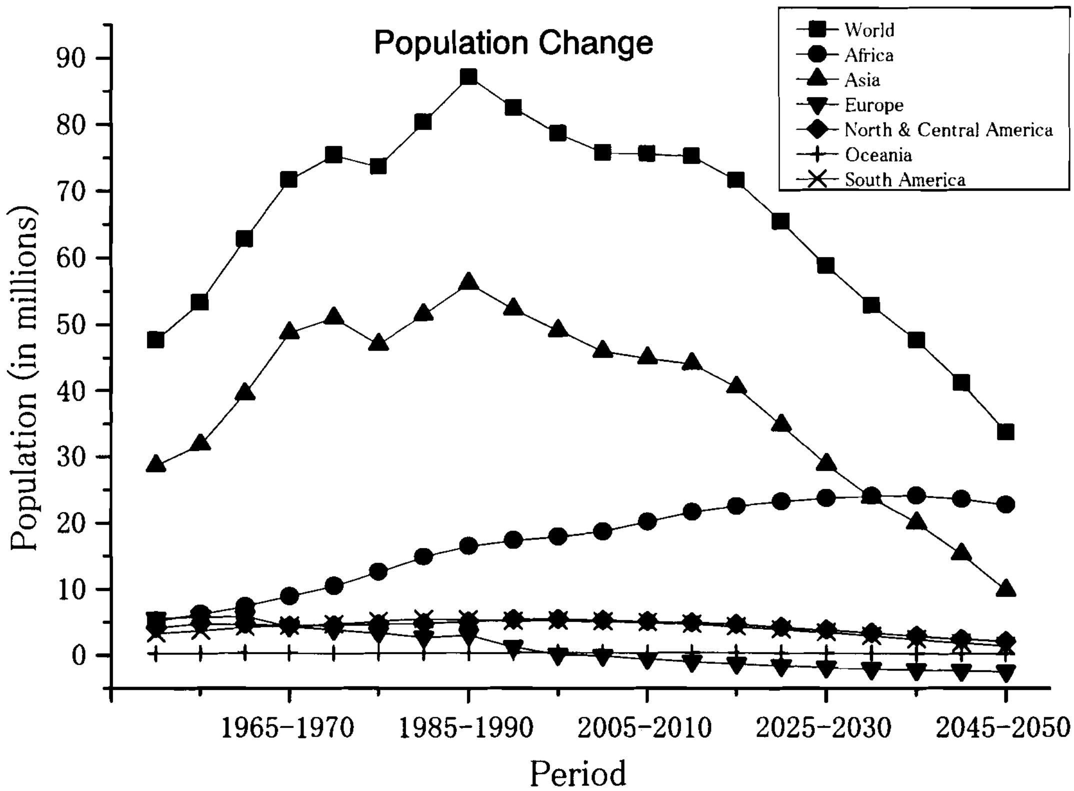

Figure 3.3 Regional Population Changes

3.3 Population Growth Rate

In the 1960s, the population growth rate in the world was 2%. However, it is expected to decrease more in the future. From 1975 to 1990, the world population increased by 1.74% every year, but, in the next 60 years, the population growth rate will be reduced to less than 1%. Caution is required when considering trends in Africa, where the population growth rate is expected to be 3%. Moreover, Africa has the highest population growth rate. Although the population growth rate will decrease in every region, the negative growth rate in Europe is significant. These tendencies are shown in Figure 3.4. The decreasing growth rate of the population has a large influence on the production of wheat.

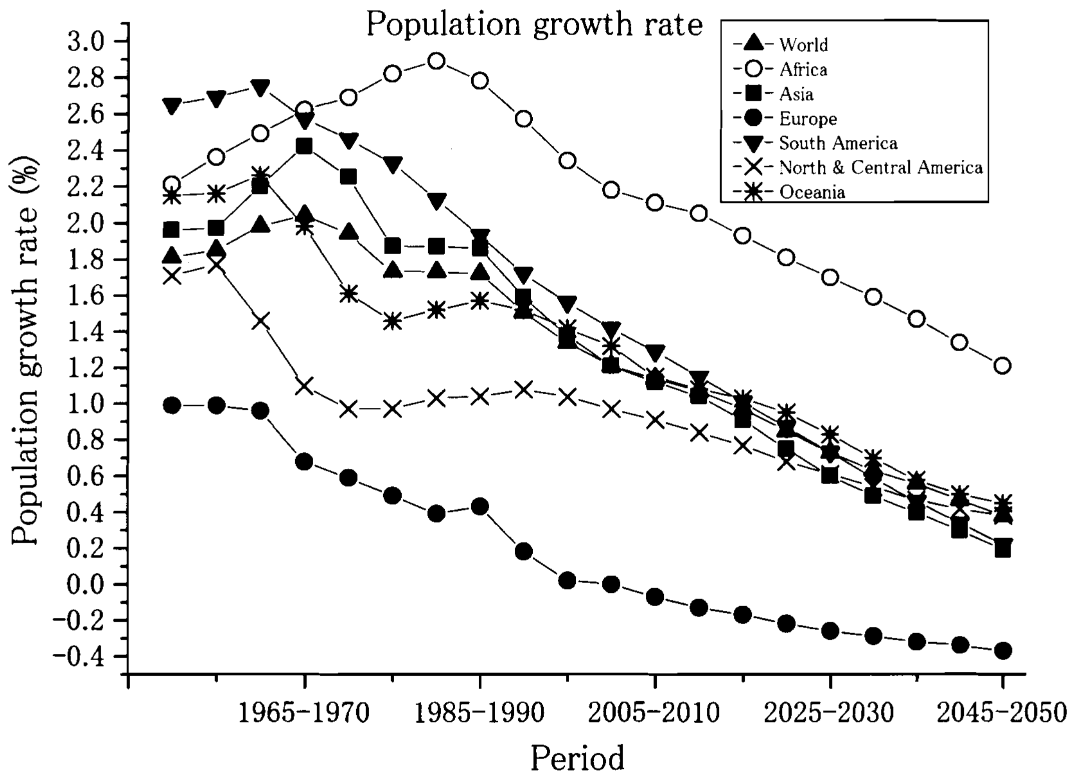

Figure 3.4 Growth Rates of Regional Population

3.4 The Cause of Population Increasing

The main cause of population explosion is decline of death rate. Table 3.1 shows the change of birth data and death rate between industrial countries and developing countries. It is clear that increasing of population come from the decline of death rate because the birth rate is bigger than death rate.

Table 3.1 Birth Rate and Death Rate (Annual Birth and Death Rate per 1,000 persons)

		1950−55 year	1990−95 year
Birth rate	Industrial countries	22.0	13.6
	Developing countries	44.6	28.1
Death rate	Industrial countries	10.2	9.7
	Developing countries	24.3	9.1
Population growth Rate	Industrial countries	11.8	3.9
	Developing countries	20.3	19.0

3.5 Conclusions

The conclusions could be summarized as follows:

1. A steep increase in the global population is expected, mostly in Asia and Africa.
2. An important point is that the change of population in Africa will exceed the change of Asia and become No.1 after 2030.
3. The population growth rate will decrease in every region; the negative growth rate in Europe is significant.
4. The cause of population explosion comes from the decline of death rate.

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Chapter 4 A Continental Method for Estimating Wheat Production, Supply, Trade and Maritime Transportation

4.1 Introduction

4.1.1 Harvested Area

Figure 4.1 shows the harvested area of every region. As shown in Figure 4.1, the wheat-harvested area changed little in 40 years. A downward worldwide tendency, however, was observed for the harvested area after 1997. Although new harvested areas have continuously been used for production, the production capacity has declined due to damage from various factors, including salt water, urbanization and desertification.

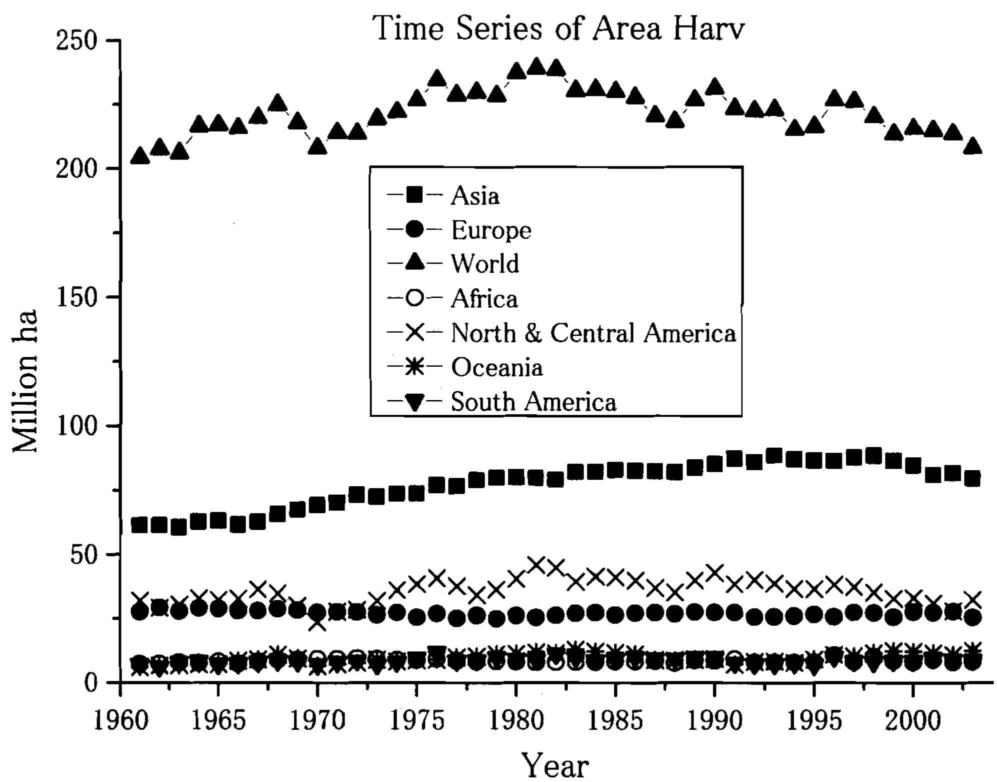

Figure 4.1 Time Series of Harvest Area

4.1.2 Yield per Hectare

Figure 4.2 shows the yield per hectare in every region. Improvements in technology over the past 40 years have made it possible to double the yield. However, increases have been disturbed to some extent by weather conditions. Worldwide wheat production and yield are discussed in the following text.

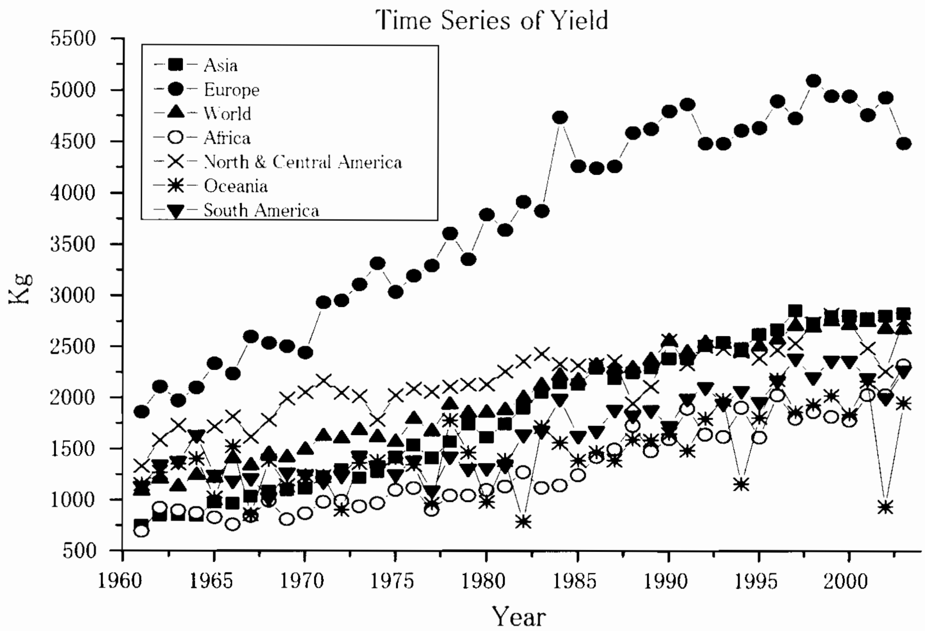

Figure 4.2 Time Series of Yield

Figure 4.3 shows the relation between worldwide yield and production; a linear relation (determination coefficient =0.9803) can be observed between the two. Now, the figure clearly shows that wheat production is based on technical improvements of yield rather than expansions of farmland. The so-called Green Revolution contributed significantly to increased productions of wheat in the 1960s and 1970s. It is generally assumed that gains in yield are dependent on new technology.

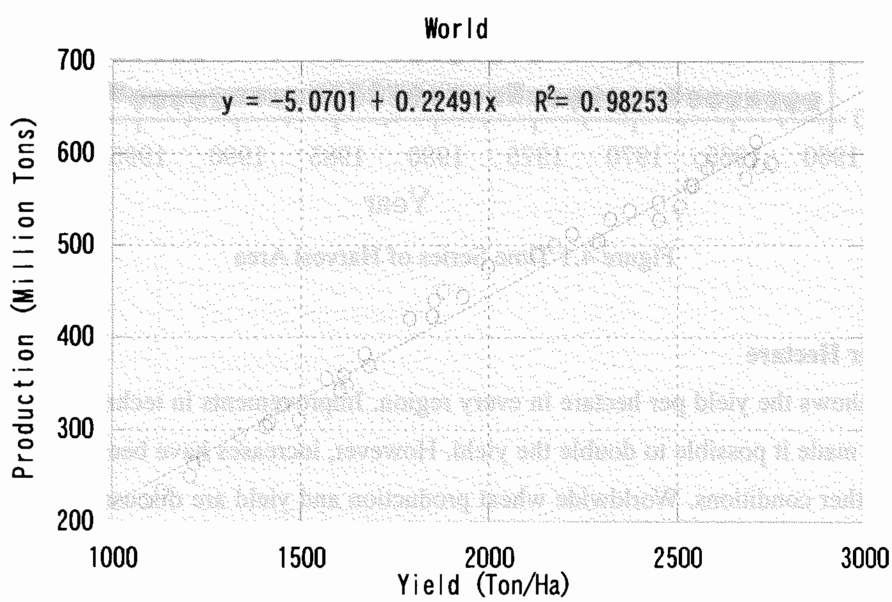

Figure 4.3 Relationships between Yield and Production (worldwide)

4.1.3 Regional Production and Supply

As shown in Figure 4.4, the worldwide production of wheat has increased by more than 350 million tons since the late 1970s. The highest production recorded was in 1997, at 613.27 million tons. Within about 25 years, global wheat production nearly doubled. Wheat production in developed nations increased from 90 million tons to 137 million tons during this period, and it more than doubled in developing countries.

On the other hand, the worldwide wheat supply for flour milling and for feed has shown an increasing trend, as shown in Figure 4.5. With the prediction of depressed wheat production, the supply was expected to decrease slightly after 1997; however, it gradually increased again in 2000.

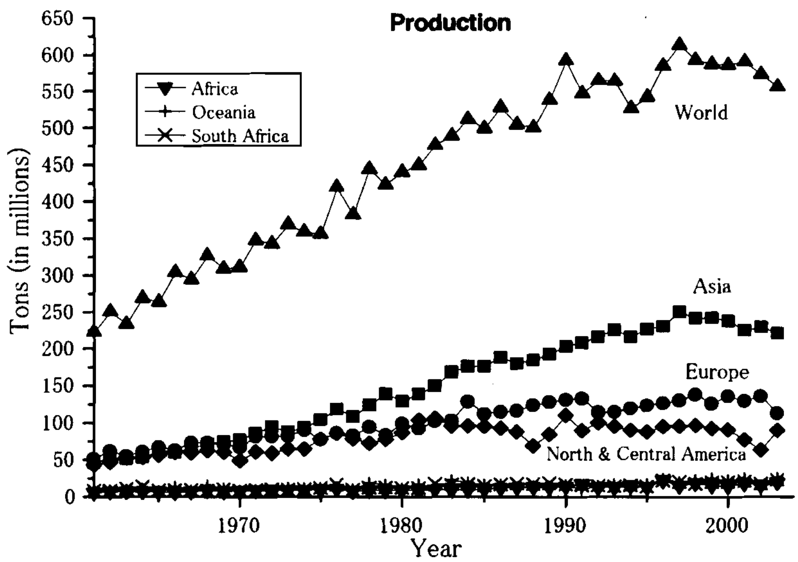

Figure 4.4 Regional Changes in Wheat Production

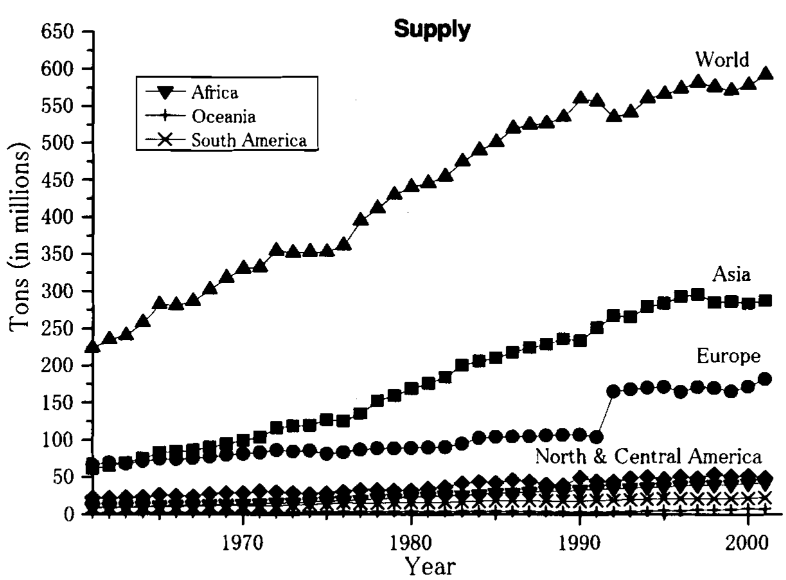

Figure 4.5 Regional Changes in Wheat Supply

The slowest growth is projected for Africa and Asia. Among the main factors contributing to this deceleration is sagging growth in yield improvement, owing mostly to water scarcity problems coupled with the more limited possibilities to bring new land into production. In Africa, harvested area is projected to contract in most wheat growing countries, except in Egypt, Ethiopia and Tanzania where plantings are projected to expand, albeit slightly and at a slower pace than in the 1990s. In Asia, most countries are likely to register an increase in their production but the growth would be more subdued than in the 1990s, especially in India and Bangladesh, mainly due to reduced plantings. In China, the gradual shift away from quantity to quality grains would also limit growth in planted areas.

4.1.4 Stock of Wheat

4.1.4.1 Stock-to-consumption Ratio of Wheat

Figure 4.6 shows the change of stock-to-consumption ratio (world). The stock-to-consumption ratio is decreasing continually since 1998. Now it is the lowest in last 30 years. According to the report of FAO, if the ratio is less than 18%, it will be a dangerous state. Now since the stock-to-consumption ratio is above 20%, it should be regarded as safety.

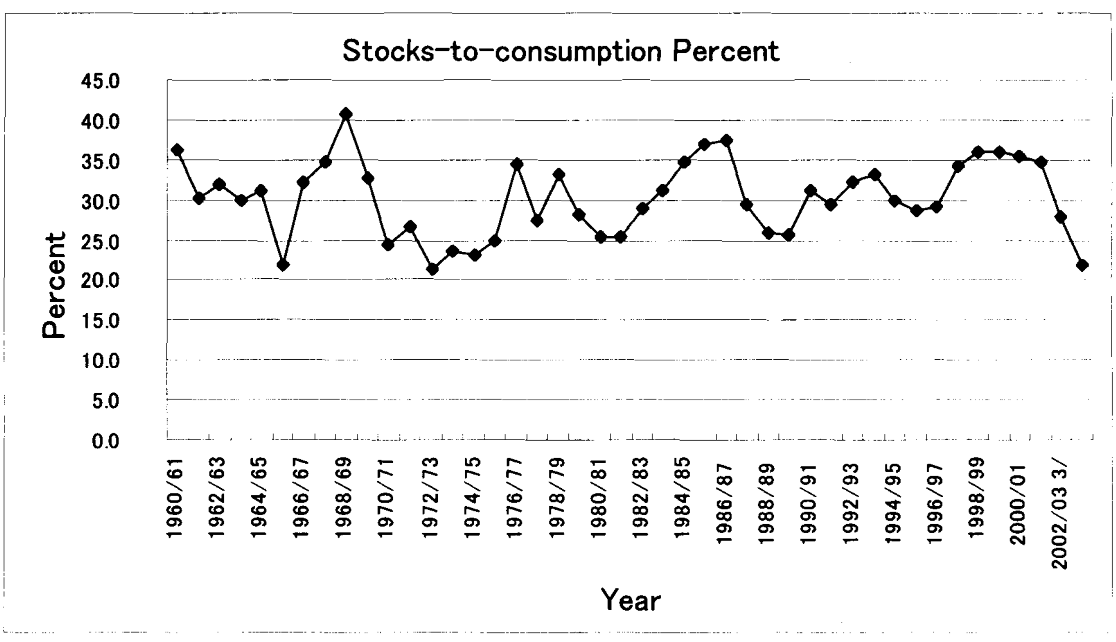

Figure 4.6 Stock-to-consumption Ratio of Wheat（World）

4.1.4.2 Stock of Wheat in China and World

The wheat amount of stock is about 200 million tons. Among them, the stock of china occupies the half of the world. As shown in the Figure 4.7, the stock of china reduces form 129 million tons of

2000 to 42 million tons of 2004. Adjustment of production and export expansion coming from China pull down the stock of world. So, China will bring about a strong effect to the wheat market of world.

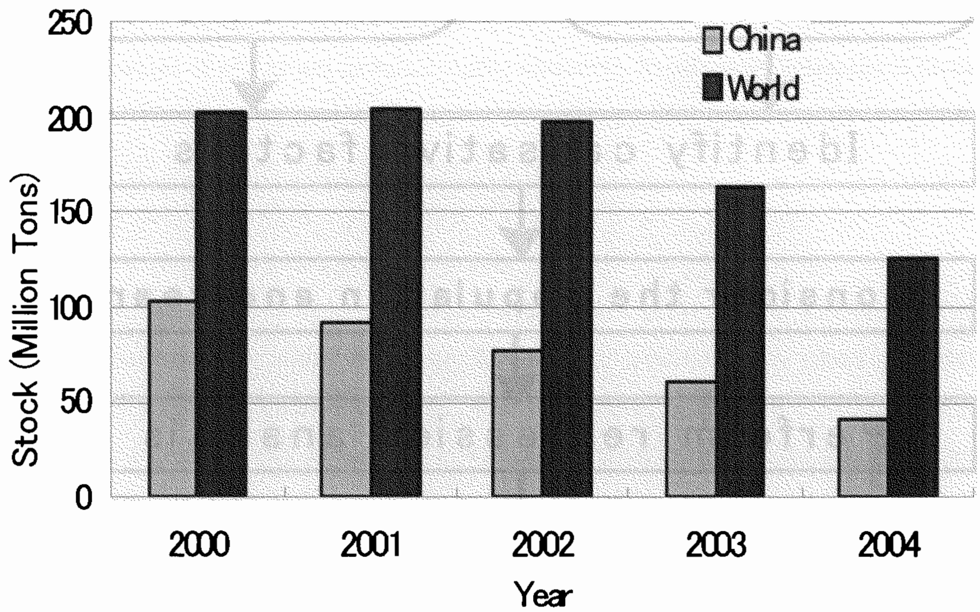

Figure 4.7 Stock of Wheat in China and World

4.2 Research Method

The method of this study is to obtain regional wheat production, supply, and trade statistics (FAO 2004) and to analyze population trends. Year and United Nations population projections to 2030 (UN 2004) are used to elucidate factors causing changes in the production and supply of wheat. Regional wheat shortages are quantified in relation to production and supply. Finally we analyze the maritime transportation of the wheat (Figure 4.8).

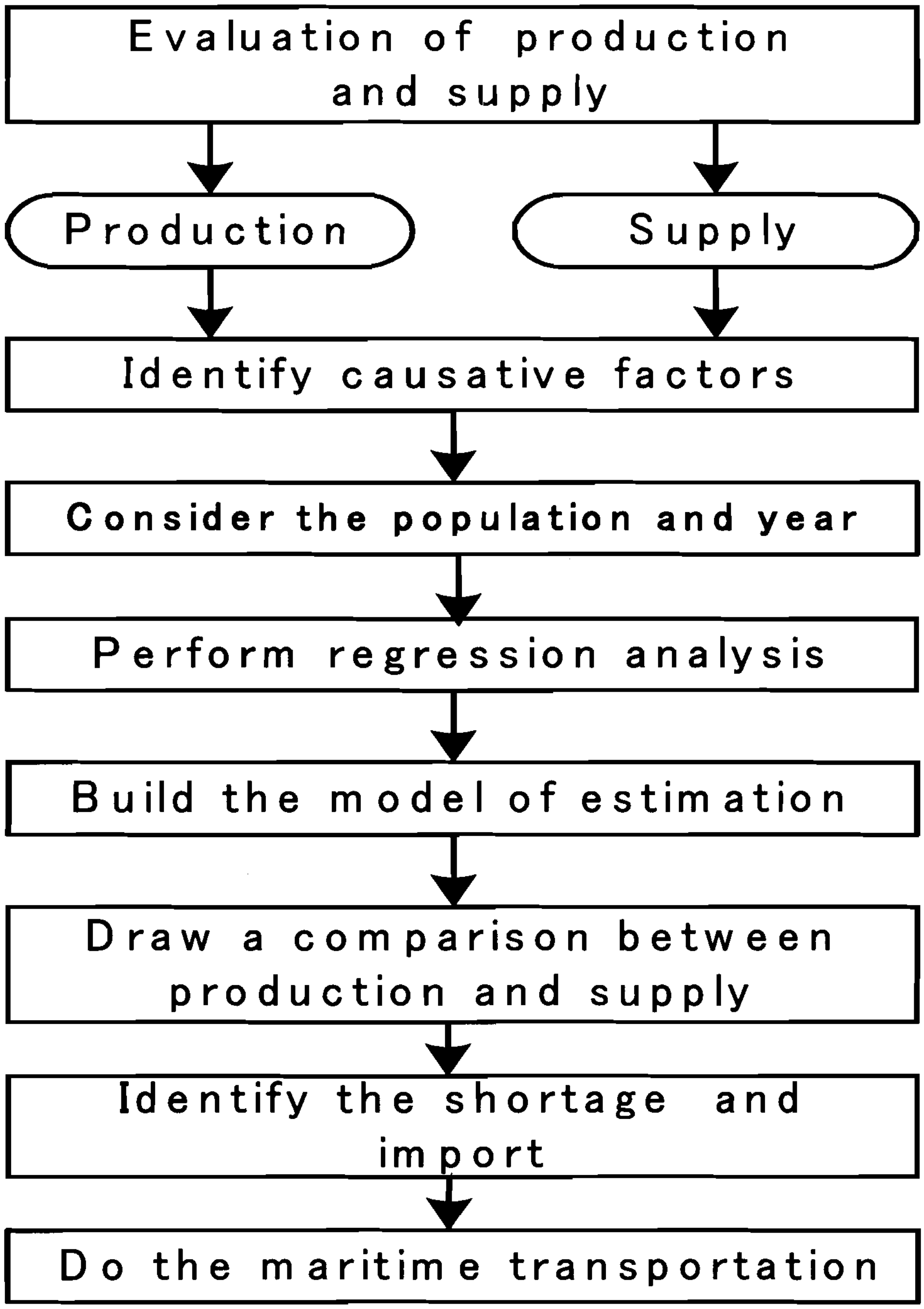

Figure 4.8 Model Framework

4.3 Factor Analysis of Population in Relation to Wheat Production and Supply

4.3.1 Wheat Production and Supply in Relation to Population

A country-by-country analysis of wheat production and supply shows sharp differences, making it difficult to build a long-term forecasting model. Consequently, research institutions such as the FAO and IFPRI have come up with different predictions.

In this paper, we deal with the wheat problem on a continent-by-continent basis (Kubo 2004), which allows a smoother analysis of annual changes in production, supply, and import/export. The relationship between the production and supply of wheat can thereby be obtained, and more precise predictions can be made (Kubo 2005). Here, according to the FAO, there are various ways of defining supply and, in fact, various concepts are in use. The elements involved are production, imports, exports and changes in stocks (increases or decreases). There is no doubt that production, imports and decreases in stocks are genuine supply elements. Exports and increases in stocks might, however, be considered as utilization elements. Accordingly, the following are possible ways of defining supply:

Supply for domestic utilization = production + imports - exports + changes in stocks (decrease or increase). This concept is used also in this research.

For this study, we used the data of annual production reports by the UN and the FAO. The population of each country since 1961 and the various conditions for wheat production were examined. The areas investigated were Asia, Africa, Europe, North and Central America, South America, and Oceania, as well as the whole world. We especially directed our attention to areas where there are food shortages.

We investigated the variables that have influenced wheat production and supply. The regression model was used to analyze every area by making population or year an explaining variable. We presume Equation (1) - (3).

$$P_z(t) = a_z POP_z(t) - b_z \quad (1)$$

$P_z(t)$: t, year; z, production within an area

$POP_z(t)$: t, year; z, population within an area

a_z, b_z : z, area coefficient

$$P_z(t) = a_z t - b_z \quad (2)$$

$P_z(t)$: t, year; z, production within an area

t : year

a_z, b_z : z, area coefficient

$$S_z(t) = c_z POP_z(t) - d_z \quad (3)$$

$S_z(t)$: t, year; z, supply within an area

$POP_z(t)$: t, year; z, population of an area

c_z, d_z : z, area coefficient

Figures 4.9-4.11 show the scattering diagram and a regression line between production and population, production and year, supply and population in the every area. The results of regression are summarized into Table 4.1-4.3

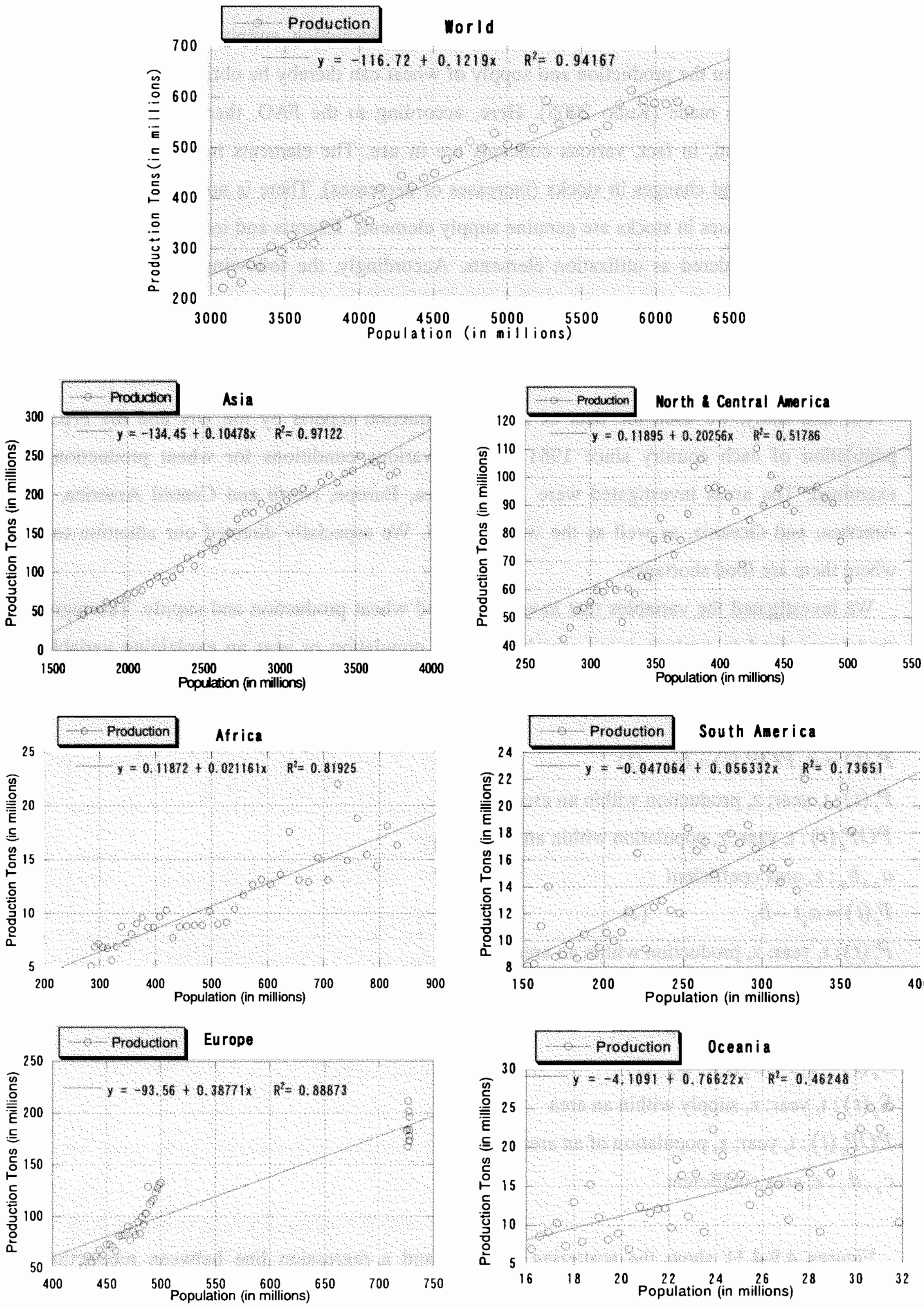

Figure 4.9 Relationships between Production and Population（Every Area）

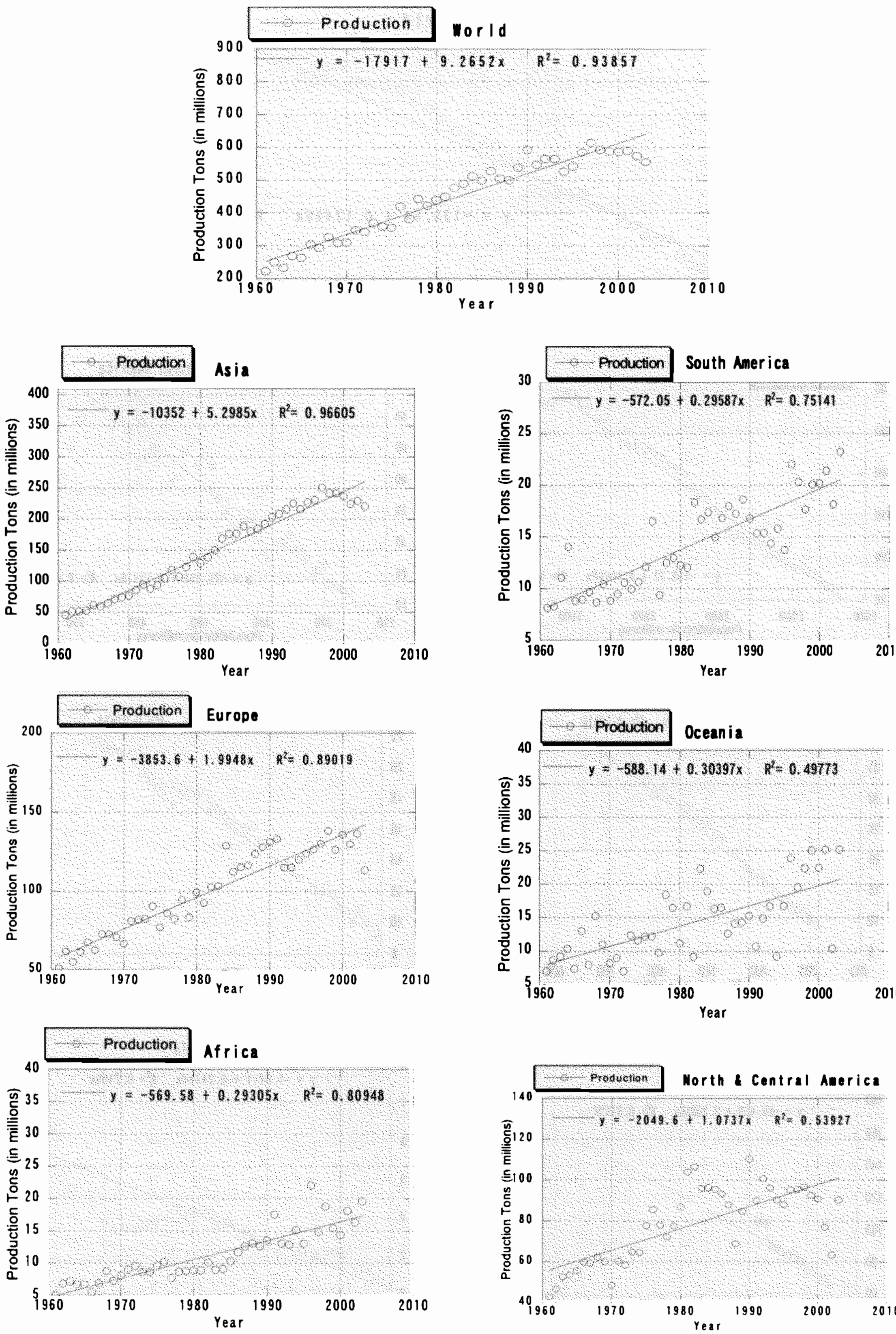

Figure 4.10 Relationships between Production and Year（Every Area）

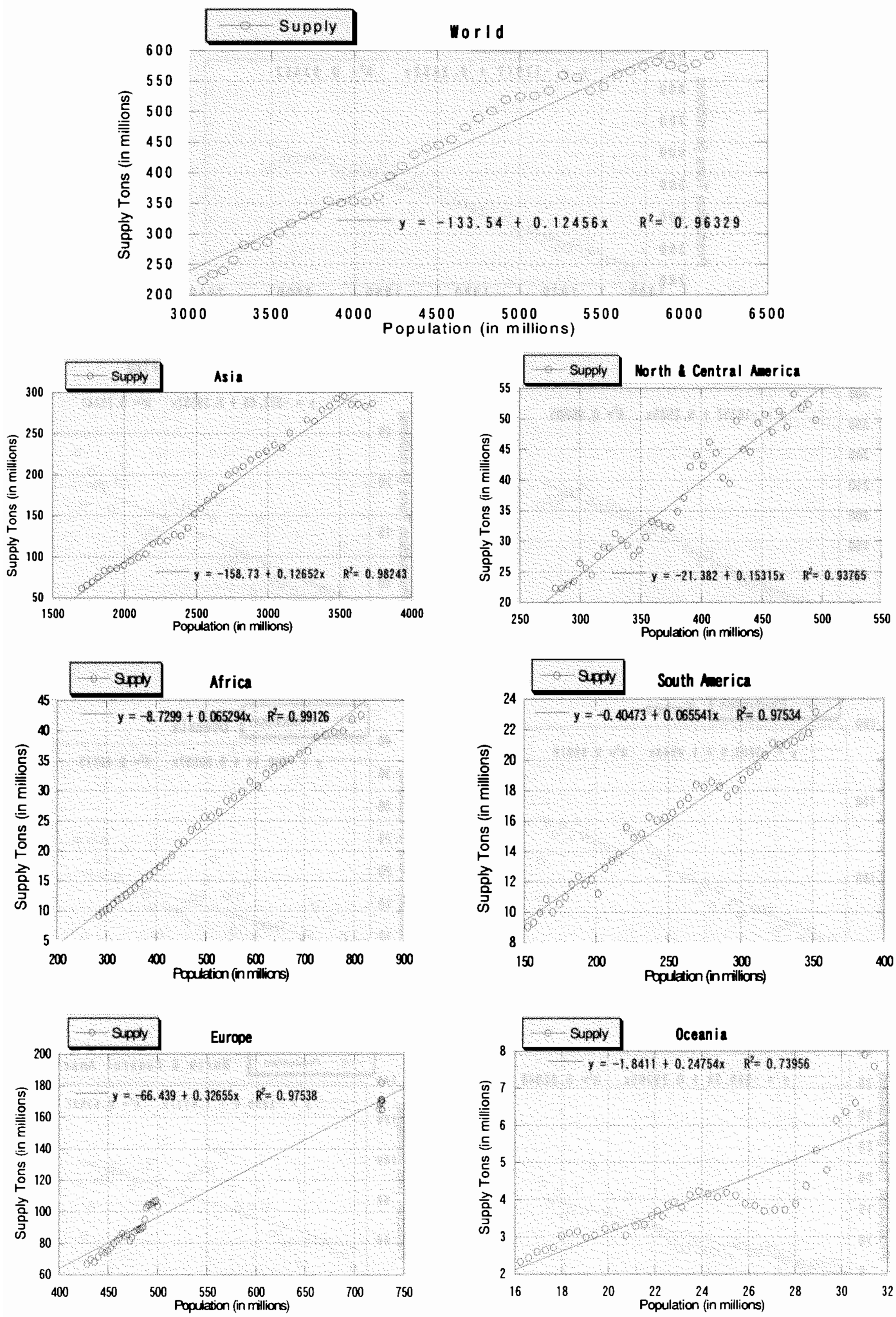

Figure 4.11 Relationships between Supply and Population (Every Area)

Table 4.1 shows that the correlation between the production and population is high in Asia, Africa, and the World. When the population is used as an explanation variable, the coefficient of determination of North and Central America and Oceania, is lower than that in other areas. Asia leads in the production of wheat; Europe is second, and North and Central America are third in the world. The objective behind wheat production in North and Central America is to improve their business opportunities; as a result, it is possible that the production could be destabilized.

Table 4.1 Regression Result between Production and Population

Dependent Variables(Area)	Coefficients		t value		Linear R^2	R	SE	F value	DW
z	a	b	a	b	people				
Asia	0.105	-134.4	36.74	-17.05	**0.971**	0.9855	11.606	1350	0.507
Europe	0.167	9.7354	6.621	0.701	**0.523**	0.7231	18.73	43.84	0.438
World	0.122	-116.7	25.41	-5.184	**0.942**	0.9704	29.413	645.77	0.858
Africa	0.021	0.1187	13.46	0.139	**0.819**	0.9051	1.6877	181.29	2.193
North & Central America	0.203	0.1189	6.555	0.01	**0.518**	0.7196	12.999	42.963	0.532
Oceania	0.766	-4.109	5.867	-1.302	**0.463**	0.6801	3.8588	34.417	1.804
South America	0.056	-0.047	10.57	-0.034	**0.737**	0.8582	2.1332	111.81	1.65

Table 4.2 Regression Result between Production and Year

Dependent Variables(Area)	Coefficients		t value		Linear R^2	R	SE	F value	DW
z	a	b	a	b	year				
Asia	5.298	-10352	34.16	-33.67	**0.966**	0.9829	12.623	1166.7	0.449
Europe	1.995	-3854	18.23	-17.77	**0.890**	0.9435	8.9037	332.38	1.192
World	9.265	-17917	25.03	-24.42	**0.939**	0.9688	30.123	626.46	0.813
Africa	0.293	-569.6	13.2	-12.94	**0.810**	0.8997	1.8068	174.2	1.931
North & Central America	1.074	-2050	6.927	-6.672	**0.539**	0.7343	12.613	47.989	0.649
Oceania	0.304	-588.1	6.374	-6.222	**0.498**	0.7055	3.8807	40.629	2.083
South America	0.296	-572	11.13	-10.86	**0.751**	0.8668	2.1628	123.93	1.687

Table 4.3 Regression Result between Supply and Population

Dependent Variables(Area)	Coefficients		t value		Linear R^2	R	SE	F value	DW
z	c	d	c	d					
Asia	0.127	-158.7	46.7	-21.42	**0.982**	0.9912	10.617	2181	0.286
Europe	0.327	-66.44	39.31	-14.68	**0.975**	0.9876	5.9492	1545	0.406
World	0.125	-133.5	31.99	-7.376	**0.963**	0.9815	22.996	1023.5	0.205
Africa	0.065	-8.73	66.49	-16.68	**0.991**	0.9956	1.0067	4420.7	0.399
North & Central America	0.153	-21.38	24.22	-8.714	**0.938**	0.9683	2.556	586.53	1.268
Oceania	0.248	-1.841	10.52	-3.268	**0.740**	0.86	0.6676	110.75	0.301
South America	0.066	-0.405	39.28	-0.945	**0.975**	0.9876	0.6441	1542.8	0.921

Table 4.2 shows that the correlation between the production and year is high in Asia, Africa and World. When the year is used an explanation variable, the coefficient of determination of North and

Central America and Oceania is lower than the other areas. Asia leads in the production of wheat; Europe is the second, and North and Central America are third-ranked in the world. The objective behind wheat production in North and Central America is to improve their business opportunities; as a result, the production is unstable. The explanation variable in production is the fiscal year. In the case of a fiscal year, it is assumed that various factors are contained.

Taking population as an explaining variable, a close correlation is observed in Table 4.3. Although the coefficient of determination of Oceania is 0.740, most areas have a correlation in excess of 0.9. It is clear that population could be used to explain supply as a variable.

4.3.2 Relationships between Supply and Production

Figure 4.12 shows the relationships between supply and production in the every area. As shown in the Figure 4.12, high coefficient of determination can be obtained from the World and Asia rather than the whole areas.

In the case of Asia, the coefficient of determination is very high (0.9901). One possible explanation is as following. Since there is no margin for wheat business of world, the production of Asia is contributed greatly to the supply of Asia.

High coefficient of determination can not been seen in the North & Central America, Europe and Oceania. The mostly likely cause is that the purpose of production is for wheat business of world. So, the change of production is lack of stability.

In Africa, the coefficient of determination is high, but more than 0.9 can not obtained because the production of wheat is at risk such as natural calamities and civil war. South America can be self-support in some extent. The higher coefficient of determination cannot be obtained due to the change of production is big.

By the above analyze, High correlation is seen in the shortage area such as Asia and Africa. The relationship between supply and production in shortage area is more closely than surplus area. The close relationship is an important feature in the shortage area.

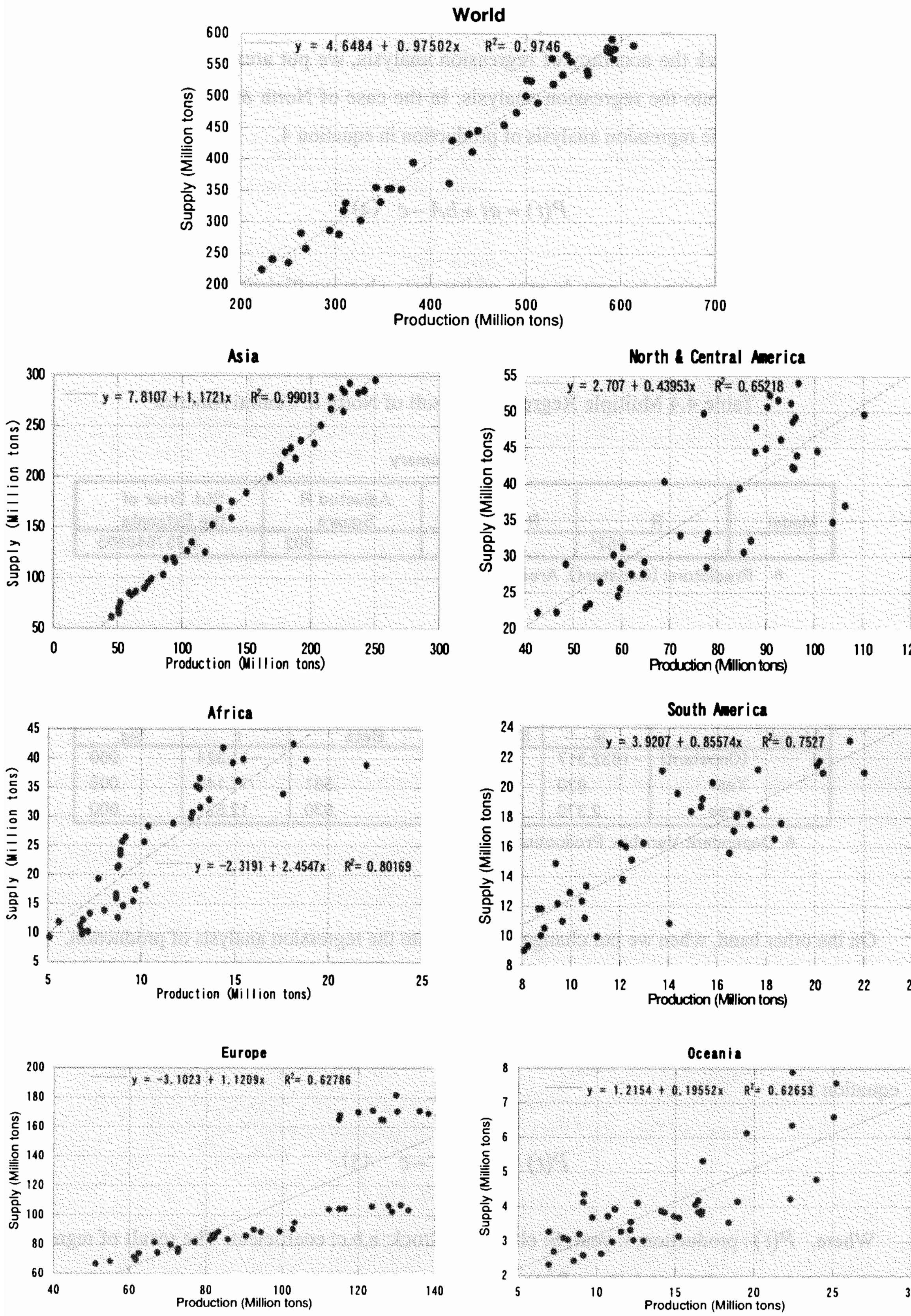

Figure 4.12 Relationships between Supply and Production (Every Area)

4.3.3 Multiple Linear Regression Analysis of North & Central America and Oceania

In order to improve the accuracy of regression analysis, we put area of harvest or change of stock as parameter into the regression analysis. In the case of North & Central America, we put area of harvest into the regression analysis of production in equation 4.

$$P(t) = at + bA - c \quad (4)$$

Here, $P(t)$: production; t: year; A: area of harvest; a,b,c: coefficient. The result of regression analysis is shown in Table 4.4. The R^2 can be increased to 0.90.

Table 4.4 Multiple Regression Result of North & Central America

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.952[a]	.906	.902	5.757648905

a. Predictors: (Constant), Area, Year

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1632.317	144.144		-11.324	.000
	Year	.820	.074	.561	11.149	.000
	Area	2.370	.189	.630	12.521	.000

a. Dependent Variable: Production

On the other hand, when we put change of stock into the regression analysis of production, R^2 is lower (0.71) than 0.90. So, the area of harvest is also important parameter in North & Central America.

In the case of Oceania, we put change of stock into the regression analysis of production in equation 5.

$$P(t) = at + bS - c \quad (5)$$

Where, $P(t)$: production; t: year; S: change of stock; a,b,c: coefficient. The result of regression analysis is shown in Table 4.5. The R^2 can be increased to 0.81.

Table 4.5 Multiple Regression Result of Oceania

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.902ᵃ	.813	.803	2.305087781

a. Predictors: (Constant), Stock chage, Year

Coefficients ᵃ

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-604.752	58.413		-10.353	.000
	Year	.312	.029	.737	10.590	.000
	Stockchage	-.715	.084	-.594	-8.545	.000

a. Dependent Variable: Production

On the other hand, when we put area of harvest into the regression analysis of production, R^2 is lower (0.65) than 0.81. So, change of stock is also important parameter in Oceania.

4.4 Surplus and Shortage in Every Region

4.4.1 The Viewpoint of Production and Supply

The surplus and shortage are the difference in production (P) and supply (S) in every region. If the difference between wheat production and supply is positive in a particular area, there will be a surplus from the viewpoint of production and supply. If not, there will be a shortage. The surplus and shortage are shown in Figure 4.14. Asia and Africa are shortage areas. The surplus areas are Europe, North America & Central America, and Oceania.

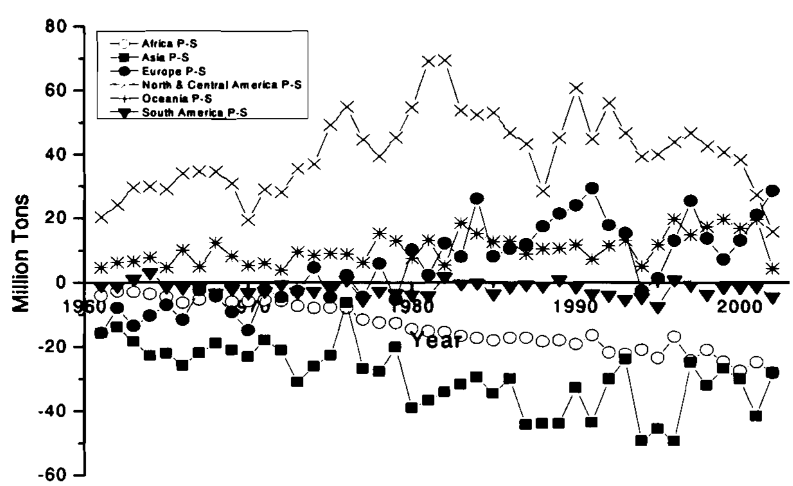

Figure 4.14 Surpluses and Shortages (Every Area)

4.4.2 The Viewpoint of Net Imports

If the difference between wheat import and export is positive in a particular area, there will be a surplus from the viewpoint of Net imports. If not, there will be a shortage. Figure 4.15 shows the situation of net imports in every area. Figure 4.16 shows the situation of import countries in the world. We make a comparison between Figure 4.15 and Figure 4.16. It is clear that the important countries decide the trade trend in their area.

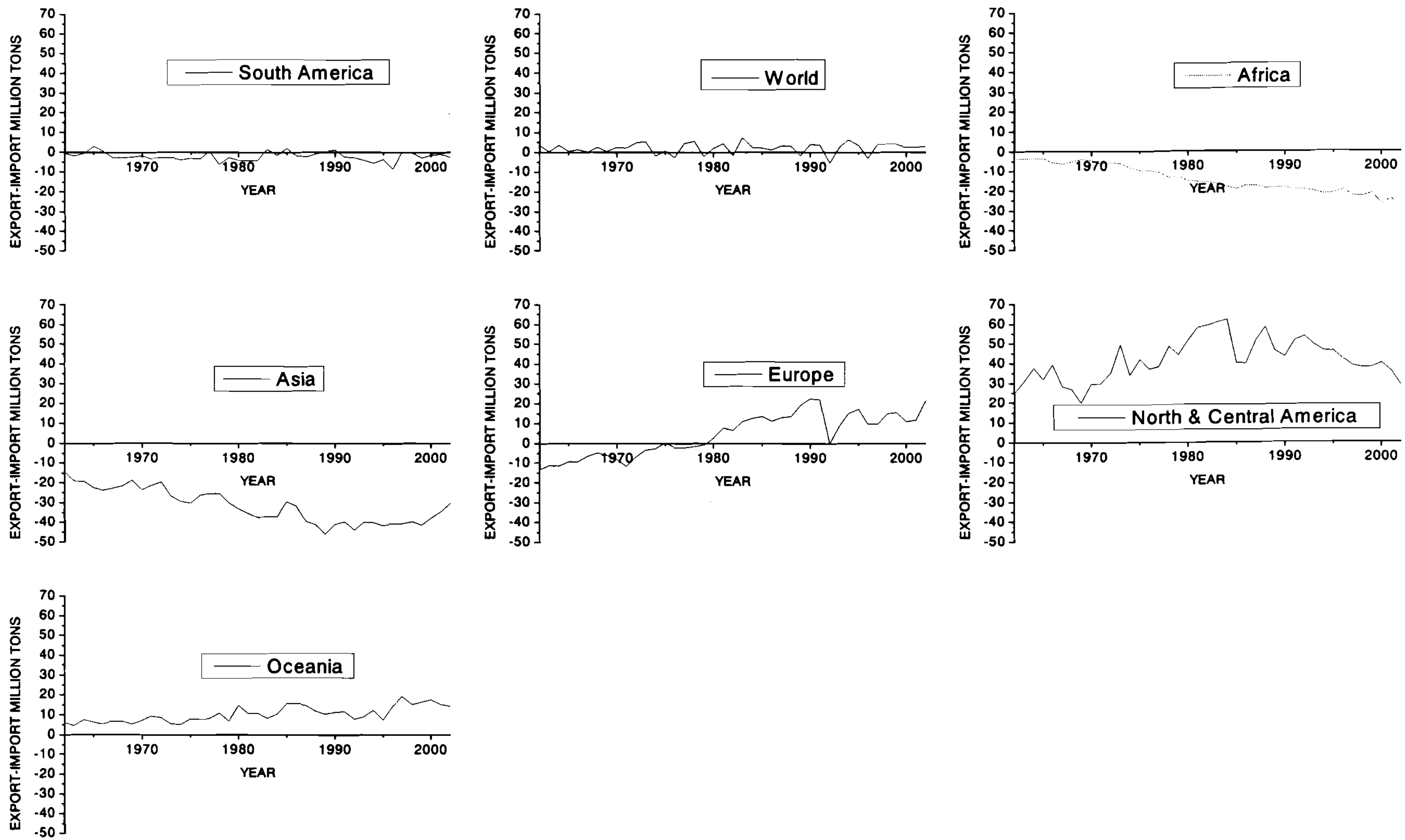

Figure 4.15 The Difference between Export and Import (Every Area)

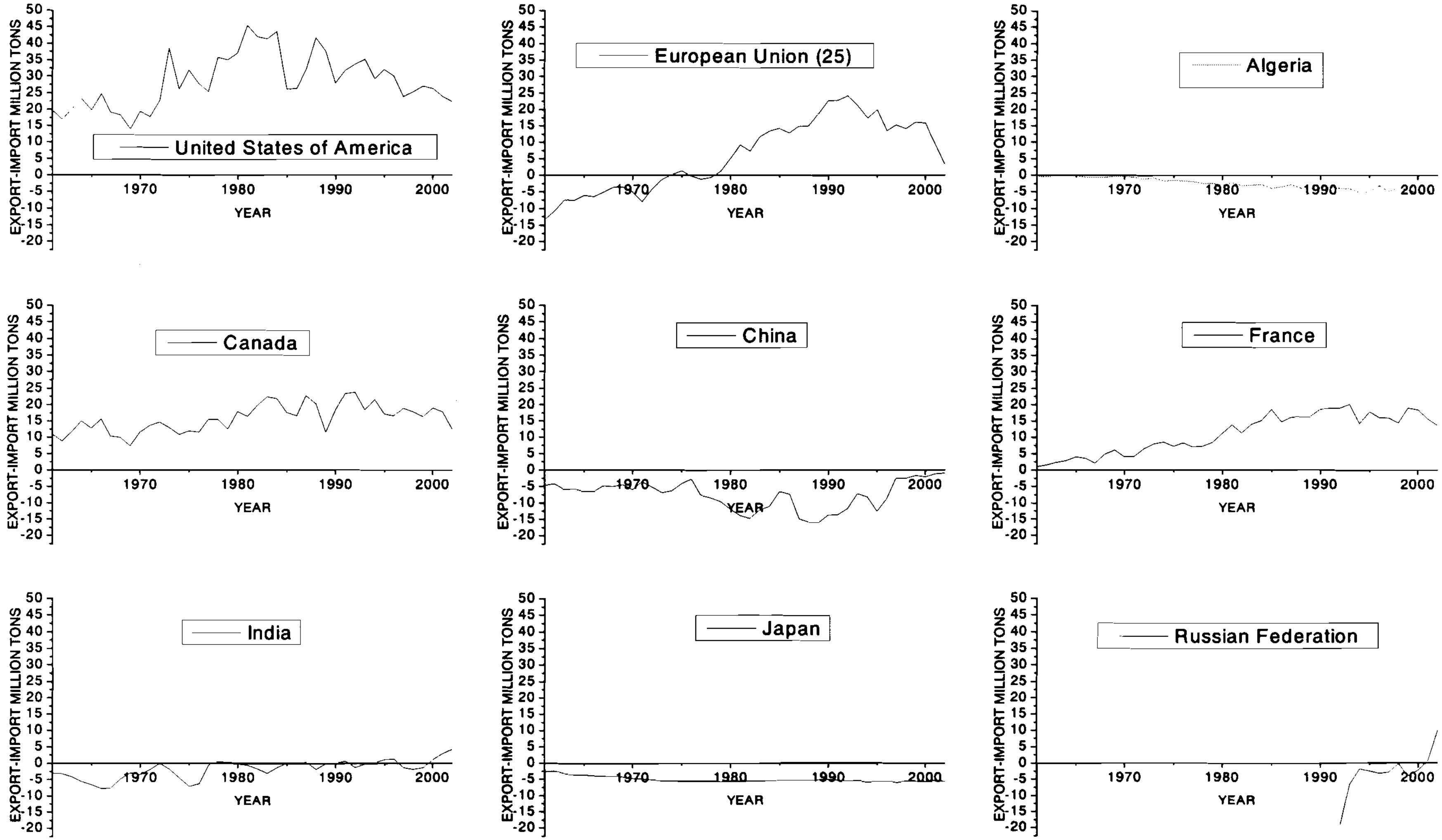

Figure 4.16 The Difference between Export and Import (Important Countries)

4.4.3 Comparison of Two Viewpoints

Figure 4.17 and 4.18 shows surplus and shortage from two viewpoints. By comparison, we find the same trend exists in the every area except Europe. The cause of Europe is a statistics problem from FAO. Before 1991, the statistics of Europe does not include USSR (Union of Soviet Socialist Republics). Since USSR dissolved in 1991, the statistics of FAO also made a change that the European part of USSR was accounted into Europe. So the difference of the trend is seen in Europe after 1991. If we make a comparison in EU12 as shown in Figure 4.19, the same trend can be obtained.

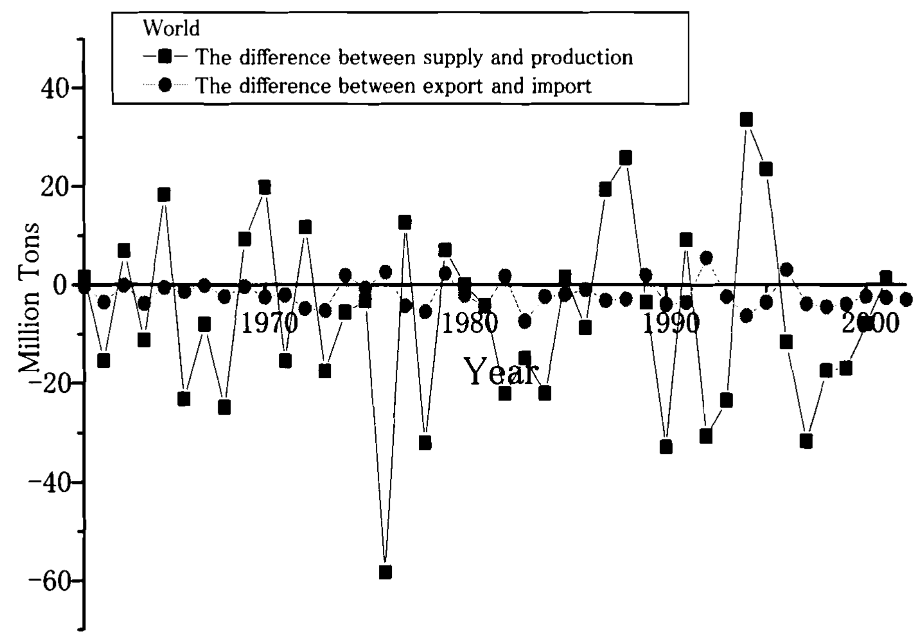

Figure 4.17 Comparison of Difference (World)

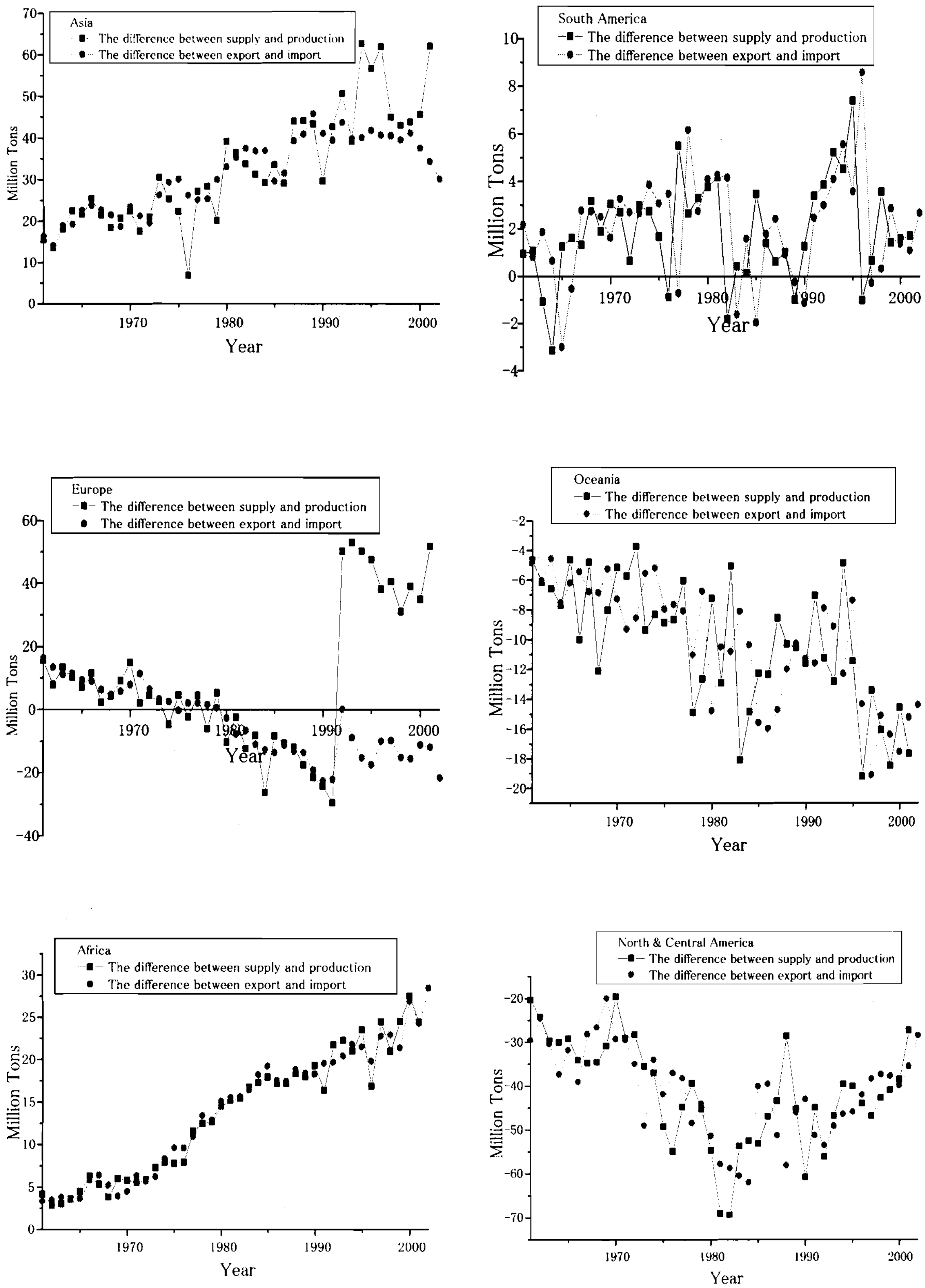

Figure 4.18 Comparison of Difference (Every Area)

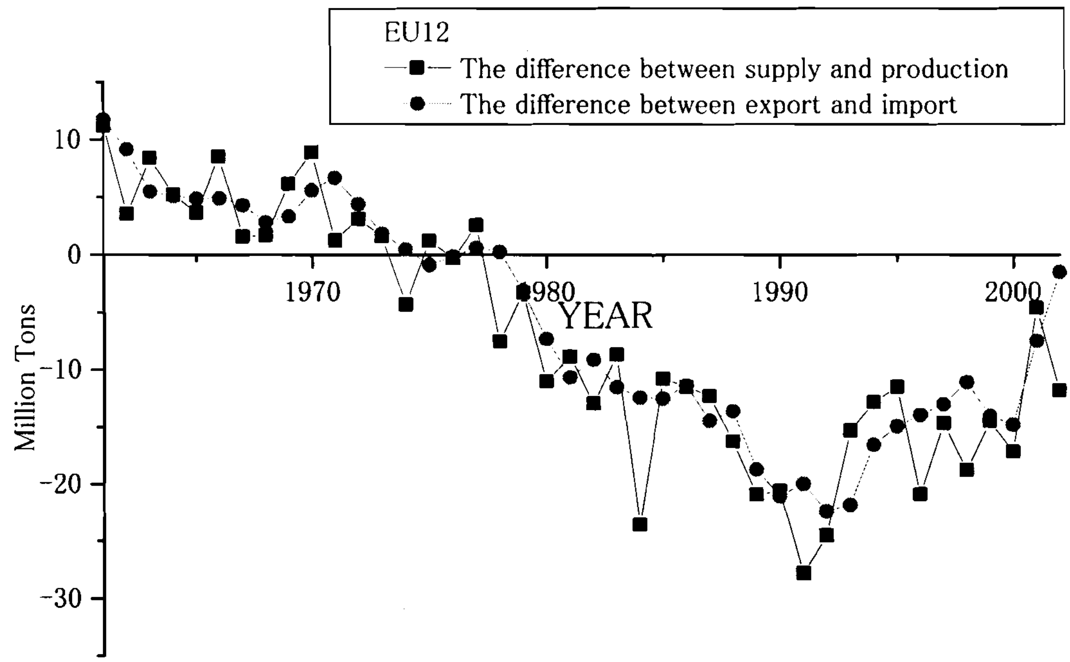

Figure 4.19 Comparison of Difference (EU12)

4.5 Future of Maritime Transportation

4.5.1 About the Forecasting

The Forecasting Process is summarized in the flow diagram in Figure 4.20. Firstly, the collection and examination of appropriate historical data are described. Then we should choose the forecasting method and decide the forecast periods. If these elements are accepted, we will make the forecasting. If not, we should reexamine the data and method.

When we will make a forecast, the selection of method becomes very important. Table 4.6 gives the technique of forecasting. There are many methods in the table. But, considering the limit of research data and forecasting cost, we choose the regression analyses for our prediction to make the medium-range forecasting. The regression analyses are also often applied into varies research and can explain the cause and effect relationship between the input and its output.

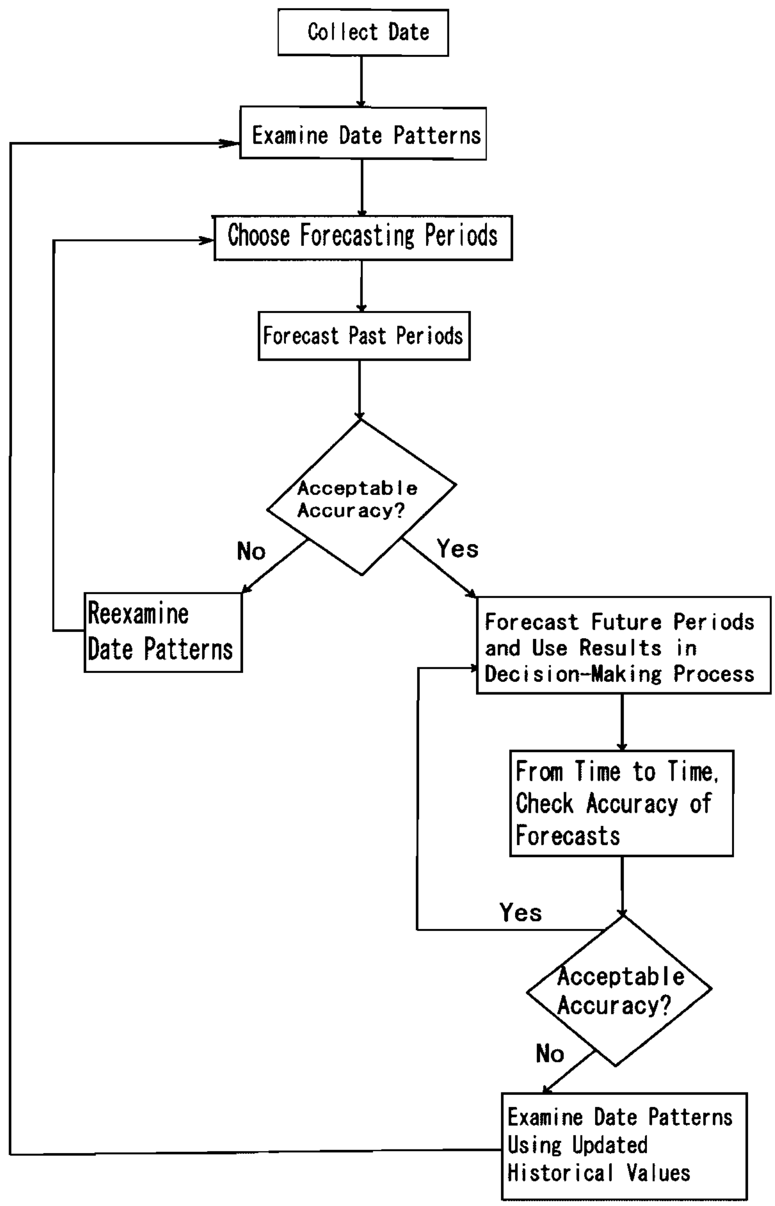

Figure 4.20 Forecasting Process (Hanke, J. E., et al. 2001)

Table 4.6 Technique of Forecasting (Hanke, J. E., et al. 2001)

Method	*Description*	*Applications*	*Computer Cost*	*Necessary?*
Causal Forecasting Models				
Regression analysis	Explanatory forecasting; assumes a cause-and-effect relationship between the input to a system and its output	Short- and medium-range forecasting of existing products and services; marketing strategies, production, personnel hiring, and facility planning	Low to medium	Usually
Multiple regression	Explanatory forecasting; assumes a cause-and-effect relationship between more than one input to a system and its output	Same as above	Low to medium	Yes
Time Series Forecasting Models				
Decomposition method	Exploratory forecasting; assumes a cause-and-effect relationship between lime and the output of a system; the system is decomposed into its components	Medium-range forecasting for new plant and equipment planning, financing, new-product development, and new methods of assembly; short-range forecasting for personnel, advertising, inventory, financing, and production planning	Low to medium	Yes
Moving averages	To eliminate randomness in a time series; forecast based on projection from time series data smoothed by a moving average	Short-range forecasts for operations such as inventory, Scheduling, control, pricing, and Timing special promotions; used to compute both the seasonal and cyclical components for the short-term decomposition method	Low	No
Exponential smoothing	Similar to moving averages but values weighted exponentially, giving more weight to most recent data	Short-range forecasts for operations such as inventory, scheduling, control, pricing, and liming special promotions	Low	Yes
Autorcgressivc models	Employed with economic variables lo account for relationships between adjacent observations in a time series	Short- and medium-range forecasting for economic data ordered in a time series; price, inventory, production, stocks, and sales	Medium	Yes
Box-Jenkins techniques	Does not assume any particular pattern in the historical data of the series to be forecast; uses an iterative approach of identifying and fitting a possibly useful model from a general class of models	Same as above	High	Yes
Neural networks	Uses sophisticated computer program to assimilate relevant data and recognize patterns by "learning" as humans do	Increasing use in a variety of forecasting applications; is in development phase	High	Yes

4.5.2 Shortage Prediction

We presume Equation (6) and (7) to calculate the shortage in the future according to the viewpoint of production and supply. Equation (6) is the Scenario 1 based on the equation (1) and (3). On the other hand, equation (7) is the Scenario 2 based on the equation (2) and (3).

$$Shortage(t) = P_z(t) - S_z(t) = (a_z - c_z)POP_z(t) - (b_z - d_z) \qquad (6)$$

$$Shortage(t) = P_z(t) - S_z(t) = (a_z t - c_z POP_z(t)) - (b_z - d_z) \qquad (7)$$

Where $P_z(t)$: z area's production, t: year, a_z, b_z, c_z, d_z: the coefficients for the z area, $S_z(t)$: z area's supply, and $POP_z(t)$: z area's population.

The shortage of scenario 1 is shown in Figure 4.21 by a long-term prediction. The worldwide balance of production and supply can be maintained theoretically on a continent-by-continent basis. In the case of Asia, its shortage will increase to 81.6 million tons in 2030. In the case of Africa, its shortage is expected to be 55.7 million tons; it is more serious than that of Asia because its speed of increase is rapid. The worldwide shortage will be 137 million tons in 2030.

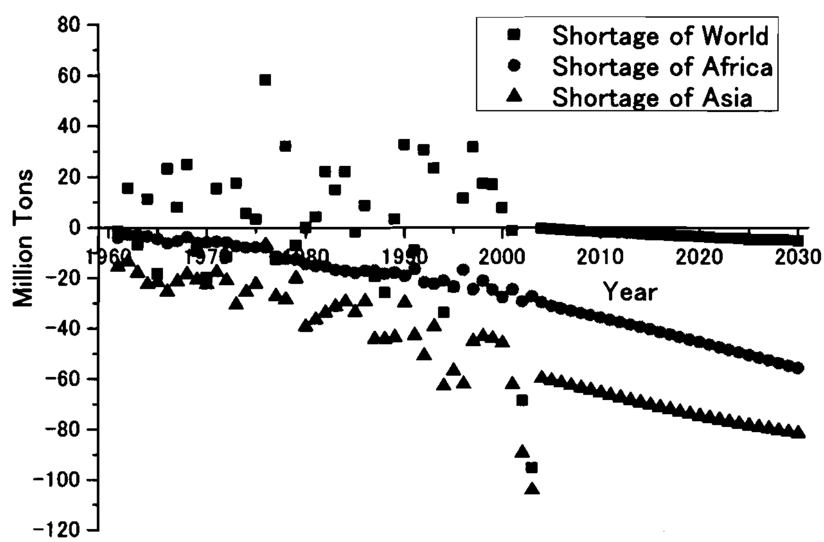

Figure 4.21 Worldwide Shortages (Scenario 1)

The shortage of scenario 2 is shown in Figure 4.22 by long-term prediction. The worldwide balance of production and supply can be maintained theoretically from a continental viewpoint. In the case of Asia, the shortage will decrease, but Asia will still need to import 50 million tons in 2030. In the case of Africa, the shortage is a more serious because it continues to increase. The worldwide shortage will be 110 million tons in 2030, and the shortage in Africa is expected to be 60 million tons more than that in Asia.

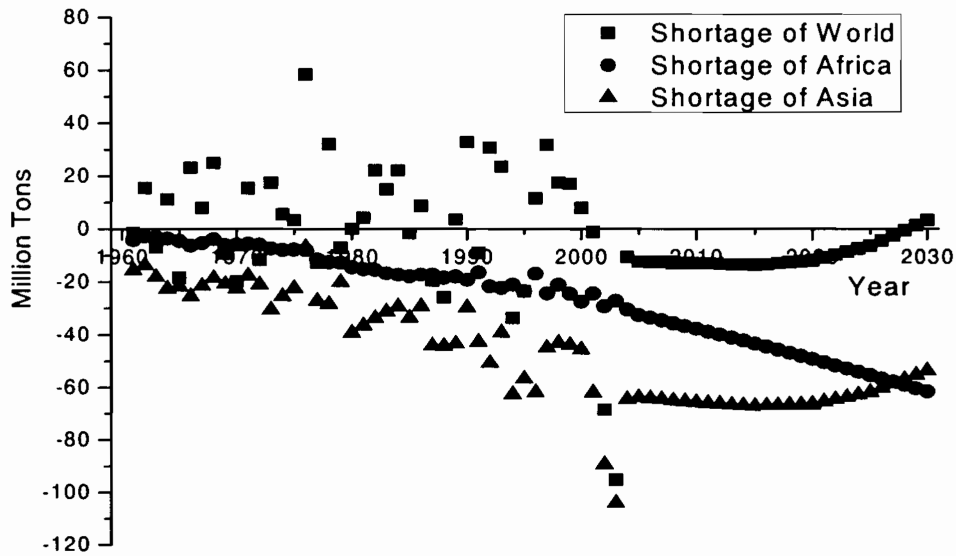

Figure 4.22 Worldwide Shortages (Scenario 2)

4.5.3 Relations among the Shortage, Import and Maritime Transportation

4.5.3.1 Relations between Shortage and Population in Areas with Food Shortages

The relations between a wheat shortage and population is shown in Figures 4.23 and 4.24. Since a high determination coefficient is obtained, we can use population to estimate wheat shortages in Asia and Africa.

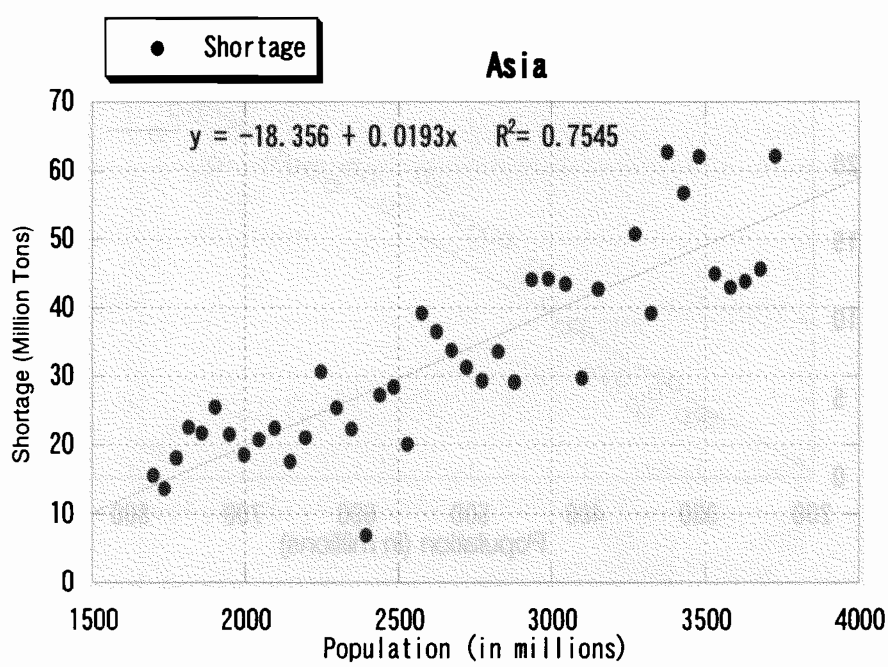

Figure 4.23 Relations between Wheat Shortage and Population in Asia

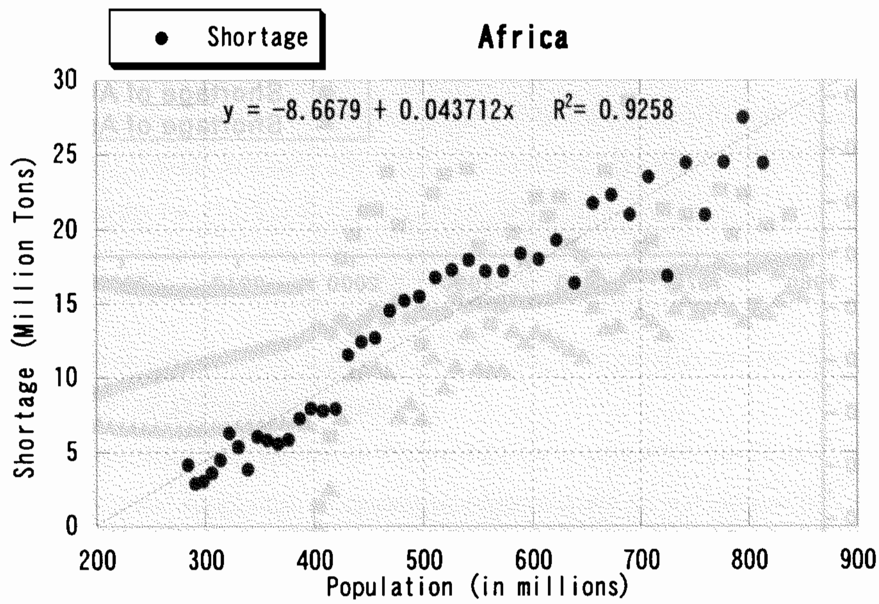

Figure 4.24 Relations between Wheat Shortage and Population in Africa

4.5.3.2 Relations between Import and Population in Areas with Food Shortages

The relations between import and population is shown in Figures 4.25 and 4.26. A high determination coefficient is obtained. Thus, we can also use population to estimate wheat import in Asia and Africa.

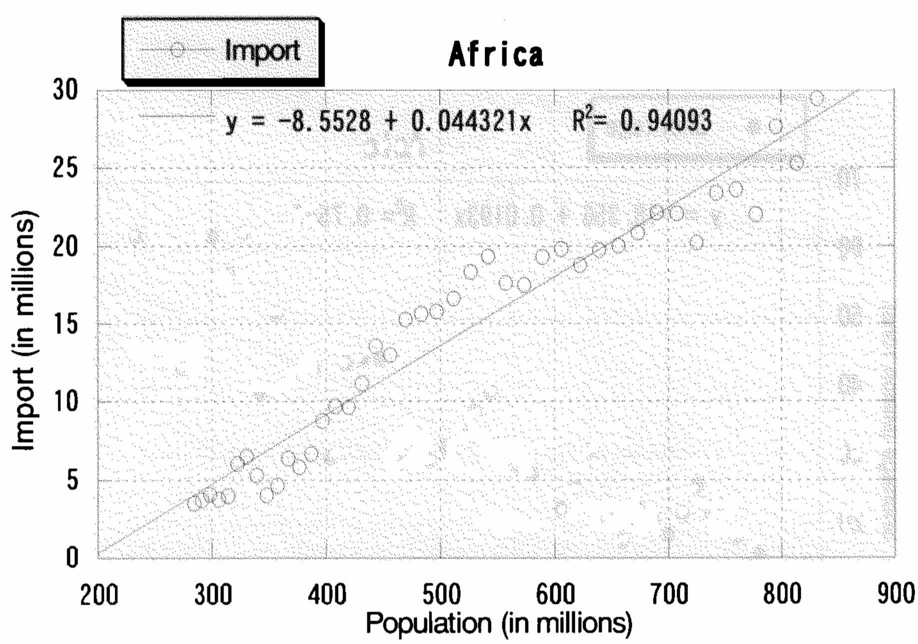

Figure 4.25 Relationships between Import and Population (Africa)

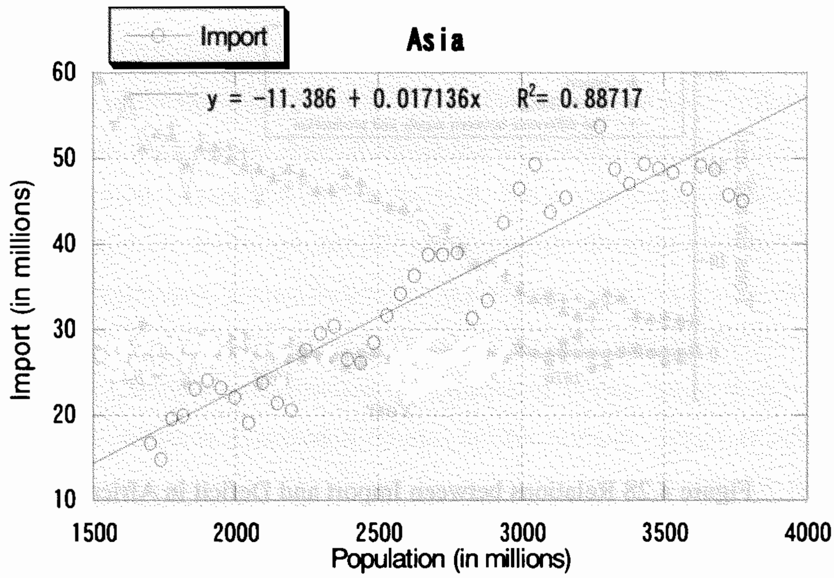

Figure 4.26 Relationships between Import and Population (Asia)

4.5.3.3 Relations between Shortages and Imports

The relations between shortages and imports in Asia and Africa is shown in Figure 4.27 and 4.28. It seems that imports greatly depend on shortages. In Figure 4.29 and 4.30, the regression line, E (y), and a 95% confidence limit of y are shown. More reliable estimates can be obtained for Africa than for Asia. From these two figures, shortage statistics can be used to estimate imports. Here, the volume of imports will be the volume of maritime transportation. At least, the volume of imports almost neared to the volume of maritime transportation because we analyze it on the basis of a continental method.

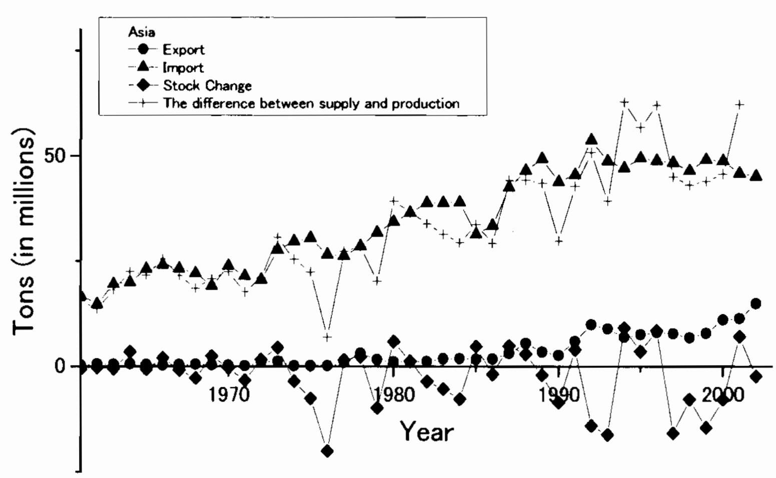

Figure 4.27 Relations between Import and Deficit in Asia

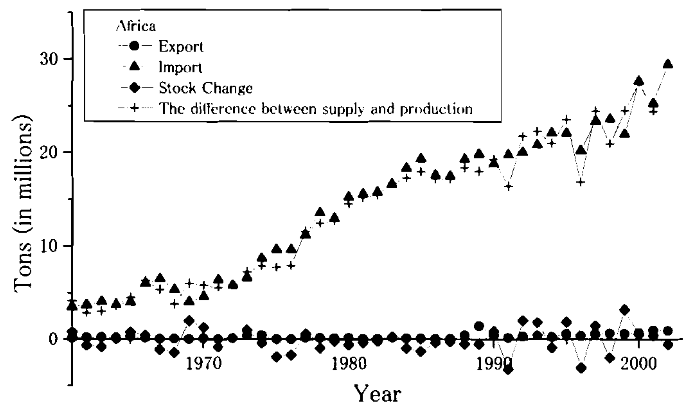

Figure 4.28 Relations between Import and Deficit in Africa

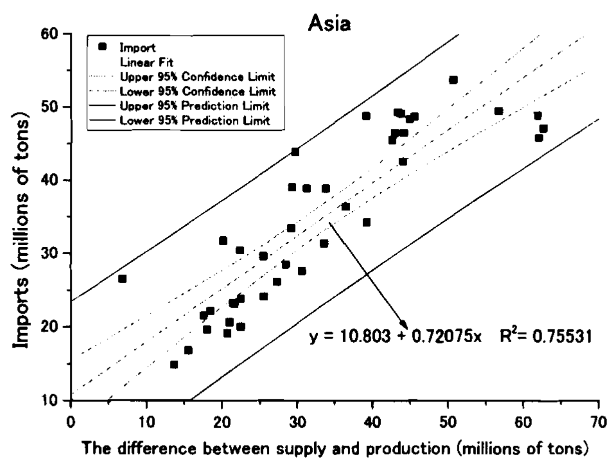

Figure 4.29 Relations between Import and Wheat Shortage in Asia

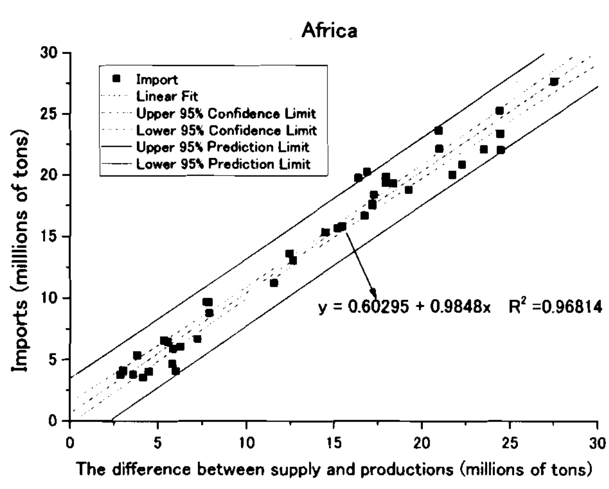

Figure 4.30 Relations between Import and Wheat Shortage in Africa

4.5.3.4 Relationships between Imports and Maritime Transportation

In the case of Asia, North-Central America and Oceania are very important exporters to Asia. The export share of wheat of the two regions was 97% in 1980, but it declined to 78% in 2000. Even now, the two regions remain important to Asia. If wheat is transported from North-Central America and Oceania to Asia, maritime transportation must be used. The export share of wheat in Europe is 9% on the average of 1989-2001. In Europe, the EU and Russia are the most important exporters. If cost and efficiency are considered, transportation by sea should be chosen. On the contrary, some countries import wheat to Asia by land, but land transportation is comparatively small. Most of the wheat is managed by maritime transportation. In the case of Africa, cargo should be shipped from other regions because Africa is surrounded by sea. In this research, wheat to Africa will only be managed by maritime transportation. Therefore, here, the imports will make up the volume of the maritime transportation. At least, the volume of imports was nearly equivalent to the total maritime transportation. Therefore, in this study, we consider the volume of imports to be the volume of maritime transportation.

4.5.4 Volume of Maritime Transportation

In the following analysis, we presume Equation (8) and Equation (9) to calculate the maritime transportation in the future.

$$MT_{Asia}(t) = 10.803 + 0.72075 Shortage_{Asia} \quad (8)$$

$$MT_{Africa}(t) = 0.60295 + 0.9848 Shortage_{Africa} \quad (9)$$

The shortage is used to estimate future maritime transportation. The results of scenario 1 are shown in Table 4.7. From the results for Asia, the volume of the maritime transportation from foreign countries to Asia is expected to be 69.58 million tons in 2030. The volume is 1.28 times that of 2005. On the other hand, wheat shipments of about 55.5 million tons will be needed in Africa from foreign countries in 2030. The volume is 1.78 times that of 2005.

Table 4.7 Predictions of Maritime Transportation in Asia and Africa (mil.t)

	2005	2010	2015	2020	2025	2030	2030/2005 (times)
Asia	54.44	57.96	61.42	64.59	67.32	69.58	1.28
Africa	31.27	35.66	40.37	45.28	50.33	55.5	1.78

The results of scenario 2 are shown in Table 4.8. From the results for Asia, the volume of the maritime transportation from foreign countries to Asia is expected to be 49.49 million tons in 2030. The volume is 1.24 times that of 2000. On the other hand, wheat shipments of about 61.29 million tons will be needed in Africa from foreign countries

Table 4.8 Predictions of maritime transportation in Asia and Africa (mil.t)

	2000	2005	2010	2015	2020	2025	2030	2030/2000 (times)
Asia	39.95	56.80	58.21	59.23	58.63	55.43	49.49	1.24
Africa	22.60	32.65	37.70	43.23	49.05	55.08	61.29	2.71

4.5.5 Role of the WTO

The WTO has an important role to promote the international trade of food. By reducing subsidies to farmers, the customs duties, and import quotas based on agricultural agreements governed by the WTO urged commercial liberalization. The establishment of the trade bloc called the EU unification market and North American Free Trade Agreement (NAFTA) removed the barrier of regional trade and helped make the trade of food prosperous. If a free-trade policy is promoted, the trade of food will accelerate. In a WTO meeting, removing the barrier of international food trade is being discussed by the Cairns Group, which is made up of primary food-production and food-exporting countries. Here, whether food trade, including wheat trade, is generated or not depends on the subsidies and customs duties in the various areas and the marine transportation fees. Whether or not the cargo is a candidate for trade depends on the subsidy, customs duty, and marine transportation fee of each country. Under the current conditions, the WTO has the authority to remove regional trade barriers. Because foods, such as wheat, are essential to life, it would seem that the regulations governing their trade would require different standards than those for industrial products. This research focuses on building a model for maritime transportation to achieve worldwide balanced production and supply of grains.

4.5.6 Improvement of the Wheat Distribution System

The worldwide gross production of cereal grains increased 2.3 times, from about 900 million tons to 2,100 million tons, from 1961 to 2000, according to FAO statistics. This increase was good because it helped to support the growing population. From 1961 to 2000, the average annual rate of increase for cereal production was about 2.1%, exceeding the population growth rate. In spite of a marked increase in population, the amount of cereal production in the world increased at a speed beyond the increase in population during this period, and the per capita amount of cereal production also increased slightly as a result. The above statistics seem to imply that the growing population can be maintained by increased cereal production (Bernard 2002). However, according to FAO estimates, about 800 million people worldwide suffer from malnutrition. As a key transportation way of the worldwide cereal trade, Maritime transportation to every continent must be increased in the future; meanwhile, the distribution of wheat must be improved.

4.6 Conclusions

Wheat is the principal food for about half of the world's population. The supply of wheat is increasing with the increase in population. In this chapter, we pursued the relevant variables in terms of the wheat supply and demand in every region. Furthermore, the presumed model of wheat production and supply in areas with food shortages was built. Then maritime transportation was estimated from shortage in Asia and Africa. By the above analyze, the results are summarized as follows:

1. Until now, although country-by-country predictions are often researched, they are hard to be estimated. In this chapter, we deal with the wheat problem by the continental method and good continent-by-continent results were obtained. The accuracy of the model and the reliability of the results were high.
2. Using populations or years as a variable, a high correlation is obtained, especially in the shortage areas; therefore, it is possible to estimate wheat production and supply.
3. A continental presumed model of wheat production and supply with food shortages was built.
4. Sufficient wheat to support the growing population can be secured.
5. We deduced a new method to estimate the maritime transportation of the future. In other words, we discovered a high correlation between the shortage and the import volume. Therefore, the shortage can be used to estimate the maritime transportation.

The wheat shortages in Asia and Africa are especially dependent on production in North and Central America, Oceania, and Europe. In order to solve the worldwide wheat shortage problem, it is necessary for the UN to improve its food plan and to establish a new maritime grain distribution system.

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Chapter 5 Trade Flow Analysis of Wheat

5.1 Introduction

The biggest country of wheat export is the United State of America. In USA, Wheat production centers are in the Southern Plains (Texas, Oklahoma, and Kansas), the Northern Plains (Nebraska, North Dakota, South Dakota, Montana, and Minnesota), and the Northwest (Washington and Idaho). Over 90% is sold off-farm; 25% to 30% typically goes to domestic flour production, 50% to 60% is exported, and the remainder is used for feed and seed (U.S. Department of Agriculture, 1986).

Competition among railroads and between railroads and barges for export occur in several ways. First, elevators with favorable transport rates can offer higher bid prices to farmers, and thus they can attract grain away from competing local elevators with unfavorable rates. Second, elevator operators faced with high rail rates can sell grain locally, or ship it by truck (or short-haul rail) to other elevators on competing rail or barge lines. Finally, an elevator may be served by competing rail or barge lines. In the first two cases the cost of truck transport to alternative rail and barge lines becomes the critical factor in restraining railroad market power.

But, wheat areas have relatively poor access to competing water transport (except for Washington locations, which are near the Columbia River). Eastern parts of the Plains states usually have access to several rail lines, but other wheat areas usually have access to only one or two. So, Wheat has until recently moved in smaller rail shipments (MacDonald, 1987).

In this study, the scope of our research is maritime transportation and logistics systems between ports and ports, not including the inland logistics as shown in Figure 5.1. We focus the maritime transportation to the shortage areas (Asia and Africa). We analyze the maritime transportation and logistics systems of wheat in the global scale including maritime Ton, Ton-Miles, trade value, number of bulk carriers needed and emissions of CO_2. As a preparing for the maritime transportation and logistics systems of Asia and Africa, in this chapter, we analyze the trade flow and trade feature built on the time series data and cross section data.

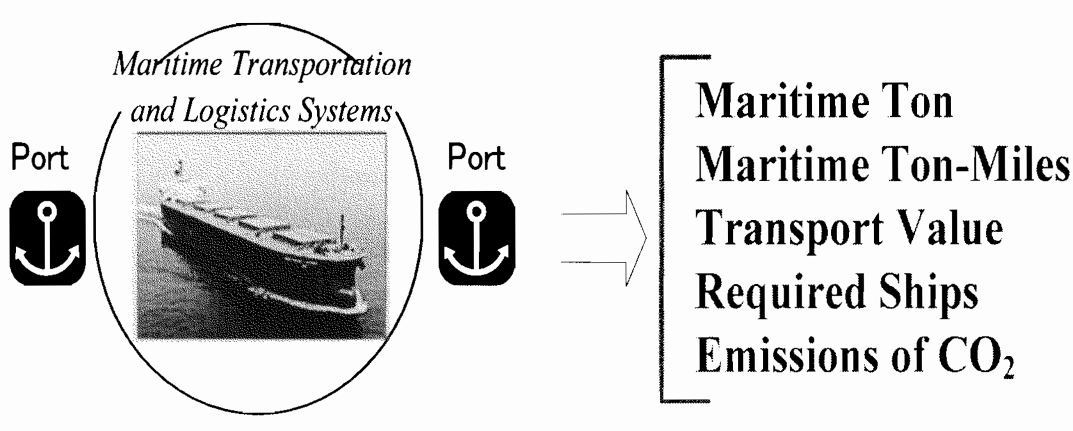


Figure 5.1 Scope of This Research

5.2 International Trade of Wheat

Now, the international wheat market is an oligopoly, which includes the United States, Canada, the EU, Australia, and Argentina. These countries hold 85% of the whole share in the international market. Change of these countries' export will greatly affect the international market of wheat. In following test, we will discuss the situation of wheat trade.

5.2.1 Trade of Asia

The exports from various regions to Asia are shown in Figure 5.2. Figure 5.2 shows that:

(1) The import volume of Asia is in the following order: North-Central America, Oceania, and Europe. Europe started to export to Asia in the 1990s.

(2) Imports from North and Central America are declining.

The important partner countries of Asia are the United States, Canada, and Australia. Figure 5.3 shows that the export volume from the United States, Canada, and Australia to Asia represents almost the entire volume of exports to Asia.

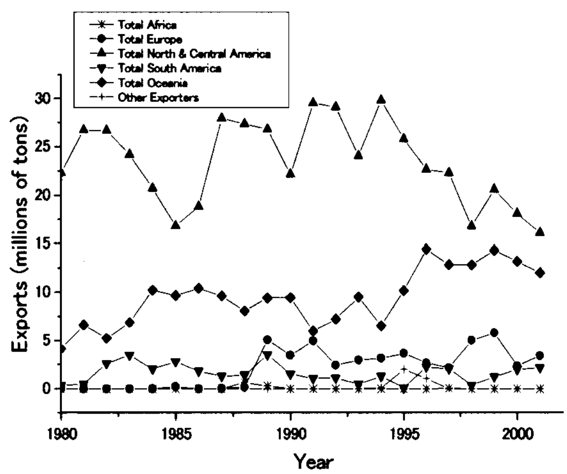


Figure 5.2 Changes in Imports to Asia

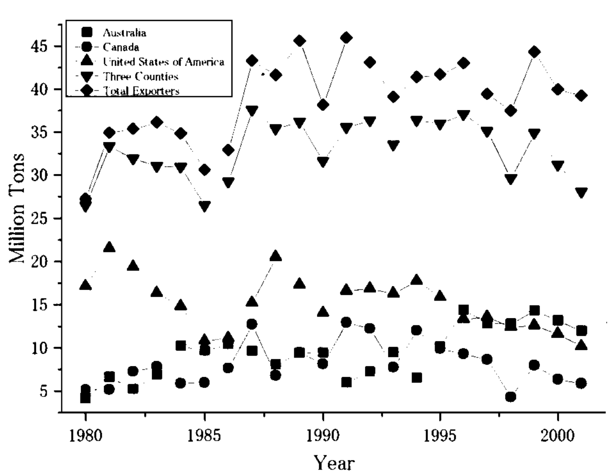


Figure 5.3 Exports to Asia from the United States, Canada, and Australia

5.2.2 Trade of Africa

The exports from various regions to Asia are shown in Figure 5.4. Figure 5.4 shows that:

(1) The volume of imports from North and Central America, Europe, and Oceania is large. Europe began to export to Africa in the 1990s.

(2) The exports from Europe are increasing.

The important partner countries of Africa are the EU, the United States, Canada, and Australia. Figure 5.5 shows that the export volume from the EU, the United States, Canada, and Australia to Africa represents almost the entire volume of exports to Africa.

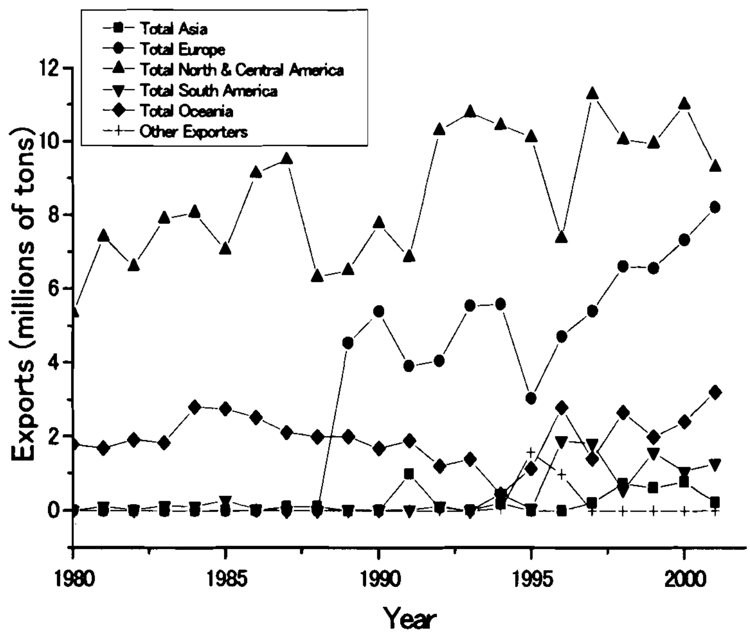


Figure 5.4 Changes in Imports to Africa

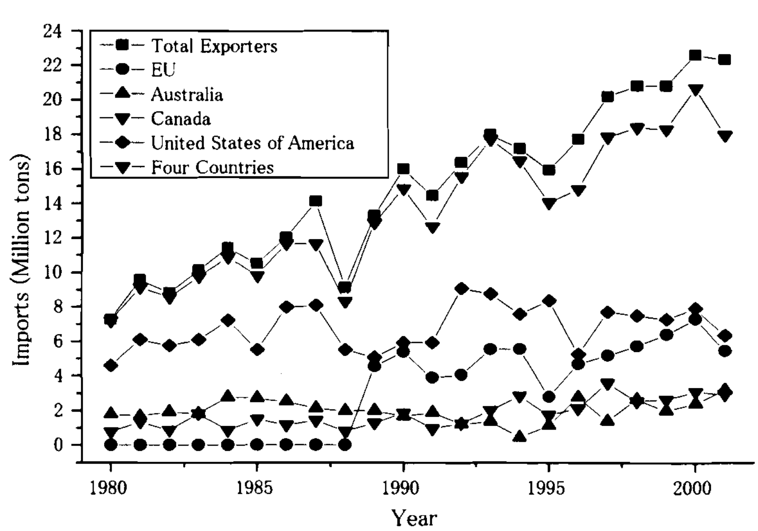
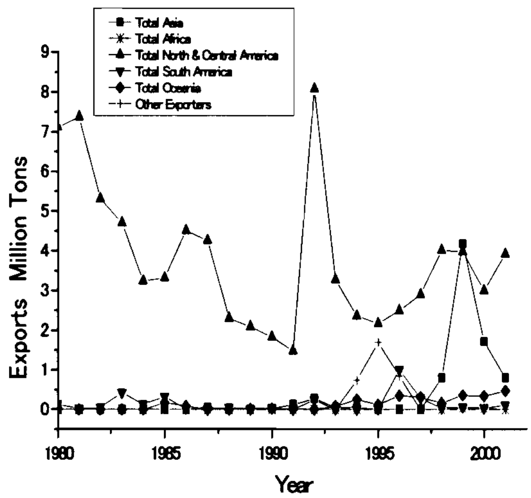


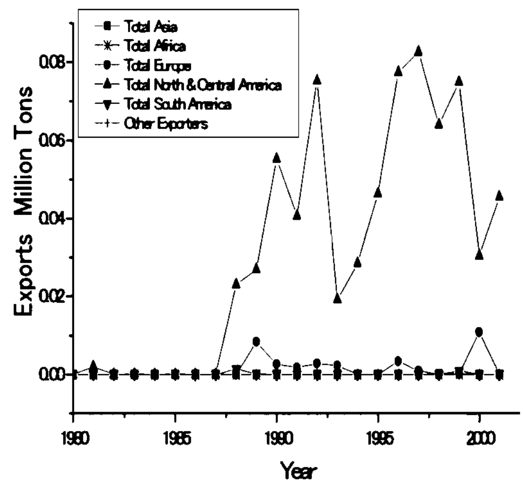
Figure 5.5 Exports to Africa from the EU, the United States, Canada, and Australia

5.2.3 Trade of other Areas

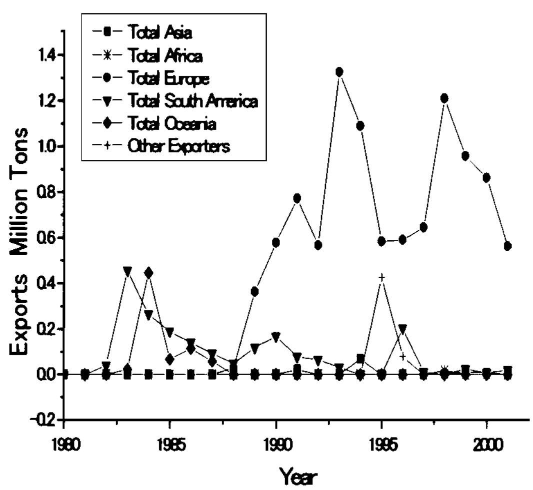
Figure 5.6 shows the change of trade in the other areas. As partner areas between North & Central America and Europe, the trade volume is the most. It can be considered that the different sorts of wheat are exchanged between them. In the case of Oceania and South America, the volumes from North & Central America occupy mostly.



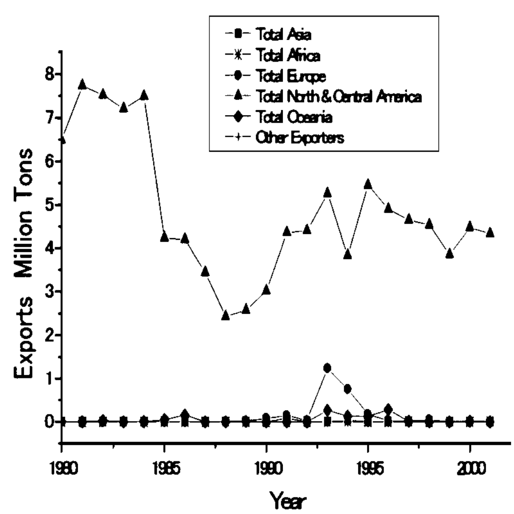
Europe



Oceania



North & Central America



South America

Figure 5.6 Changes in Exports to other Areas

5.2.4 The Future of Wheat Trade

As a whole, the exports from North and Central America represent at least one half of the worldwide market. Europe was particularly significant before the 1990s. It is because Europe began to pay subsidies to its farmers as an agricultural policy; after that, its exports began to increase.

Global wheat trade is projected to expand significantly during the outlook period after slow growth during the 1990s. Rising by nearly 2 percent per year, world trade in wheat would reach the all-time high of 129 million tones. Nearly all of this expansion would be attributed to higher import demand among the developing countries, especially China. At the current level, this expansion would be mostly on account of a continuing rapid increase in import demand in Asia and Africa, capturing 43 percent and 23 percent respectively of the global share.

On the export side, the overall share of the traditional major exporters is projected to decline slightly. Australia, Canada and the United States could find their market share fall, even though this would not necessarily imply a decline in the absolute level of their exports. Wheat shipments by Argentina and the EU (15) are projected to increase, leading to some increase in their market share.

5.3 Share Analysis of the International Wheat Export Market

The export shares to Asia from Oceania, North and Central America, and Europe are shown in Figure 5.7. Figure 5.8 shows export shares from North and Central America, Oceania, and Europe together. When a correlation coefficient was calculated for the annual market share of North and Central America, Europe, and Oceania from 1980 to 2001, the result showed a strong negative correlation of –0.92 (Figure 5.9). A negative correlation also was seen for Africa (Figure 5.10-5.12). The export volume from Europe and Oceania increased when the export volume of North and Central America decreased. In other words, for the 20 years indicated above, while the market share of Europe and Oceania was increasing, the market share of North and Central America was decreasing. Although the world wheat market is influenced by all three areas, it is thought that the above statistics are directly related to the agricultural policy of North and Central America.

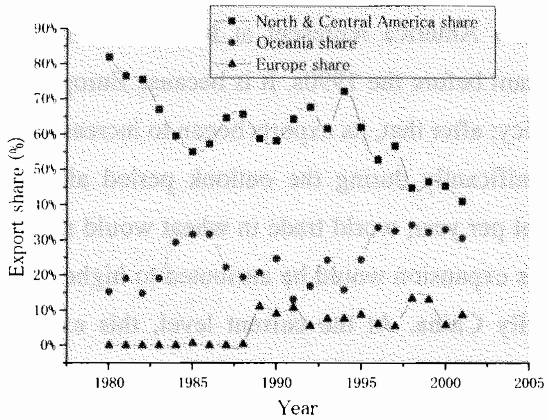


Figure 5.7 Export Shares to Asia from three areas

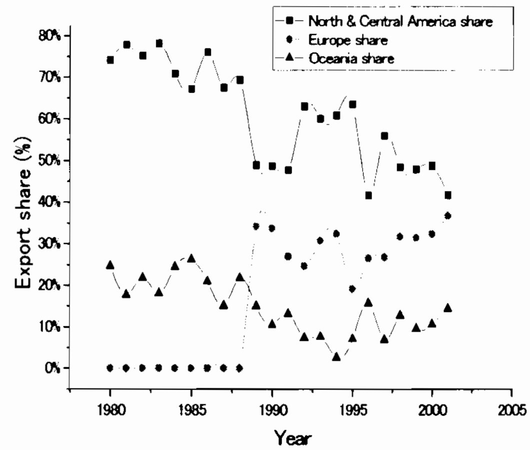


Figure 5.10 Export Shares to Africa from three areas

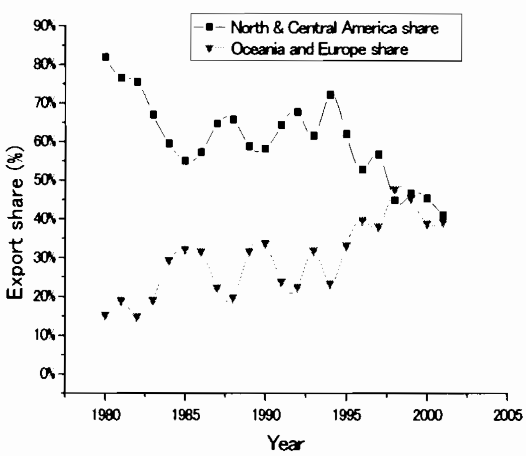


Figure 5.8 Export Shares to Asia from two areas

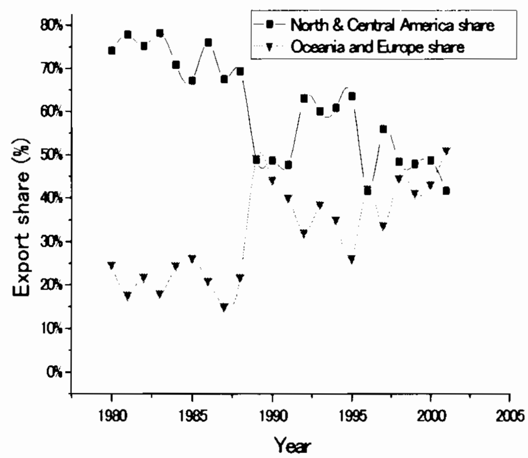


Figure 5.11 Export Shares to Africa from two areas

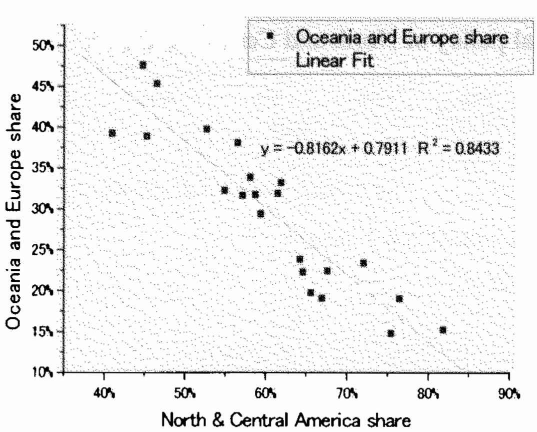


Figure 5.9 Relative Shares of Exports to Asia

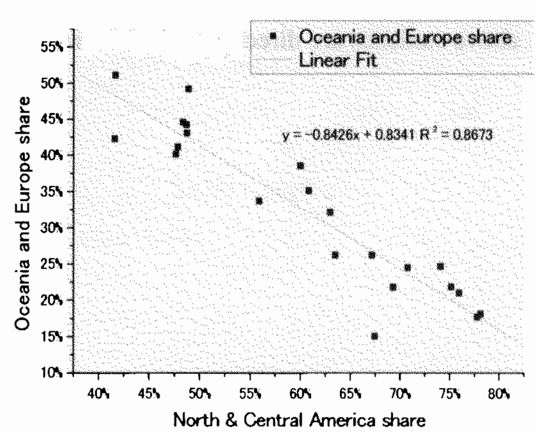


Figure 5.12 Relative Shares of Exports to Africa

5.4 Trade Flow Data

Here, we mainly analyze the maritime transportation and logistics systems using the panel data of trade flow as shown in Figure 5.13. Panel data sets are two-dimensional, whereas time series and cross-sectional data are both one-dimensional. The cross-sectional data are the O-D data of wheat trade. Time series data shows the volume of imports from the partner countries from 1980 to 1998 (FAO, 2001).

A commodity flow data matrix can be visualized with rows as origins and columns as destinations. Usually the m origins and destinations are point locations (urban centers, transportation terminals, or transport junction). However, sometimes they are aggregated to n regions, where $n < m$ (Smith, 1970). In this study, the $n \neq m$. A matrix of origin–destination flows, or OD flows, is extracted from the FAO trade data. We use the program of EXCEL Visual Basic for Applications (EXCEL VBA) to build the OD cross section data from FAO trade time series data as shown in Figure 5.14 (Program can be seen in Appendix A). We built the 19 OD tables in Asia and Africa, respected. It will be the preparation for analyzing the maritime transportation and logistics systems in Asia and Africa.

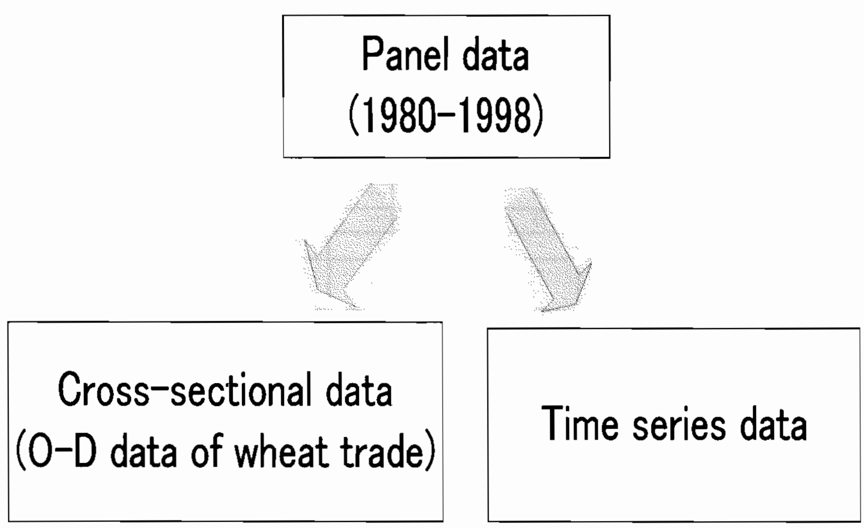


Figure 5.13 Panel Data

Country	Parter Country	1980	1981	…	1996	1997	1998
EU (15) Excl.Intra-Trade	Afghanistan			…	37461	2500	8000
Australia	Afghanistan			…	6309	0	0
Canada	Afghanistan			…	21500	0	0
United States of Americ	Afghanistan			…	0	30000	29802
EU (15) Excl.Intra-Trade	Azerbaijan, Republic of			…	2850	39000	0
Canada	Azerbaijan, Republic of			…	0	0	0
Hungary	Azerbaijan, Republic of			…	0	2865	0
Lithuania	Azerbaijan, Republic of			…	0	951	0
Russian Federation	Azerbaijan, Republic of			…	0	0	224200
Ukraine	Azerbaijan, Republic of			…	0	0	10500
…	…	…	…	…	…	…	…
Argentina	Yemen		0	…	0	109800	24700
Australia	Yemen		446800	…	503783	619948	529497
Canada	Yemen		0	…	0	0	0
Hungary	Yemen		0	…	0	0	0
Poland	Yemen		0	…	0	0	30104
United States of Americ	Yemen		0	…	593000	545000	320593

O-D (1998)	Afghanistan	Azerbaijan	Bahrain	Bangladesh	…	United Arab Emirates	Uzbekistan	Viet Nam	Yemen
EU (15) Excl.Intra-Trade	8000	0	–	635200	…	48100	0	–	0
Australia	0	–	40229	144763	…	519434	–	386613	529497
Canada	0	0	–	141500	…	151300	0	0	0
United States of America	29802	–	–	673804	…	13465	0	11000	320593
Hungary	–	0	–	0	…	–	0	–	0
Lithuania	–	0	–	–	…	–	–	–	–
Russian Federation	–	224200	–	–	…	–	4200	–	–
Ukraine	–	10500	–	–	…	–	–	–	–
EU (12) Excl.Intra-Trade	–	–	0	–	…	–	–	0	–
Argentina	–	–	–	0	…	0	–	–	24700
Bulgaria	–	–	–	0	…	–	–	–	–
Mexico	–	–	–	0	…	–	–	–	–
Panama	–	–	–	0	…	–	–	–	–
Romania	–	–	–	0	…	–	–	–	–
Poland	–	–	–	–	…	–	–	–	30104
Uruguay	–	–	–	–	…	–	–	–	–
Brazil	–	–	–	–	…	–	–	–	–
Peru	–	–	–	–	…	–	–	–	–
Slovenia	–	–	–	–	…	–	–	–	–
Colombia	–	–	–	–	…	–	–	–	–
Norway	–	–	–	–	…	–	–	–	–
Croatia	–	–	–	–	…	–	–	–	–
Paraguay	–	–	–	–	…	–	–	–	–
Slovakia	–	–	–	–	…	–	–	–	–

Figure 5.14 Concept of Data Translation by VBA

5.5 Panel Data Analyses of Asian Wheat's Import

5.5.1 Estimation Model

We put the population and GDP of Asian countries as variables into the panel regression model. The basic framework for this discussion is a regression model of the form using a pool object. It may be written as:

$$IM_{it} = \alpha + POP_{it}'\beta + GDP_{it}'\gamma + \delta_i + \gamma_t + \varepsilon_{it} \quad (1)$$

where IM_{it} (import of Asian countries) is the dependent variable, and POP_{it}' *and* GDP_{it}' is a k-vector of regressors, and ε_{it} are the error terms for i=1,2,...,M cross-sectional units observed for dated periods t=1,2,...,T. The α parameter represents the overall constant in the model, while the δ_i and γ_t represent cross-section or period specific effects (random or fixed). Identification obviously requires that the coefficients have restrictions placed upon them. They may be divided into sets of common (across cross-section and periods), cross-section specific, and period specific regressor parameters. But in this section, we only discuss the random effects and fixed effects. Missing data are very common in panel data sets. The situation exists in the wheat trade flow data. For this reason, we selection the unbalanced panels to analyze.

5.5.2 Random Effects

Firstly, we make the analyses using the random effects model. The estimation model can be rewritten as:

$$IM_{it} = \alpha + POP_{it}'\beta + GDP_{it}'\gamma + \delta_i + \varepsilon_{it} \quad (2)$$

The model should be applied using the generalized least square method (GLS). Table 5.1 presents the result of random effects. Furthermore, the R-squared is very low (0.011). Figure 5.15 shows the residual and actual and fitted value. The above result shows the fit is not good.

Table 5.1 The Result of Random Effects

	Coefficient	Std. Error	t-Statistic	Prob.
C	744726.9	132287.1	5.629627	0.0000
POP	1.403947	0.481534	2.915572	0.0036
GDP	0.349131	0.121922	2.863560	0.0043

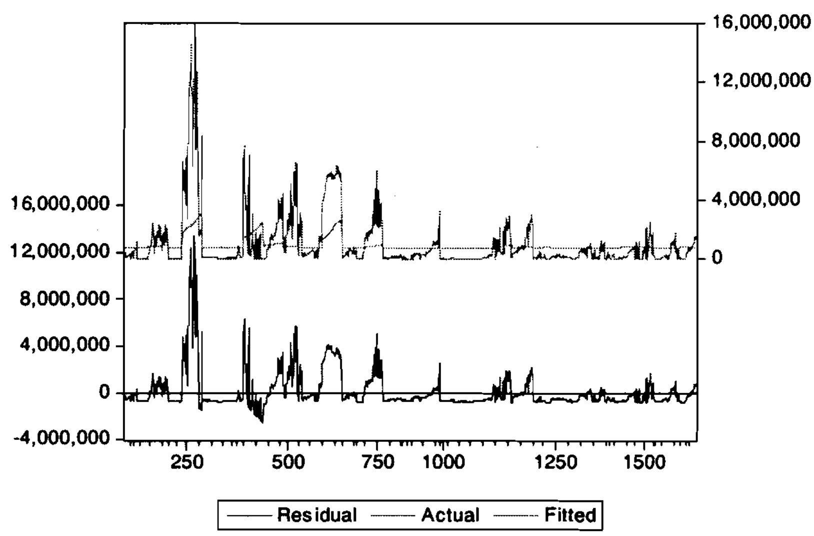


Figure 5.15 The Residual and Actual and Fitted Value of Random Effects

5.5.3 Hausman Specification Test for the Random Effect Model

The Hausman specification test (Hausman 1978) is the classical test of whether the fixed or random effects model should be used. The research question is whether there is significant correlation between the unobserved person-specific random effects and the regressors. If there is no such correlation, then the random effects model may be more powerful and parsimonious. If there is such a correlation, the random effects model would be inconsistently estimated and the fixed effects model would be the model of choice.

The test for this correlation is a comparison of the covariance matrix of the regressors in the least squares dummy variables (LSDV) model with those in the random effects model. The null hypothesis is that there is no correlation. If there is no statistically significant difference between the covariance matrices of the two models, then the correlations of the random effects with the regressors are statistically insignificant. The Hausman test is a kind of Wald χ^2 test with k-1 degrees of freedom (where k=number of regressors) on the difference matrix between the variance-covariance of the LSDV with that of the Random Effects model (Greene, 2003.).

Table 5.2 presents the result of Hausman test. According the result the test, null hypothesis is rejected. So, the model will be a fixed effect models

Table 5.2 Test Cross-section Random Effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	95.865837	2	0.0000

5.5.4 Fixed Effect

The fixed effects model can also be rewritten as:

$$IM_{it} = \alpha + POP_{it}'\beta + GDP_{it}'\gamma + \gamma_i + \varepsilon_{it} \quad (3)$$

The model is usually referred to as LSDV model. Table 5.3 presents the result of fixed effects. Furthermore, the R-squared is very high (0.71). Figure 5.16 shows the residual and actual and fitted value. The above result shows the fit is very good. In the above discussed, we can draw a conclusion that the import of wheat is dependent on the population and GDP of Asian countries.

Table 5.3 The Result of Fixed Effects

	Coefficient	Std. Error	t-Statistic	Prob.
C	1296769.	70555.17	18.37951	0.0000
POP	-2.642918	0.707229	-3.737003	0.0002
GDP	0.234866	0.140260	1.674500	0.0943

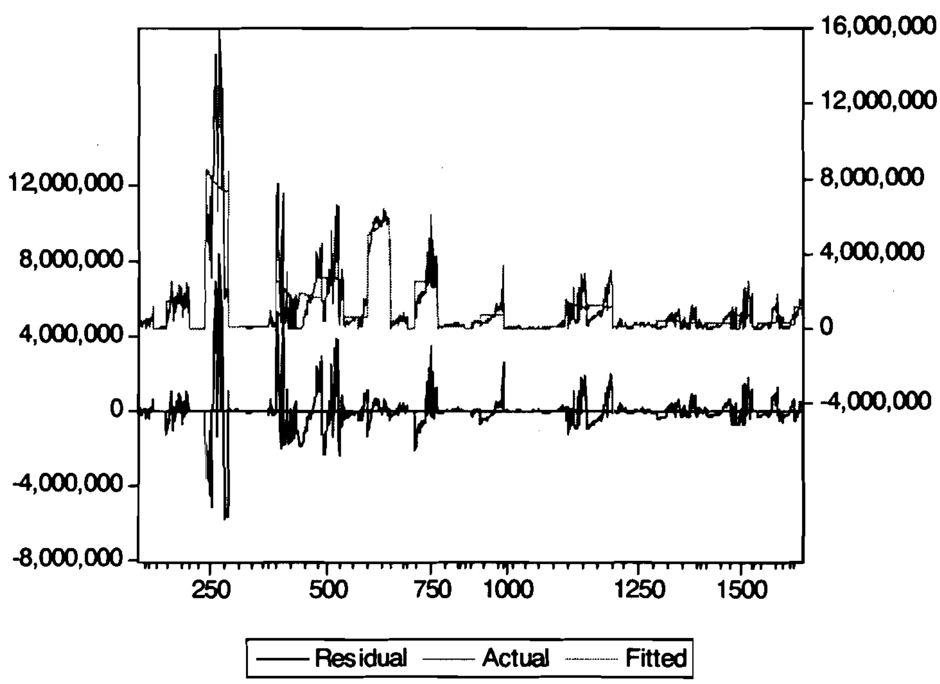


Figure 5.16 The Residual and Actual and Fitted Value of Fixed Effects

5.6 Conclusions

The results are summarized as follows:

1. A negative correlation among surplus areas is obtained for the market share of wheat.
2. Using the program EXCEL VBA, we build the OD tables in the Asia and Africa.
3. By the panel data analyses, we find that the import of wheat dependents on the population and GDP of Asian countries.

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Chapter 6 Maritime Transportation and Logistics Systems of Asia

In chapter 6, we will analyze the maritime transportation and logistics systems of Asia including maritime Ton, Ton-Miles, trade value, number of bulk carriers needed and emissions of CO_2 in the maritime transportation.

6.1 Asian Transportation Tons

We will focus on the Japan, China and Korea because the 3 countries' import is the greatly in the Asia. Using the panel data of import, we analyze the situation of Asian maritime transportation and logistics systems. Here, the cross-section data selected is the trade flow data of 1998. Time series data is partner countries of 3 countries from 1980 to 1998 (FAOSTAT, 2001).

Firstly, we discuss the trade situation of Japan using the cross-section data in 1998. Figure 6.1 shows the import of Japan from the partner countries. Many countries are the partners of Japan. Considering the share base of Japan's import, the USA, Canada and Australia is the important partner countries. Their share is 54%, 26% and 20%, respected. Secondly, the import of China from the partner countries is shown in Figure 6.2. The USA, Canada and Australia are the important partner countries of China. The share from USA, Australia and Australia is about 72%, 14% and 12%. Finally, Figure 6.3 shows the import of Korea from the partner countries. The same feature can be seen in the Korea. The import partner countries are the USA, Canada and Australia. Their share is 43%, 4% and 30%, respected. From the above analyze, the USA, Canada and Australia are the import partner countries in the Asian wheat trade.

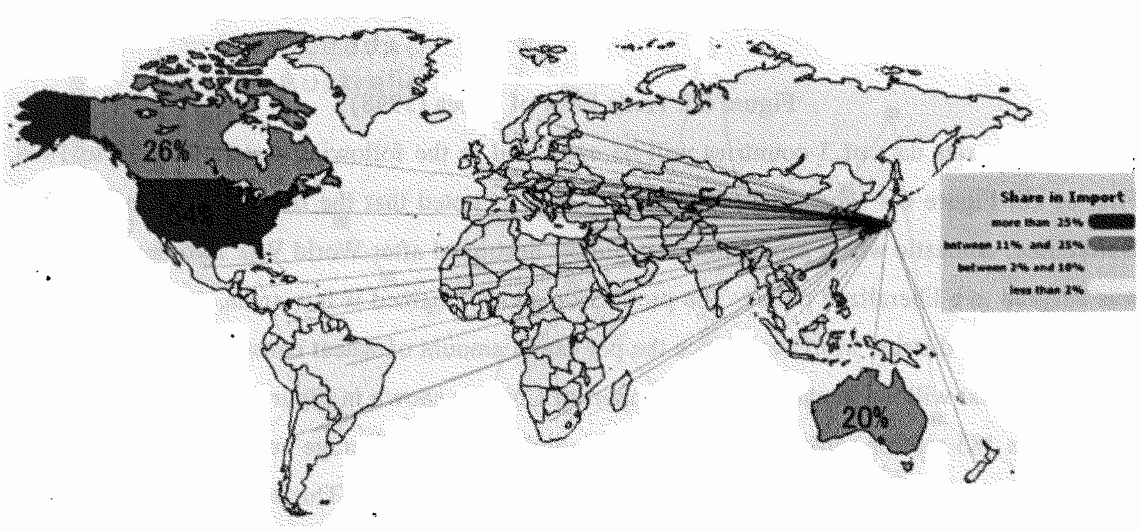

Figure 6.1 Trade Flow of Japan (1998)

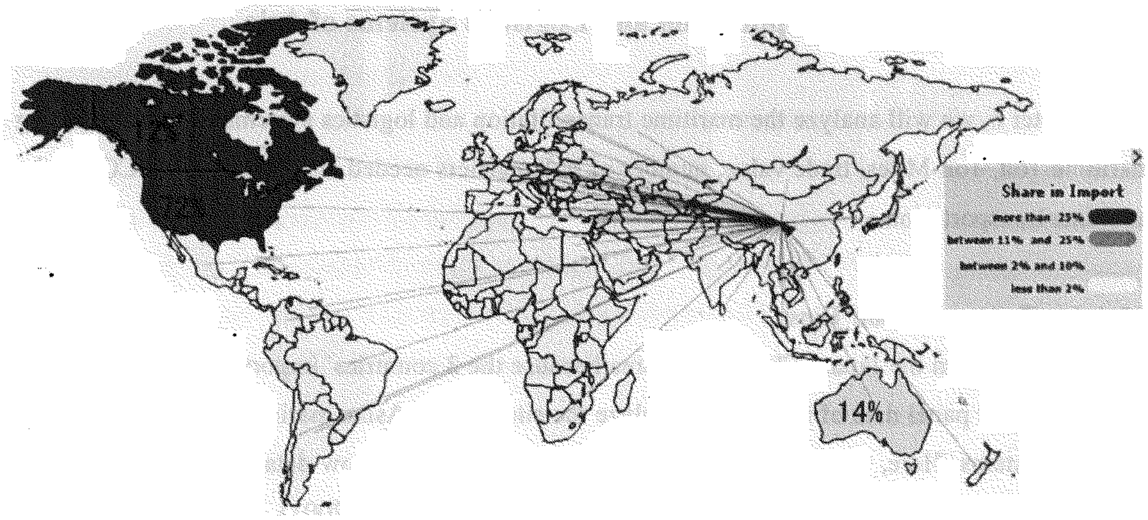

Figure 6.2 Trade Flow of China (1998)

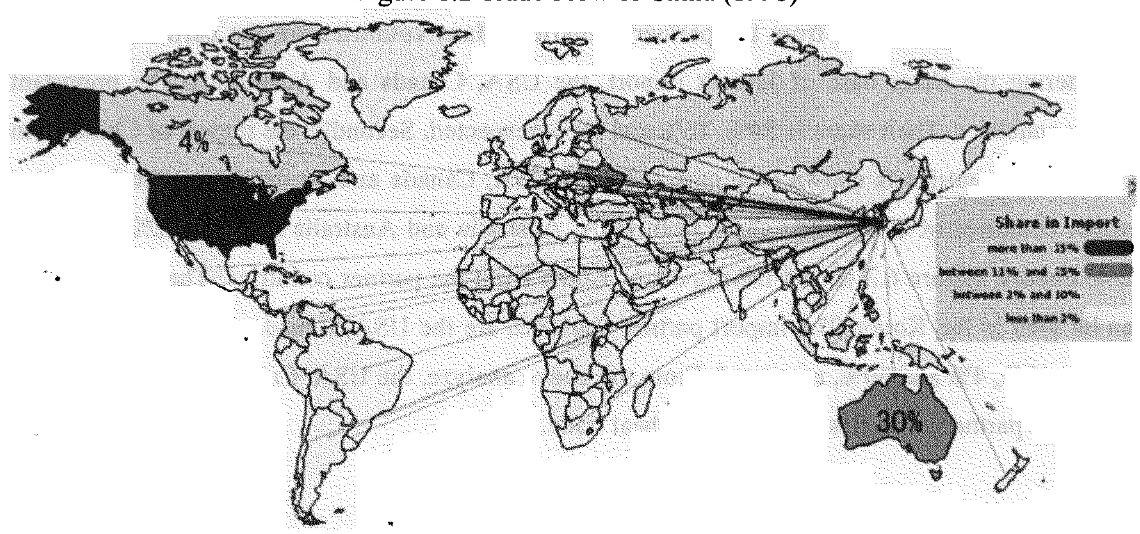

Figure 6.2 Trade Flow of Korea (1998)

The time series data of 3 countries will be examined in the following test from 1980 to 1998. First of all, Figure 6.4 shows the import of Japan. It is noted that the import of Japan is steady. Unlike rice, domestic wheat production was almost destroyed after World War Two because wheat was adapted to a liberalized policy. The production areas remained is few areas, such as Hokkaido and the Kyushu district. Moreover, since the per capita amount of wheat consumption is stable, the import of wheat will not be changed. The import of China is shown in Figure 6.5. The total amount of import is 185 million tons from 1980 to 1998, and the annual average volume of import is 9.74 million tons. It is about 10.97% of total wheat production in China. The volume of wheat import changed between 6 and 17 million tons before 1995. But, the import of China decreased from 1996 to 1998 because of continuous increase of domestic production. Figure 6.6 shows the import of Korea. The import of Korea peaked in the 1986, 1990 and 1993. The volume of import is about 4, 4.3 and 5.7 million tons. Even if the import was changed in the twenty year, the increasing trend can be observed.

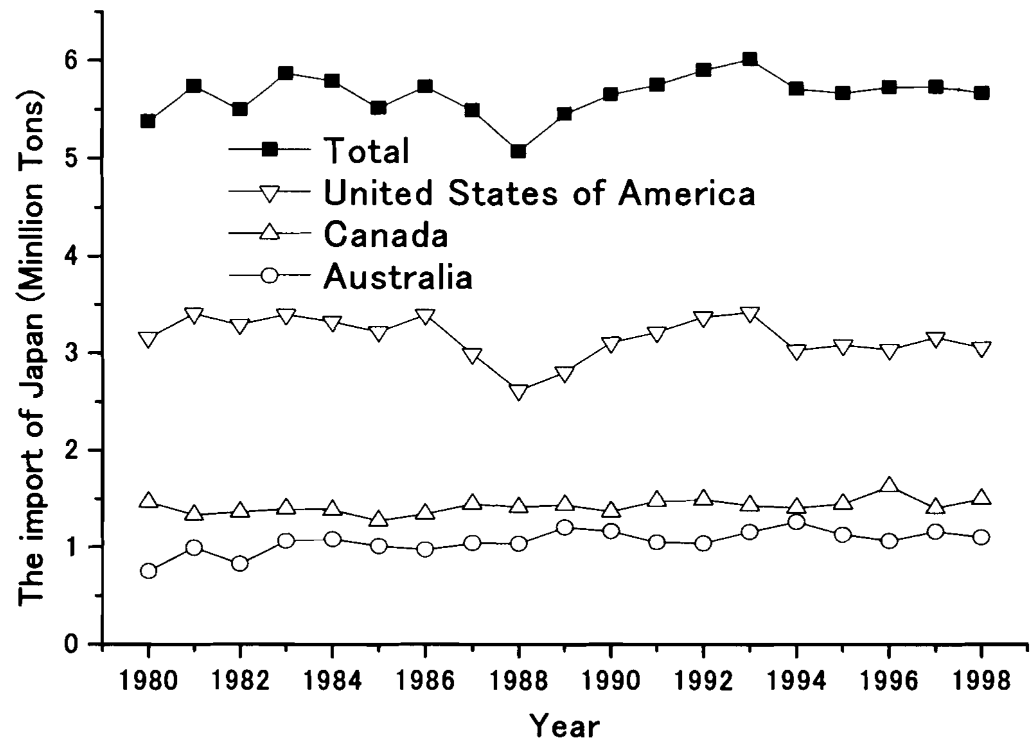

Figure 6.4 Import of Japan

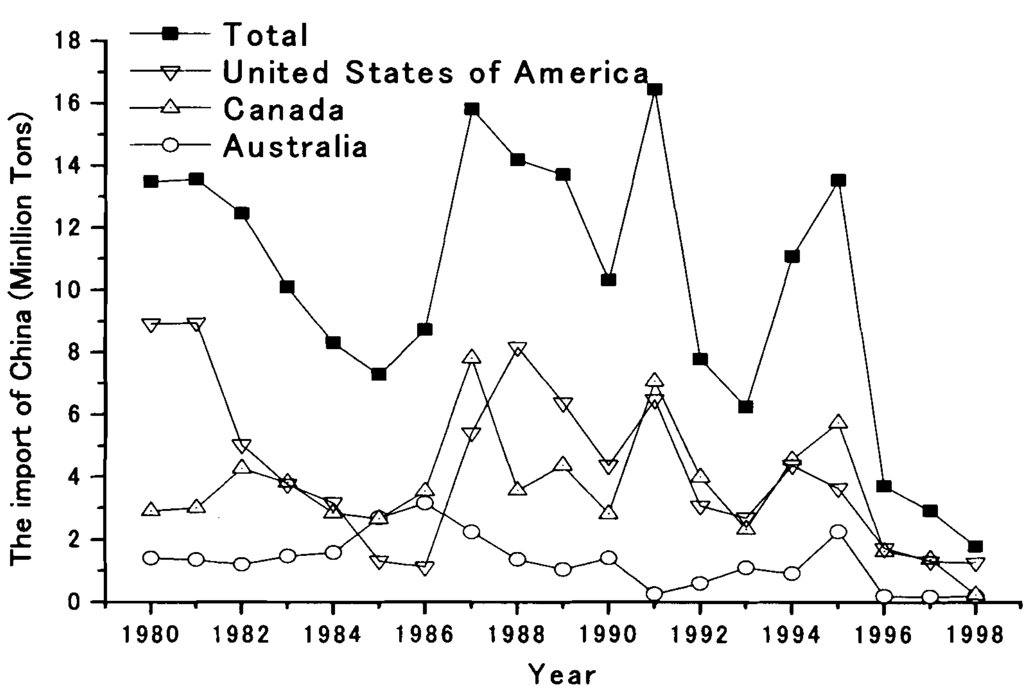

Figure 6.5 Import of China

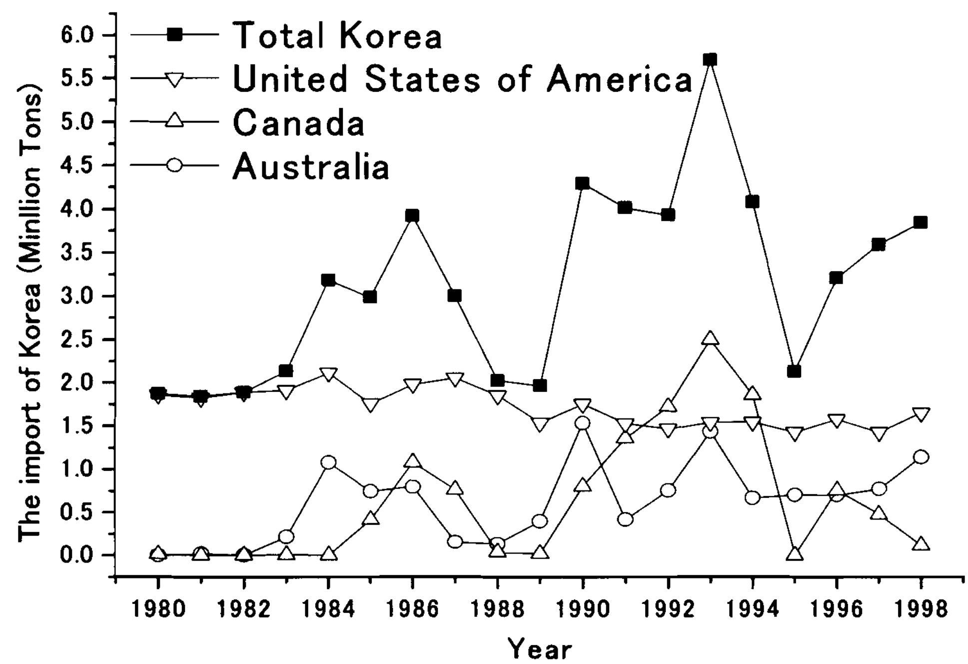

Figure 6.6 Import of Korea

On the other hand, in the case of partner countries, Asia imports wheat from Europe, North and Central America, South America, and Oceania. From 1980 to 1998, 42 countries imported wheat from the other 23 countries, including 4 North and Central American countries, 13 European countries, 5 South American countries, and 1 country in Oceania.

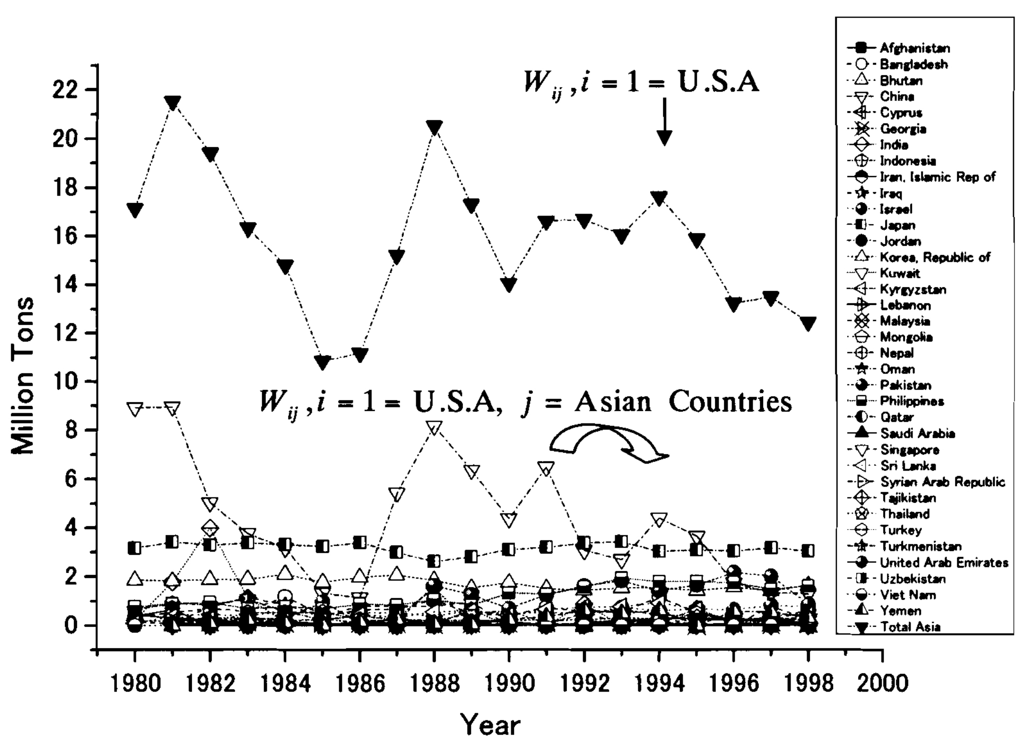

Figure 6.7 Exports from the United States to Asia (Tons)

The export volume is shown in Figure 6.7. i is an exporting country, and j is an importing country. For example, exports from the United States to Asian countries changed frequently, resulting in an unclear trend in the trade volume. The top part of Figure 6.7 shows the export volume from the United States to Asia. The total volume exported from the United States to Asia was rather consistent and predictable. From a continental viewpoint, Figure 6.8 shows that the export volume from North and Central America and the other areas to Asia is generally consistent. The information above shows clear export patterns from one continent to another. As a whole, the exports from North and Central America represent at least one half of the worldwide market.

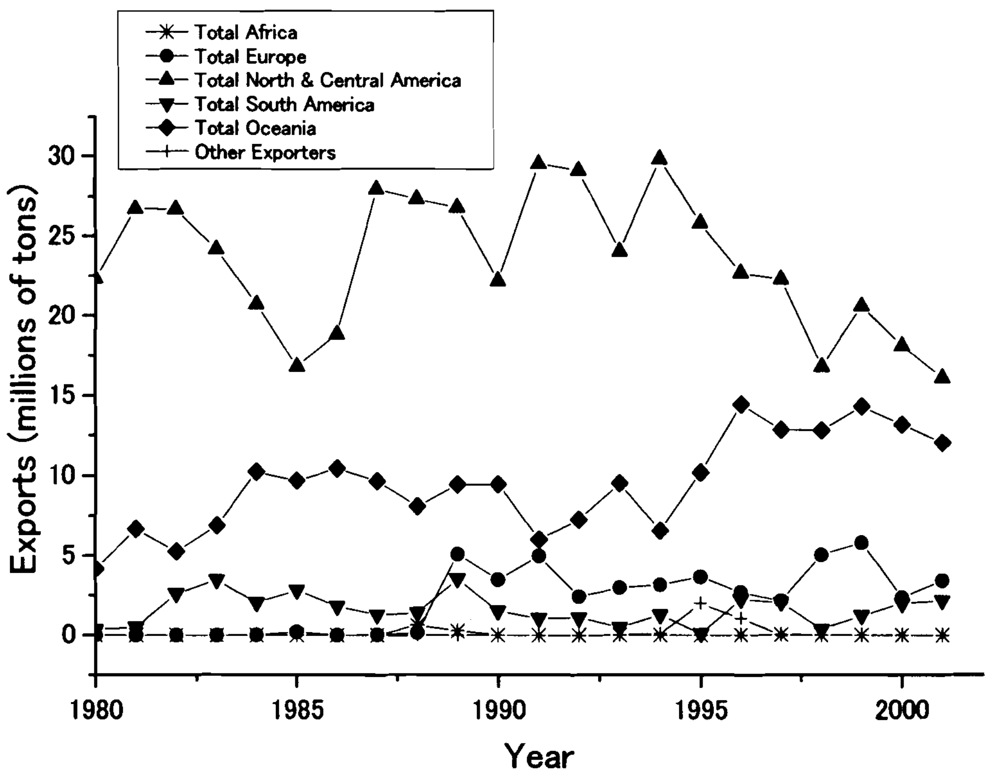

Figure 6.8 Changes in Exports to Asia (Tons)

6.2 Maritime Transportation in Shortage Areas (Ton-Miles)

6.2.1 A Conceptual Figure of Distance (the Shortest Voyage Distance)

Voyage distance is the shortest distance between the port of import and the port of export. For example, a conceptual figure of distance is shown in Figure 6.9, and in the case of the United States and Korea, the voyage distance is the shortest voyage distance between New Orleans and Busan. Navigation distance was obtained using data from the Worldwide Distance Chart (Japan Navigating Officers' Association 1990) and World Distance Tables (Ports of the World, LLOYD'S, 2006).

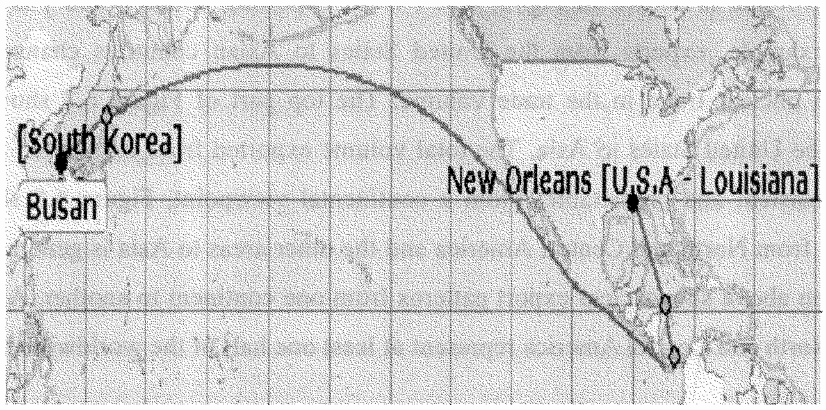

Figure 6.9 Concept of Distance

6.2.2 Selection of Import and Export Ports

Since there are many ports in the world, the selection of specific ports as export and import ones is important. Therefore, we made the following selections:

1) The depth of the selected ports exceeds 10m.

2) Landlocked countries import wheat from ports of neighboring countries.

3) One country has one port.

4) Those exporting ports should frequently be used to export grain and are near the port of wheat production. Those ports for import should be used for importing grain and are near the country's capital (in consideration of the population).

5) Maritime transportation is always carried out from exporting country to importing country without calling at other ports in route.

As a result, in the case of Asia, 20 exporting ports to Asia and 32 importing ports for Asia were determined, respectively. Using the selected ports, we calculated the shortest navigation distance between the exporting ports and importing ports (Appendix B).

6.2.3 The transportation distance of the USA

We then discuss the Ton-Miles in the following text. First, the export Ton-Miles from the United States to Asian countries are shown in Figure 6.10. In the figure, i is an exporting port; here, i=1 as the United States' port, and j is an importing port. The Ton-Miles from the United States to Asian countries changed in an irregular manner, resulting in an unclear trend for the Ton-Miles. The total volume Ton-Miles from the United States to Asia are generally regular.

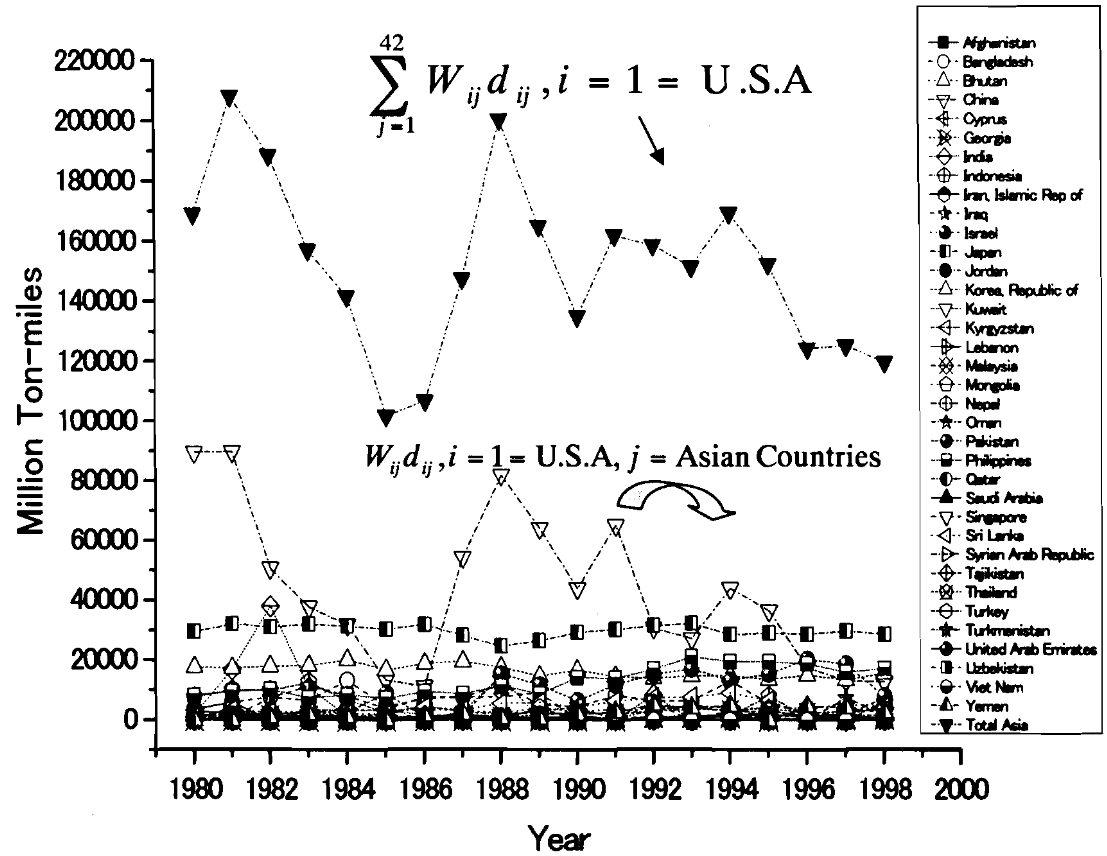

Figure 6.10 Exports from the United States to Asia (Ton-Miles)

6.2.4 The transportation distance of Asia

From a continental viewpoint, Figure 6.11 shows that Ton-Miles from North and Central America to Asia are very smooth. The information above shows clear export Ton-Miles from one continent to another. The results of exports from various regions to Asia are shown in Figure 6.11.

Figure 6.11 demonstrates the following:

(1) The Ton-Miles of Asian imports are in the following order: North-Central America, Oceania, and Europe. Europe started to export to Asia in the 1990s. The same observations are made here as in the analyses of transportation tons.

(2) The Ton-Miles of imports from North-Central America are decreasing and from Oceania are increasing.

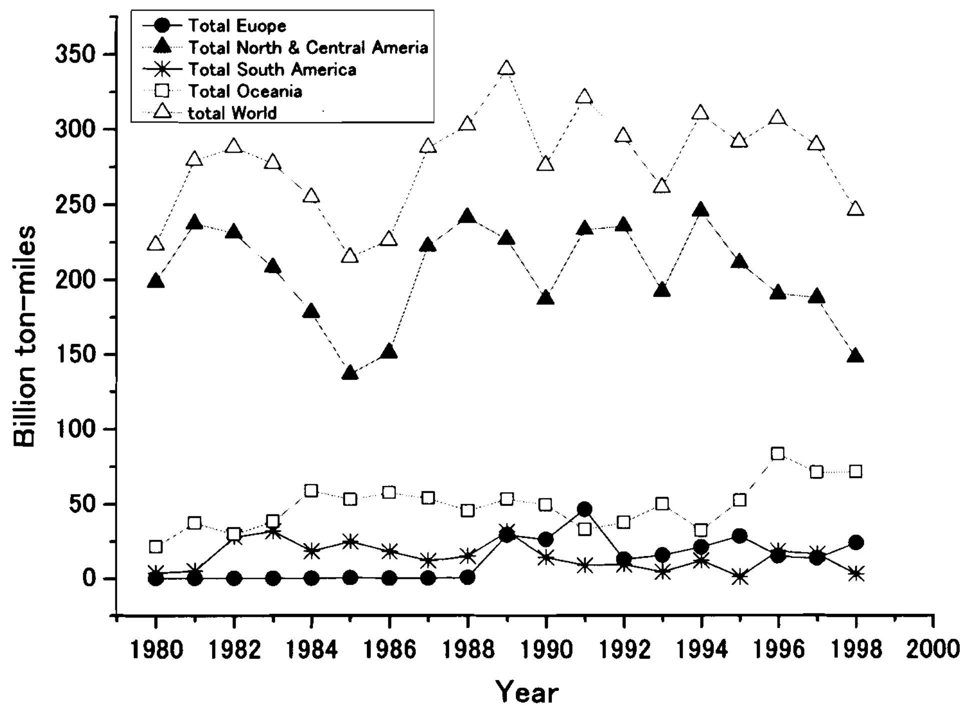

Figure 6.11 Changes in Exports to Asia (Ton-Miles)

In addition, Figure 6.12 shows the relation between the transportation ton and Ton-Mile in Asia. A high correlation between them can be seen.

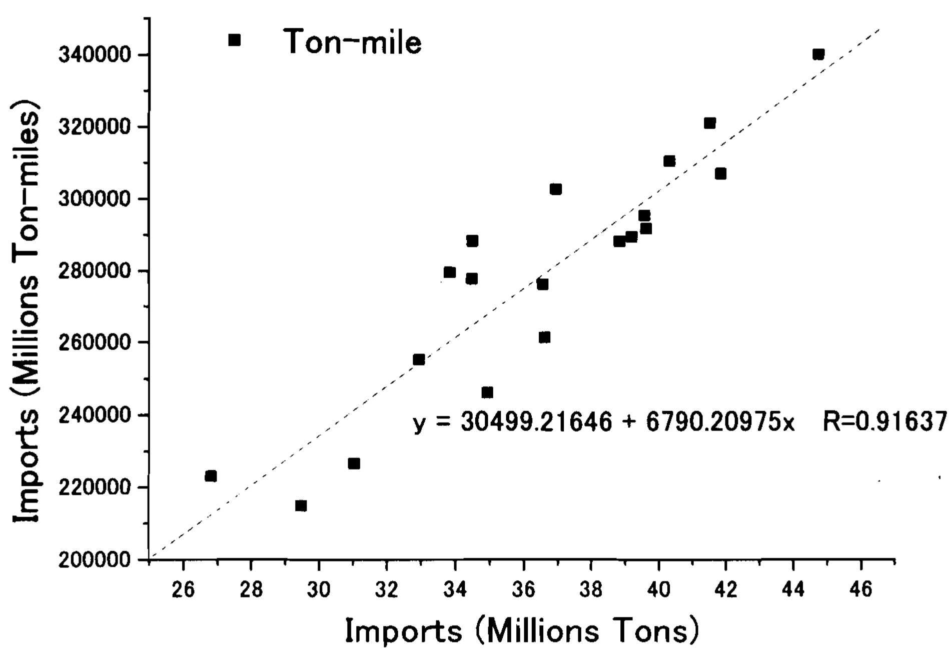

Figure 6.12 Relationships between Tons and Ton-miles (Asia)

6.3 Trade Value

Figure 6.13 shows the import values of three nations in Asia. Although Japan and Korea demonstrate an upward trend, the trend of China is unsteady.

Figure 6.14 demonstrates the import values of Asia. It clearly shows the slowly increasing tendency of import values of Asia. The import values of Asia are 6.63 billion dollars in 1980 but expanded to 7.2 billion dollars in 1998.

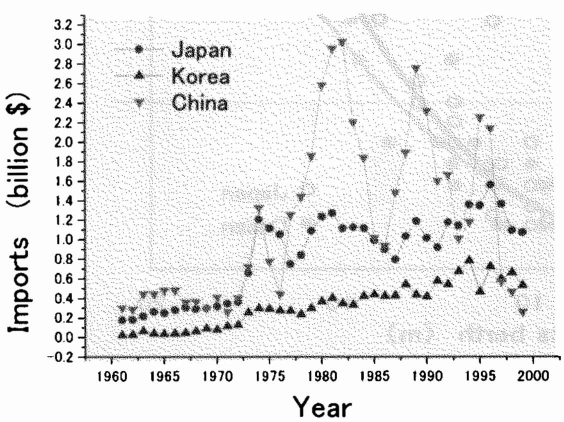

Figure 6.13 Changes of Import Value (3 Countries)

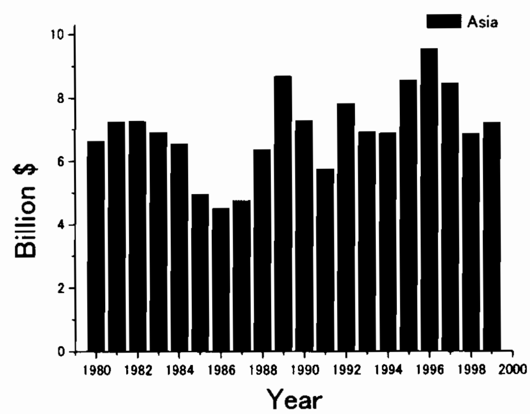

Figure 6.14 Changes of Import Value (Asia)

6.4 Forecasting the Required Number of Wheat Bulk Carriers

Forecasting the required number of wheat bulk carriers is difficult at the country level because the changing tendency of the import volume is sharp. Therefore, in this research, we predict the import volume at the continental level. According to this method, compared to the case of the country level, the import volume becomes very flat and smooth, the function system can be applied, and the accuracy can be raised (Kubo 2004).

6.4.1 Examination of Wheat Bulk Carrier Size and Depth of Water

Grain transportation is usually performed by maritime transportation. The means of transport is grain bulk carriers. The Panamax Ship is the dominant type of all ships. The Ship of Panamax type is the largest ship which can pass through the Panama Canal, and its loading capacity is about 70,000 tons or less.

We analyzed data from the association for the promotion of international trade, Japan (JAPIT, 2003) in order to consider the relationship between the ports' depths and the DWT of bulk carriers. The data from Japan and China were examined and analyzed as an example. Figure 6.15 shows the relation between the ports' depths and the DWT of bulk carriers. The coefficients of determination and multiple correlations are high; therefore, it appears that the relationships are accurate.

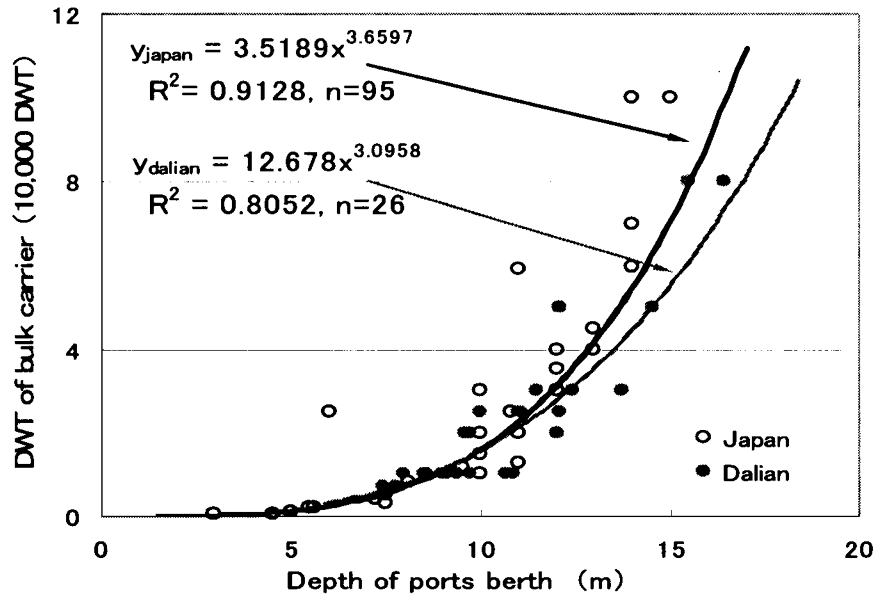

Figure 6.15 Relations between the DWT of Bulk Carriers and Port Depth

Figure 6.16 shows the frequency analysis of DWT of Bulk carriers. It turns out that 10,000~60,000 DWT bulk carriers are often used on the left of the histogram. Figure 6.17 shows frequency analysis result of depth of ports berth. According to the normal distribution of the depth of water, it turns out that 8~14 (m) are often used in the middle of the histogram.

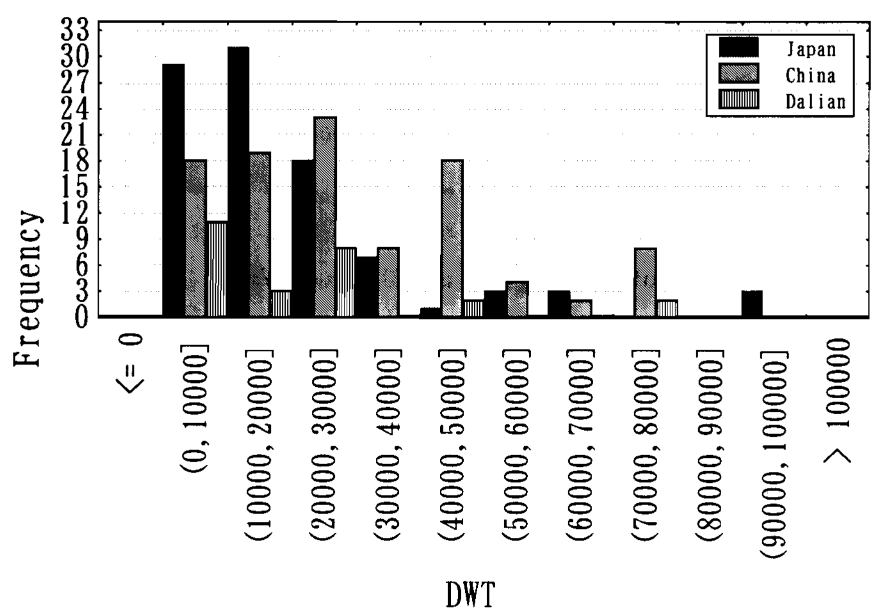

Figure 6.16 Frequency Analysis Results of DWT of Bulk Carriers

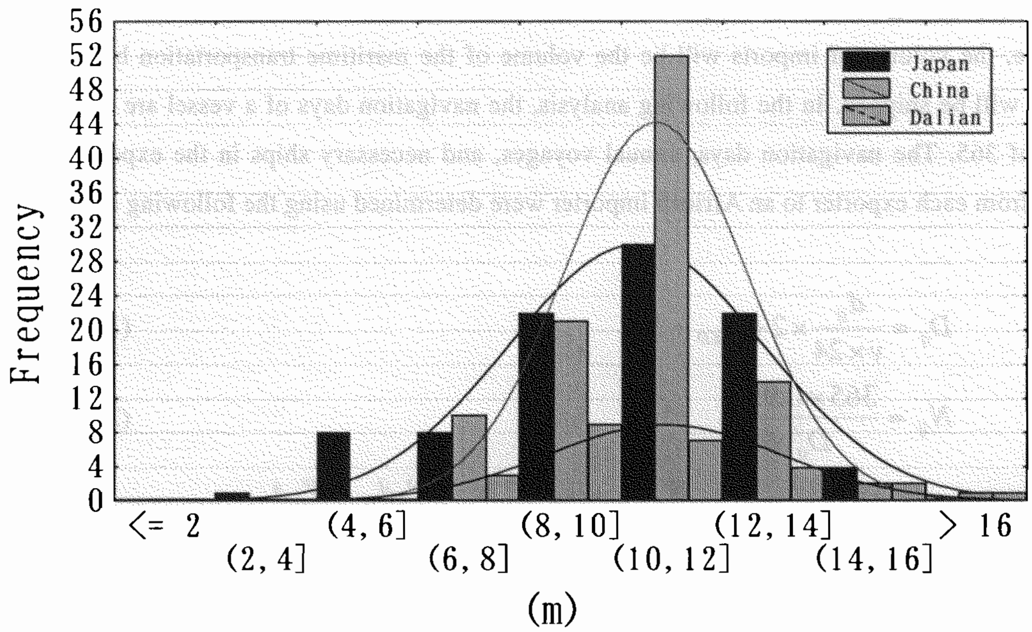

Figure 6.17 Frequency Analysis Result of Depth of Ports Berth

As shown in Figure 6.18, the average depth of each strait on the navigation route is 20 meters or more; therefore, it appears that bulk carriers from 10,000 to 60,000 DWT could navigate the waters. The depth of importing and exporting ports is 10 meters and greater; therefore, 60,000 DWT bulk carriers are suitable for shipping and unloading wheat at ports.

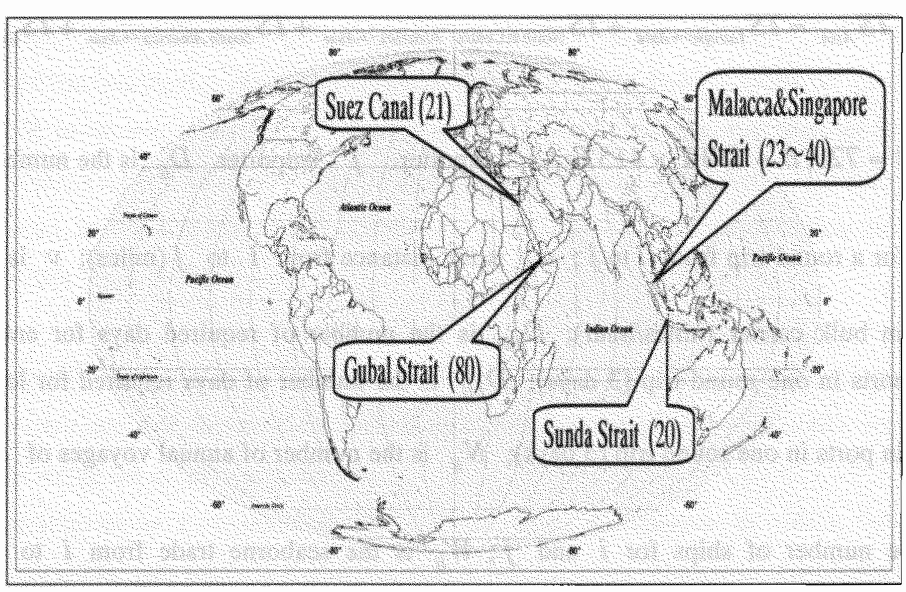

Figure 6.18 Depths of the Navigation Routs' Straits (Unit: Meters)

6.4.2 Forecasting Model for Required Number of Wheat Bulk Carriers

Here, the volume of imports will be the volume of the maritime transportation because whole wheat will be shipped. In the following analysis, the navigation days of a vessel are considered as 95% of 365. The navigation days, annual voyages, and necessary ships in the export navigation route from each exporter to an African importer were determined using the following equations.

$$D_{ij} = \frac{d_{ij}}{v \times 24} \times 2 + D_{ED} + D_{LU} \tag{1}$$

$$N_{ij} = \frac{365 \times 0.95}{D_{ij}} \tag{2}$$

$$TS_{ij} = \frac{W_{ij}}{DWT \times N_{ij}} = \frac{W_{ij}d_{ij} + W_{ij} \times 72v}{DWT \times 4161v} = \frac{W_{ij}d_{ij} + W_{ij}A}{B} \tag{3}$$

$$TS_{Europe \to Asia} = \frac{1}{B}\sum_{i=1}^{13}\left(\sum_{j=1}^{42} W_{ij}d_{ij} + A\sum_{j=1}^{42} W_{ij}\right) \tag{4}$$

$$TS_{\text{North\&Central America} \to Asia} = \frac{1}{B}\sum_{i=14}^{17}\left(\sum_{j=1}^{42} W_{ij}d_{ij} + A\sum_{j=1}^{42} W_{ij}\right)$$

$$TS_{South\ America \to Asia} = \frac{1}{B}\sum_{i=18}^{22}\left(\sum_{j=1}^{42} W_{ij}d_{ij} + A\sum_{j=1}^{42} W_{ij}\right)$$

$$TS_{Oceania \to Asia} = \frac{1}{B}\sum_{i=23}^{23}\left(\sum_{j=1}^{42} W_{ij}d_{ij} + A\sum_{j=1}^{42} W_{ij}\right)$$

$$TS_{Asia} = TS_{Europe \to Asia} + TS_{\text{North\&Central America} \to Asia} + TS_{South\ America \to Asia} + TS_{Oceania \to Asia}$$

Here, $A = 72v, B = DWT \times 4152v$, i : exporter, j : importer. D_{ij} is the number of days necessary for a round trip from i to j; d_{ij} is the distance from i to j (miles); v is the speed of the grain bulk carrier (miles/hour); D_{ED} is the number of required days for entering and departing ports in one round trip (3 days); D_{LU} is the number of days required for loading and unloading in ports in one round trip (3 days); N_{ij} is the number of annual voyages of i and j; TS_{ij} is the number of ships for i and j; W_{ij} is the seaborne trade from i to j (tons); DWT is the dead weight tonnage of a grain bulk carrier. Based on this model, the required number of grain bulk carriers can be predicted from the maritime tons and maritime ton-miles.

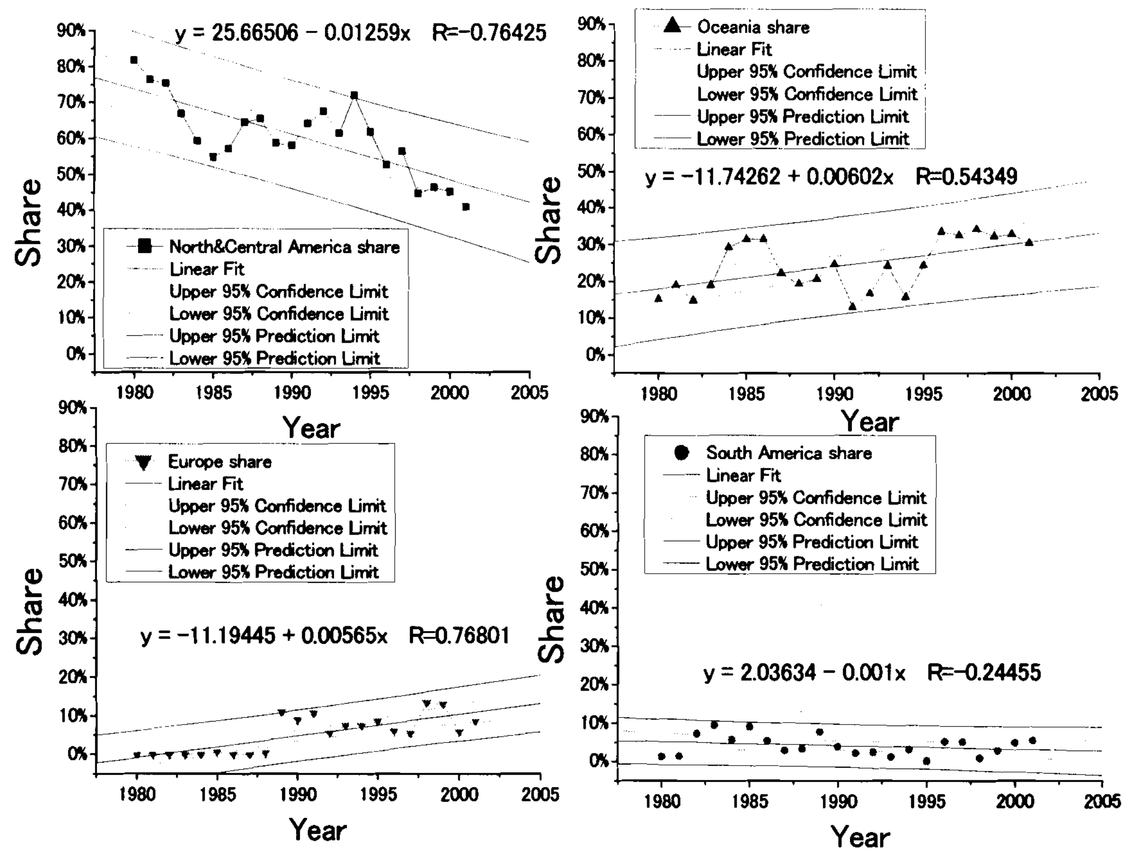

Figure 6.19 Least Squares Fit of Partner Areas' Share

Figure 6.19 shows the export share from the other areas to Asia. The partner area of Asia is North & Central America, Oceania, Europe and South America. Although the export share of North & Central America and Oceania were about 97% in 1980, it decreased to 78% in 2000. Two areas are still important partners to Asia. Moreover, the export share of Europe is 9% on an average from 1989 to 2001 in the wheat market of Asia. By comparison, we find that the share of North-Central America is decreasing and Oceania and Europe are increasing. In addition, the export share of South America is low and stable. We can make a prediction by the approximation straight line of export share for the four areas.

6.4.3 The Relationship between International Wheat Price and Residual of Export Share

In the section, we will discuss the relationship between international wheat price and residual of export share using the cross correlation.

Cross correlation is a standard method of estimating the degree to which two series are correlated. Consider two series x(i) and y(i) where i=0,1,2...N-1. The cross correlation r at delay d is defined as

$$r = \frac{\sum_i \left[\left(x(i) - \bar{x} \right) \left(y(i-d) - \bar{y} \right) \right]}{\sqrt{\sum_i \left(x(i) - \bar{x} \right)^2} \sqrt{\sum_i \left(y(i) - \bar{y} \right)^2}} \qquad (5)$$

Where $\bar{x}$ and $\bar{y}$ are the means of the corresponding series. If the above is computed for all delays d=0, 1,2,...N-1 then it results in a cross correlation series of twice the length as the original series.

$$r(d) = \frac{\sum_i \left[\left(x(i) - \bar{x} \right) \left(y(i-d) - \bar{y} \right) \right]}{\sqrt{\sum_i \left(x(i) - \bar{x} \right)^2} \sqrt{\sum_i \left(y(i) - \bar{y} \right)^2}} \qquad (6)$$

The observations of one series are correlated with the observations of another series at various lags and leads. Cross-correlations are often presented in a plot. Cross-correlations help identify variables which are leading indicators of other variables. CCF is the Cross-Correlation Function. We put times series of international wheat price and residual in to the model. The international price is considered as leading indicator (here is y (i-d)). The results are as shown in Figure 6.20. If cross-correlation exceeds confidence limit (95% confidence limit), the international price will greatly effect the change of export share's residual. So, the lag -1 of wheat price has a strongest effect on the residual of export share in the North & Central America and Oceania. Though the lag -2 of wheat price also has a strong effect on the residual of export share in the South America, it doesn't exceed the confidence limit. In the case of Europe, it is different with the other areas because the lag 4 of wheat price has a strong effect on the residual. From the above analysis, we also draw a conclusion that the speculation exists in the wheat marketing.

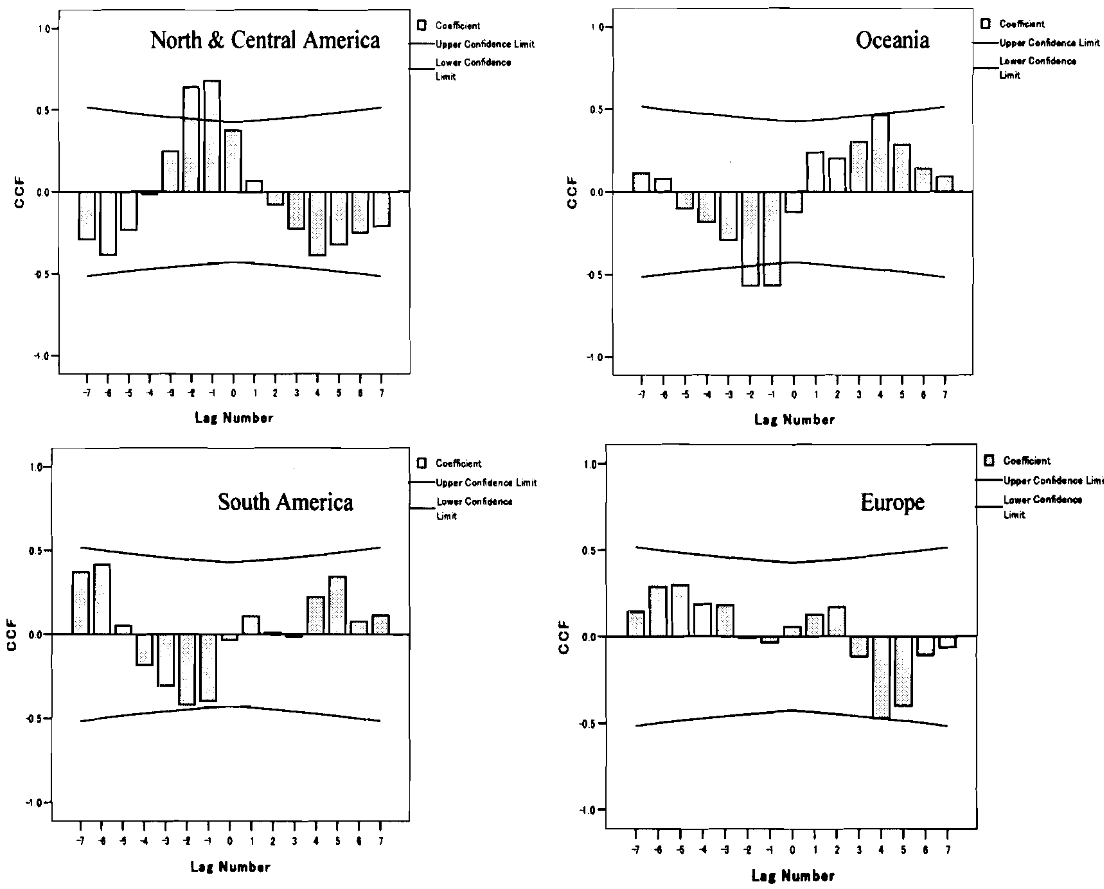

Figure 6.20 Cross-correlations Analysis (Price with the Share Residual of 4 Areas)

However, since the prediction of international wheat price is difficult, the international wheat price is not included in the export share of prediction.

6.4.4 Transportation Ton and Ton-miles

First of all, the maritime transportation tons will be obtained from scenario 1 in Chapter 4. Based on the prediction of export share, we can prediction the maritime tons from the North and Central America, South America, Oceania and Europe. Secondly, the prediction of maritime transportation ton-miles can be done from the relation between ton and ton-miles. As shown in Figure 6.21, the coefficient of determination is more than 0.94, so strong correlations can be seen. It shows that the partner countries of trade do not change in four areas. It satisfies the conditions of a sufficient prediction, so the required number of grain bulk carriers can be predicted from the maritime tons and maritime ton-miles.

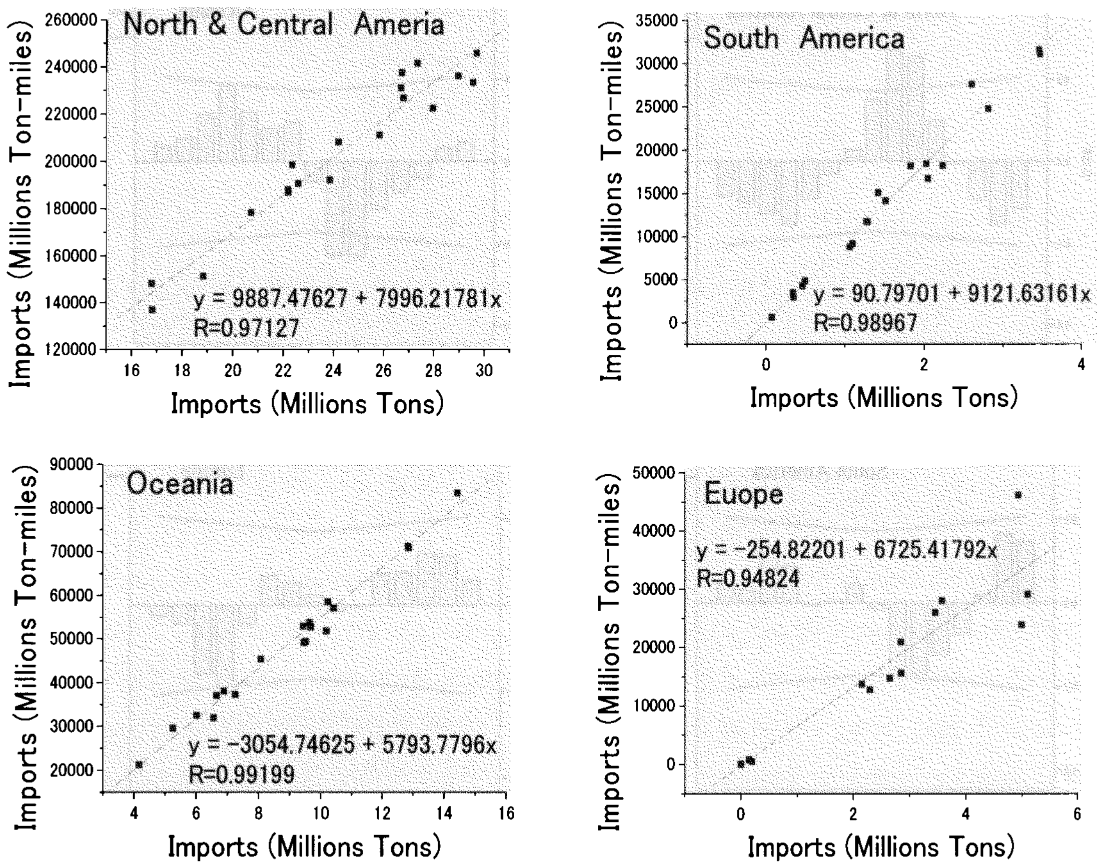

Figure 6.21 Relationship between Transportation Tons and Ton-miles

6.4.5 Prediction Result

By using 60,000 DWT grain bulk carriers and considering 10 nautical miles/hour, we make a prediction using the above model and get the results as shown in Table 6.1. The number of grain bulk carriers will decrease to 57 and 4, respectively, from North and Central America and South America. On the other hand, the number of grain bulk carriers will increase to 69 and 42, respectively, from Oceania and Europe in 2020. Therefore, the total number of carriers needed for Asia is 172. It shows an increasing tendency in Asia.

Table 6.1 Predicted Numbers of Bulk Carriers Needed (Asia)

Year	North & Central America	South America	Oceania	Europe	Total
2005	84	7	45	22	158
2010	77	6	53	28	164
2015	67	5	61	35	169
2020	57	4	69	42	172

6.5 Emissions of CO_2

The Kyoto Protocol was adopted at the third session of the Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 1997 in Kyoto, Japan. The Kyoto Protocol is an agreement under which industrialized countries will reduce their collective emissions of greenhouse gases by 5.2% compared to the year 1990. The objective of the Kyoto Protocol is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". But the emission of greenhouse gas excludes international aviation and shipping. For this reason, the reduction of international shipping is considered as the examination subject by IMO. Here, we performs metrical examination of CO_2's emission for the increasing maritime transportation of wheat because what kind of influence on earth environment is very important for social progress. Using equation 7, we can get the emission of CO_2 from 4 areas to Asia.

$$E_{CO_2} = \sum_i \sum_j C_{CO_2} W_{ij} d_{ij} \qquad (7)$$

Where, E_{CO_2} is emission of CO_2, C_{CO_2} is incident rate of CO_2 (5.5 t- $CO_2/10^6$ ton・km) (Ship & Ocean Foundation, 2001). The results are presented in Figure 6.22.

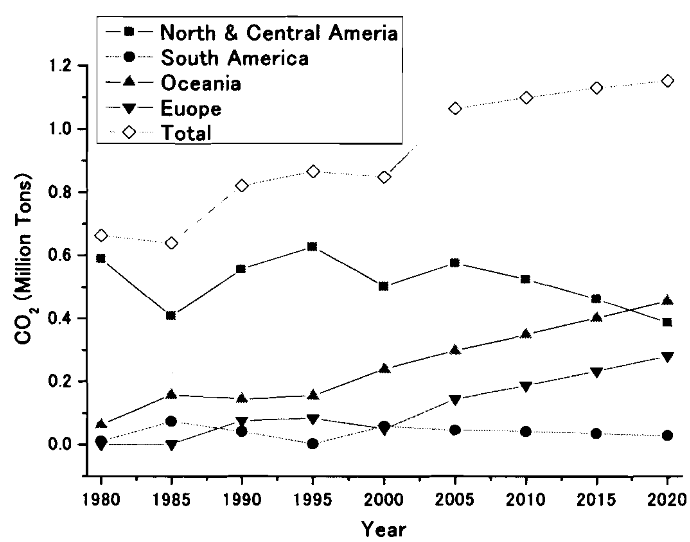

Figure 6.22 Emissions of CO_2 (Asia)

6.6 Conclusions

We summarize the results as follows:

1. We analyzed the panel data of Asian trade and developed an analyzing system for maritime transportation and logistics of Asia including maritime Ton, Ton-Miles, trade value, number of

bulk carriers needed and emissions of CO_2 in the maritime transportation.

2. We find the coefficient of determination is high between the ports' depths and the DWT of bulk carriers.
3. A strong correlation between the tons and ton-miles can be concluded. The information was valuable for predicting the appropriate number of required ships.
4. The model was built to estimate the number of grain bulk carriers needed for wheat.
5. The international price greatly effects the change of export share's residual by cross correlation.
6. The speculation exists in the wheat marketing.

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Chapter 7 Maritime Transportation and Logistics Systems of Africa

In recent years, especially in Africa, the present agricultural condition is dangerous. Starvation frequently happens in many countries in Africa. The cause of starvation is often considered to be the explosive growth of the population in Africa. However, climatic aberration, civil war, the depression of national economies, and the failure of economic policy in the world economy system are also important factors. In other words, the cause is composed of various complex factors, such as natural, social, and political factors. As a result, food shortages are very serious for the African people.

In chapter 7, we will analyze the maritime transportation and logistics systems of Africa including maritime Ton, Ton-Miles, trade value, number of bulk carriers needed and emissions of CO_2 in the maritime transportation.

7.1 Analysis of Maritime Transportation in Africa (Tons)

We analyze the maritime transportation and logistics systems of wheat by analyzing the maritime Ton, Ton-Miles, trade value, number of bulk carriers needed and emissions of CO_2. Now, the international wheat market is an oligopoly, which includes the United States, Canada, the EU, Australia, and Argentina. These countries hold 85% of the trade share. On the other hand, Table 7.1 shows the seaborne trade of main African countries. The share of these countries is more than 73% in Africa. Egypt, Algeria, and Morocco are the top three importing countries in Africa. The amount of import of the three countries was 7.76 million tons and the total share of the three countries was 66% in 1980. They became 13.7 million tons and 57% in 2000, respectively. The total share of the three countries occupied about half of African wheat marketing. The other four secondary countries are Nigeria, Tunisia, Sudan, and Ethiopia. The total import of all seven countries was 9.67 million tons, and the total share of the seven countries was 82% in 1980. They became 19.47 million tons and 81% in 2000. The total share of the seven countries is about 80% of the African wheat market.

Table 7.1 Seaborne Trade of Important African Countries

	1980		1985		1990		1995		2000		2004	
Country	**Import**	**Share**	**Import**	**Share**	**Import**	**Share**	**Import**	**Share**	**Import**	**Share**	**Import**	**Share**
Egypt	4.42	38%	4.52	31%	5.40	37%	5.07	29%	4.90	20%	4.37	18%
Algeria	1.70	14%	3.03	21%	2.61	18%	3.50	20%	5.37	22%	5.03	21%
Morocco	1.65	14%	1.92	13%	1.36	9%	2.55	14%	3.44	14%	2.65	11%
Total three	**7.76**	**66%**	**9.48**	**66%**	**9.37**	**65%**	**11.12**	**63%**	**13.70**	**57%**	**12.05**	**50%**
Nigeria	1.10	9%	1.43	10%	0.03	0%	0.61	3%	2.22	9%	2.61	11%
Tunisia	0.65	6%	0.49	3%	0.90	6%	1.65	9%	1.39	6%	1.04	4%
Sudan	0.16	1%	0.58	4%	0.50	3%	0.11	1%	1.00	4%	1.22	5%
Ethiopia	0.00	0%	0.00	0%	0.00	0%	0.51	3%	1.16	5%	0.87	4%
Total seven	**9.67**	**82%**	**11.97**	**83%**	**10.80**	**75%**	**14.00**	**80%**	**19.47**	**81%**	**17.79**	**74%**

The maritime transportation of wheat is analyzed by using FAO trade data (FAO 2001). Africa imports wheat from Europe, North and Central America, South America, and Oceania. In the case of Africa, 49 countries import wheat from 15 other countries, including three North and Central American countries, nine European countries, two South American countries, and one country in Oceania.

Here, we mainly analyze the African maritime transportation and logistics systems using the panel data of the top three countries. Panel data sets are two-dimensional, whereas time series and cross-sectional data are both one-dimensional. The cross-sectional data are the O-D data of wheat trade. Here, the O-D data of wheat trade are analyzed in 1998. Time series data show the volume of imports from the partner countries for three countries from 1980 to 1998.

In 1998 the O-D data of three countries' wheat trade are shown in Table 7.2. The trading partners of Egypt are the EU, USA, Australia, etc. The volume of import is almost totally from the EU, USA, and Australia. Based on the share of trading partners, the United States occupied 63%, and EU and Australia occupied 15% and 20%, respectively. The trading partners of Algeria are the EU, Canada, the United States, etc. Three countries occupied 96% of Algeria's importing market share. The trading partners of Morocco are the EU, Canada, Hungary, USA, etc. Based on the share of the trading partners, the EU occupied 50%, USA occupied 9%, and, Canada, Australia, and Hungary occupied 2%, 11%, and 19%, respectively.

Table 7.2 Trade Flow of Egypt, Algeria, and Morocco in 1998 (Share)

Africa	Important partner country (Share base)					
Important importing country	EU	USA	Australia	Canada	Hungary	Total 4
Egypt	15%	63%	20%	0%	0%	98%
Algeria	43%	13%	0%	40%	0%	96%
Morocco	50%	9%	2%	19%	11%	91%

Figure 7.1 shows the changes in exports to Africa. As shown from (a) to (c) in Figure 7.1, the volume of wheat import increased in Egypt, Algeria, and Morocco according to the panel data from 1980 to 1998. The EU increased the exports to the three countries from 1989. Canada is also in the expansion of exporting to Algeria and Morocco. The condition of Australia's exporting to Egypt is almost stable. In the case of the USA, the volume of exports to Egypt is increasing. However, after the volume of exports to Algeria and Morocco peaked in the 1980s, the exports declined. Therefore, there is a competitive relationship among the EU, Canada, and the USA.

Figure 7.1 (d) shows that the volume of imports from North and Central America, Europe, and Oceania is large. The volume of Europe's exports to Africa has greatly increased since 1989.

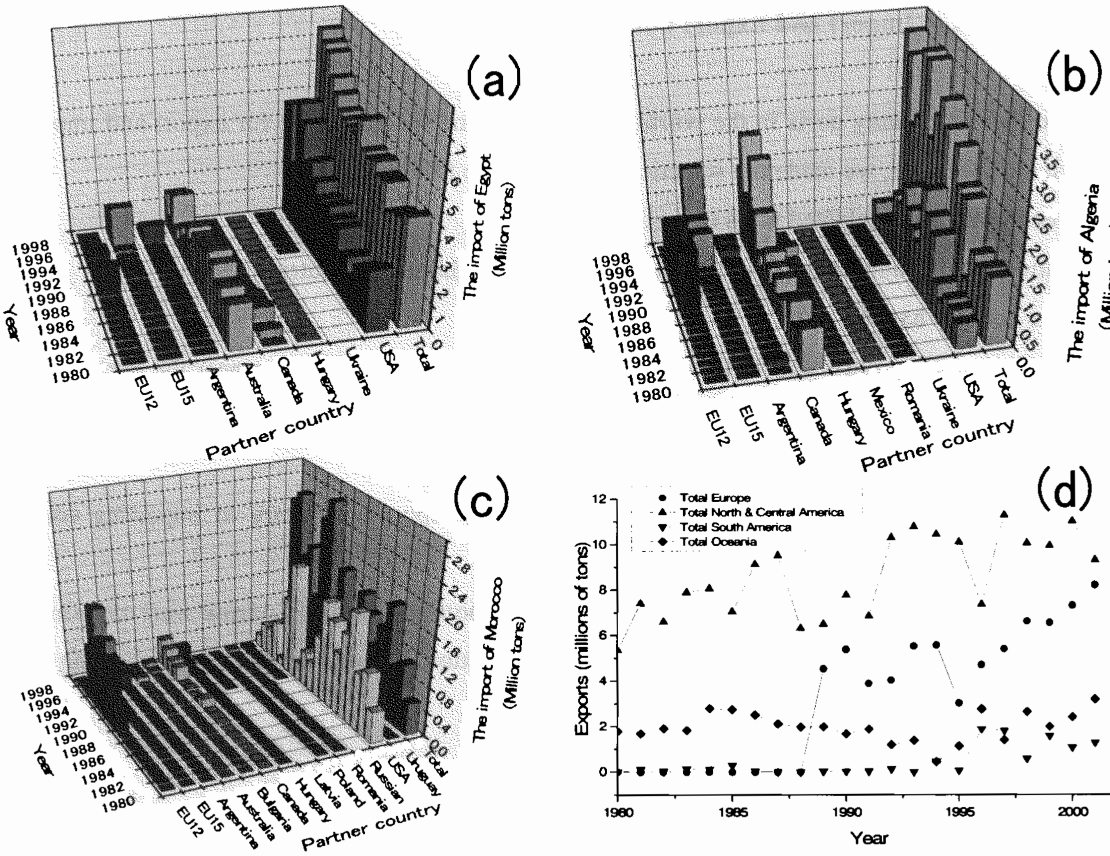

Figure 7.1 Changes in Exports to Africa (Tons)

7.2 Maritime Transportation in Africa (Ton-miles)

7.2.1 Map Illustrating the Distance (the Shortest Voyage)

The map shows the shortest distance from the port of export to the port of import. For example, the map shown in Figure 7.2 shows the shortest route between New Orleans and Alexandria. The shipping route was obtained from the Worldwide Distance Chart (Japan Navigating Officers' Association 1990) and World Distance Tables (LLOYD'S, 2006).

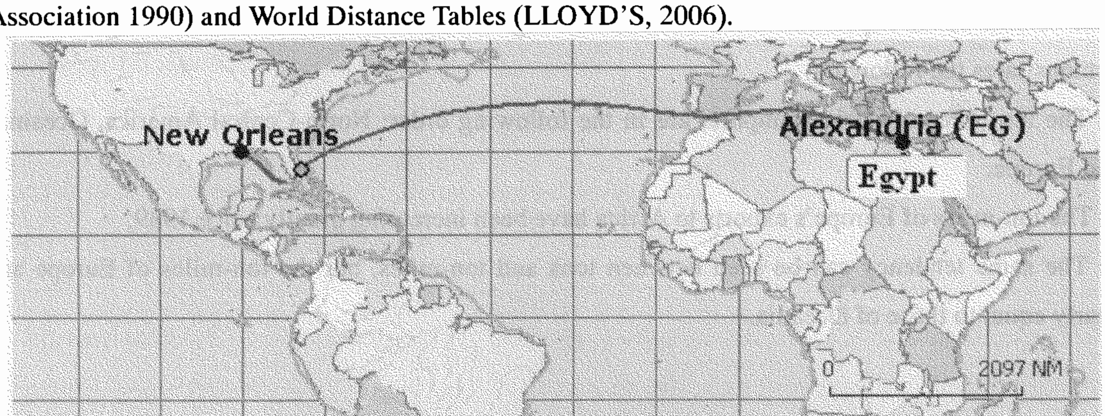

Figure 7.2 Concept of Distance

7.2.2 Selection of Import and Export Ports

Since there are many ports in the world, the selection of specific ports for export and import is important. Therefore, we made the selections based on the following:

1) The depth of the selected ports exceeds 10m.
2) Landlocked countries import wheat from ports of neighboring countries.
3) One country has one port.
4) Those exporting ports should frequently be used to export grain and are near the port of wheat production. Those ports for import should be used for importing grain and are near the country's capital (in consideration of the population).
5) Maritime transportation is always carried out from exporting country to importing country without calling at other ports.

As a result, 15 exporting ports to Africa and 31 importing ports for Africa were determined. Using the selected ports, we obtained the shortest navigation distance between the exporting ports and importing ports (Appendix C).

7.2.3 Maritime Transportation (Ton-miles)

The export ton-miles from the United States to African countries are shown in Figure 7.3(a). In the figure, i means an exporting port; here, i=1 means the United States' port, and j is an importing port. For example, in the case of exporting from the United States to African countries, the ton-miles from the United States to African countries changed in an irregular manner, resulting in an unclear trend for the ton-miles. Then the total export ton-miles from the United States to Africa are shown in Figure 7.3 (b). Figure 7.3 (b) shows that the total volume of the export ton-miles from the United States to Africa is moderate change than those in Figure 7.3 (a). From a continental viewpoint, the results of exports from various regions to Africa are shown in Figure 7.3 (c). The total volume of the export ton-miles from various regions to Africa becomes smooth. Figure 7.3 (c) demonstrates the following:

1) The ton-miles of African imports are in the following order: North-Central America, Oceania, and Europe.
2) The ton-miles of Europe's exports to Africa have been increasing greatly since 1989.
3) The same tendency can be seen between tons and ton-miles, but the ton-miles of Europe are nearly equal to those of Oceania.

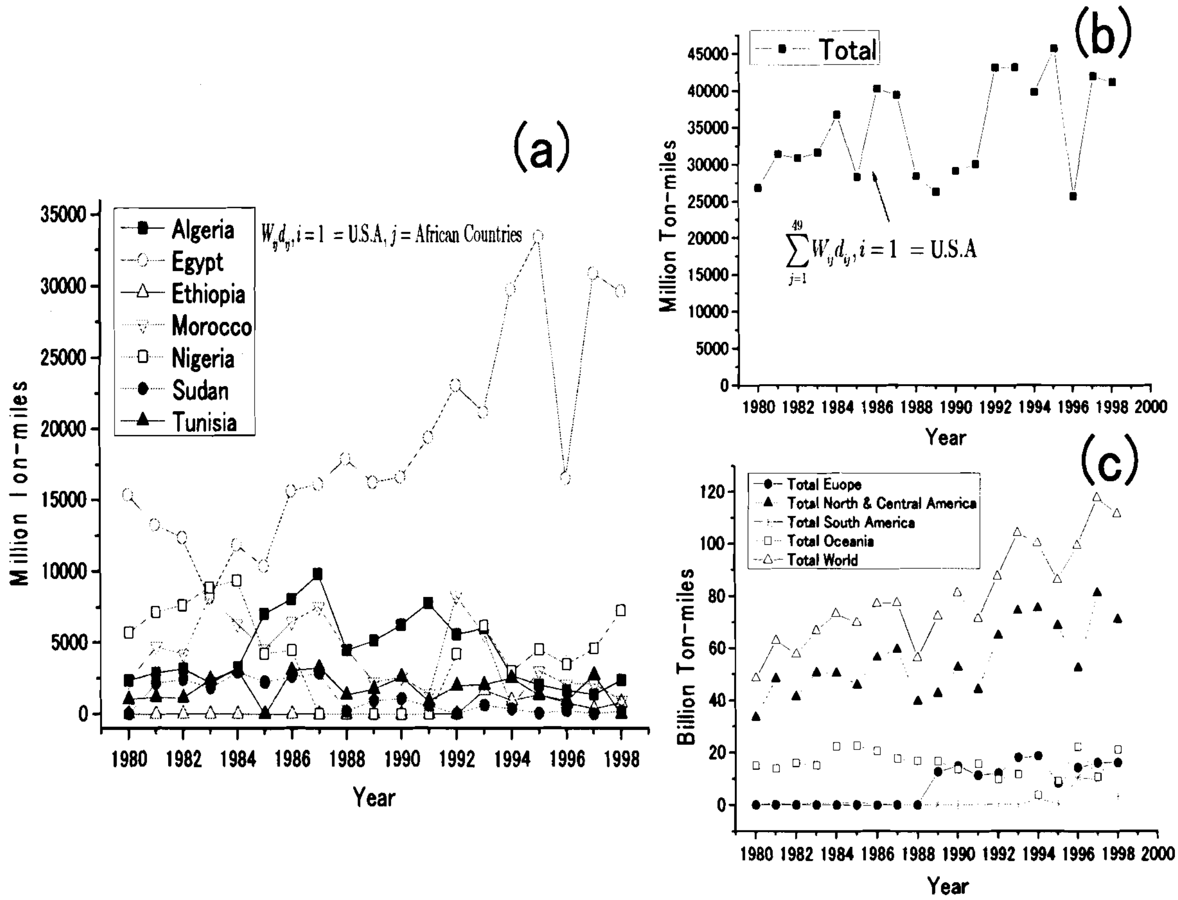

Figure 7.3 Changes in Exports to Africa (Ton-miles)

7.3 Trade value

Figure 7.4 shows changes in import amounts (three countries). As shown in Figure 7.4, in the case of Egypt, the imported volumes of wheat peaked in 1974, 1981, 1989, and 1996. In the case of Algeria, the imported volumes of wheat peaked in 1975, 1985, 1989, and 2004. Finally, the imported volumes of Morocco peaked in 1975, 1985, 1989, and 2004. It clearly shows the increasing tendency of three countries' import values.

Figure 7.5 demonstrates the amounts of imports to Africa. It clearly shows a slowly increasing tendency since 1960. The amount of imports to Africa was 2.46 billion dollars in 1980, but the increase in the amount of imports was approximately 1.13 billion dollars from 1980 to 2000. Although African imports increased slightly, the rapid increase of population may enhance the import values in the long run.

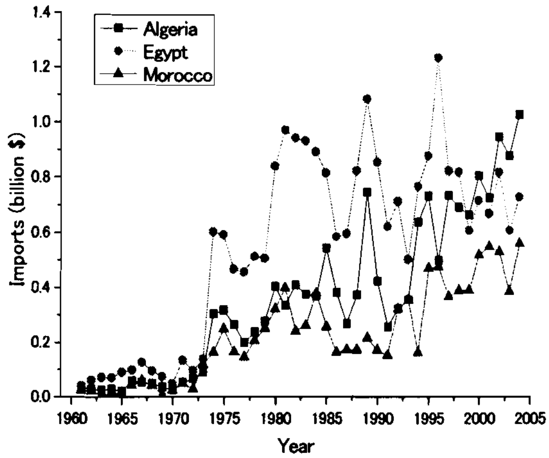

Figure 7.4 Changes of Import Value (3 Countries)

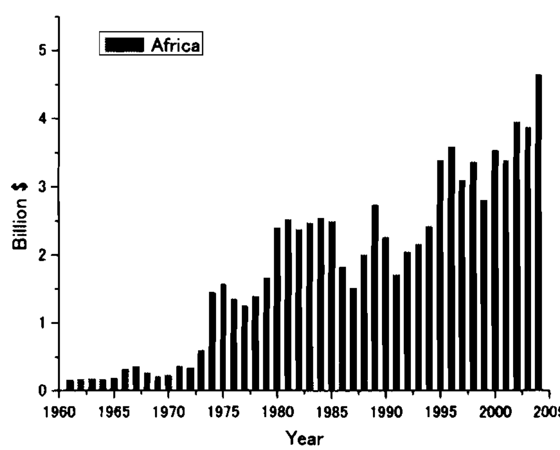

Figure 7.5 Changes of Import Value (Africa)

7.4 Forecasting the Required Number of Wheat Bulk Carriers

Forecasting the required number of wheat bulk carriers is difficult at the country level because the changing tendency of the import volume is very sharp. Therefore, in this research, we predict the import volume at the continental level. According to this method, compared to the case of the country level, the import volume becomes very flat and smooth, the function system can be applied, and the accuracy can be raised (Kubo 2004, 2006).

7.4.1 Examination of Wheat Bulk Carrier Size and Depth of Water

Grain transportation is usually performed by maritime transportation. The means of transport is grain bulk carriers, in which, the Panamax Ship is the dominant type of all ships. The Ship of Panamax type is the largest ship which can pass through the Panama Canal, and its loading capacity is about 70,000 tons or less. It is clear that 10,000～60,000 DWT bulk carriers are often used. The average depth of each strait on the navigation route is 20 meters or more; therefore, it appears that bulk carriers from 10,000 to 60,000 DWT could navigate the waters. The depth of importing and exporting ports is 10 meters and greater; therefore, 60,000 DWT bulk carriers are suitable for shipping and unloading wheat at ports.

7.4.2 Forecasting Model for Required Number of Wheat Bulk Carriers

Here, the volume of imports will be the volume of the maritime transportation because whole wheat will be shipped. In the following analysis, the navigation days of a vessel are considered as 95% of 365. The navigation days, annual voyages, and necessary ships in the export navigation route from each exporter to an African importer could be determined using the following equations (Kubo 2005):

$$D_{ij} = \frac{d_{ij}}{v \times 24} \times 2 + D_{ED} + D_{LU} \quad (1)$$

$$N_{ij} = \frac{365 \times 0.95}{D_{ij}} \quad (2)$$

$$TS_{ij} = \frac{W_{ij}}{DWT \times N_{ij}} = \frac{W_{ij} d_{ij} + W_{ij} \times 72v}{DWT \times 4152v} = \frac{W_{ij} d_{ij} + W_{ij} A}{B} \quad (3)$$

$$TS_i = \sum_j TS_{ij} = \frac{\sum_{j=1}^{49} W_{ij} d_{ij} + A \sum_{j=1}^{49} W_{ij}}{B} \quad (4)$$

$$TS_{\text{North \& Central America}} = \sum_{i=1}^{3} TS_i = \frac{1}{B} \sum_{i=1}^{3} \sum_{j=1}^{49} W_{ij} d_{ij} + \frac{A}{B} \sum_{i=1}^{3} \sum_{j=1}^{49} W_{ij}$$

$$TS_{Europe} = \sum_{i=4}^{13} TS_i = \frac{1}{B} \sum_{i=4}^{13} \sum_{j=1}^{49} W_{ij} d_{ij} + \frac{A}{B} \sum_{i=4}^{13} \sum_{j=1}^{49} W_{ij}$$

$$TS_{\text{South America}} = \sum_{i=14}^{15} TS_i = \frac{1}{B} \sum_{i=14}^{15} \sum_{j=1}^{49} W_{ij} d_{ij} + \frac{A}{B} \sum_{i=14}^{15} \sum_{j=1}^{49} W_{ij}$$

$$TS_{Oceania} = \sum_{i=15}^{15} TS_i = \frac{1}{B} \sum_{i=15}^{15} \sum_{j=1}^{49} W_{ij} d_{ij} + \frac{A}{B} \sum_{i=15}^{15} \sum_{j=1}^{49} W_{ij}$$

Here, $A = 72v, B = DWT \times 4152v$, i : exporter, j : importer. D_{ij} is the number of days necessary for a round trip from i to j; d_{ij} is the distance from i to j (miles); v is the speed of the grain bulk carrier (miles/hour); D_{ED} is the number of required days for entering and departing ports in one round trip (3 days); D_{LU} is the number of days required for loading and unloading in ports in one round trip (3 days); N_{ij} is the number of annual voyages of i and j; TS_{ij} is the number of ships for i and j; W_{ij} is the seaborne trade from i to j (tons); DWT is the dead weight tonnage of a grain bulk carrier. Based on this model, the required number of grain bulk carriers can be predicted from the maritime tons and maritime ton-miles.

7.4.3 Import Analysis of Africa (Ton and Ton-miles)

Figure 7.6 shows the analysis of imports in Africa. As shown in Figure 7.6, 1986, 1988, and 1995 are very important years because the annual tendency of trade volume changed most in these years. In the following part, we will make a detailed analysis.

In the case of 1986, the United States applied the Export Enhancement Program (EEP) as retaliatory measures against the wheat export of the EC using a subsidy. At the same time, Australia and the other 14 so-called fair exporting countries gathered together in Cairns City, Australia. They protested against such unfair trade, especially aimed at the export subsidy because they were suffering from the falling wheat prices. Hence, these countries were very seriously affected by the export volume after 1986.

In 1988, crops suffered due to the drought in North America. Therefore, wheat output decreased greatly in the North America and Central America regions, and the exports decreased. On the other hand, wheat stock of the EU was increasing and was recorded at 11,300,000t in 1989. Europe got its best chance to enhance the exports to Africa in that time.

Since the 1980's, the government of the EU has always paid a subsidy to protect domestic agriculture. Consequently, the quantity of production increased continuously and became overproduction. In order to solve this problem, the EU carried out the dumping export using the export subsidy. The result is that import demand was slumping in the developing countries, and the wheat price was dropping; moreover, the export competitiveness of traditional exporting countries, such as Canada, Australia, and Argentina, became remarkably weak. In this situation, the world's largest principal exporting nations, United States and the EU, began dumping exports. Because subsidies gradually create a trade barrier, the General Agreement on Tariffs and Trade (GATT) was established. The policies that affected agricultural trade were subjected to systematic multilateral controls for the first time by the Uruguay Round's 1994 Agreement on Agriculture (AoA). The negotiation resulted in an agricultural agreement, and the contracting states were obliged to reduce the subsidy to agricultural producers.

From 1995, the GATT became the WTO, and the WTO plays the role of an engine for international trade expansion of wheat. Based on the agricultural agreement of WTO, some policies were put into practice, such as the reduction of farm subsidies, the customs duty, and the amount of import quotas. These policies promoted trade liberalization.

Next, we make a prediction for the imports by a straight line approximation for four areas. It is difficult to make a long-term forecast because the agricultural trade is greatly affected by policies. Consequently, we made two scenarios to predict the wheat import in Africa until 2010. In the first scenario, we predict the imports from North and Central America and South America using the data from 1980 to 2001. In addition, the imports from Europe and Oceania are predicted using the data since 1995. In the second scenario, we made all predictions using the data since 1995.

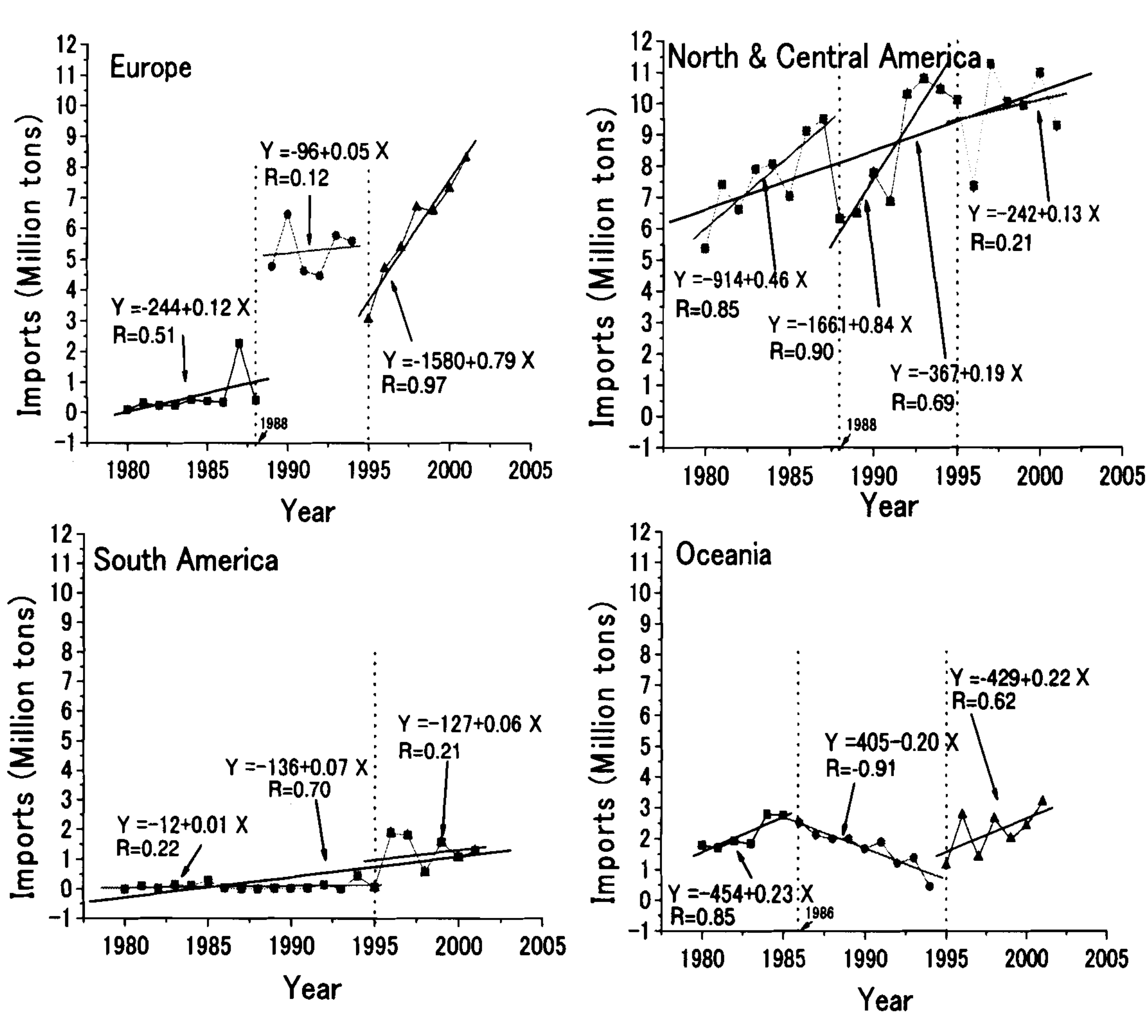

Figure 7.6 Import Analysis of Africa

The prediction of maritime transportation ton-miles can be done from the relation between ton and ton-miles. As shown in Figure 7.7, the coefficient of determination is more than 0.96, so strong correlations can be seen. It shows that the partner countries of trade do not change in four areas. It is a perfect condition for sufficient prediction, so the required number of grain bulk carriers can be predicted from the maritime tons and maritime ton-miles.

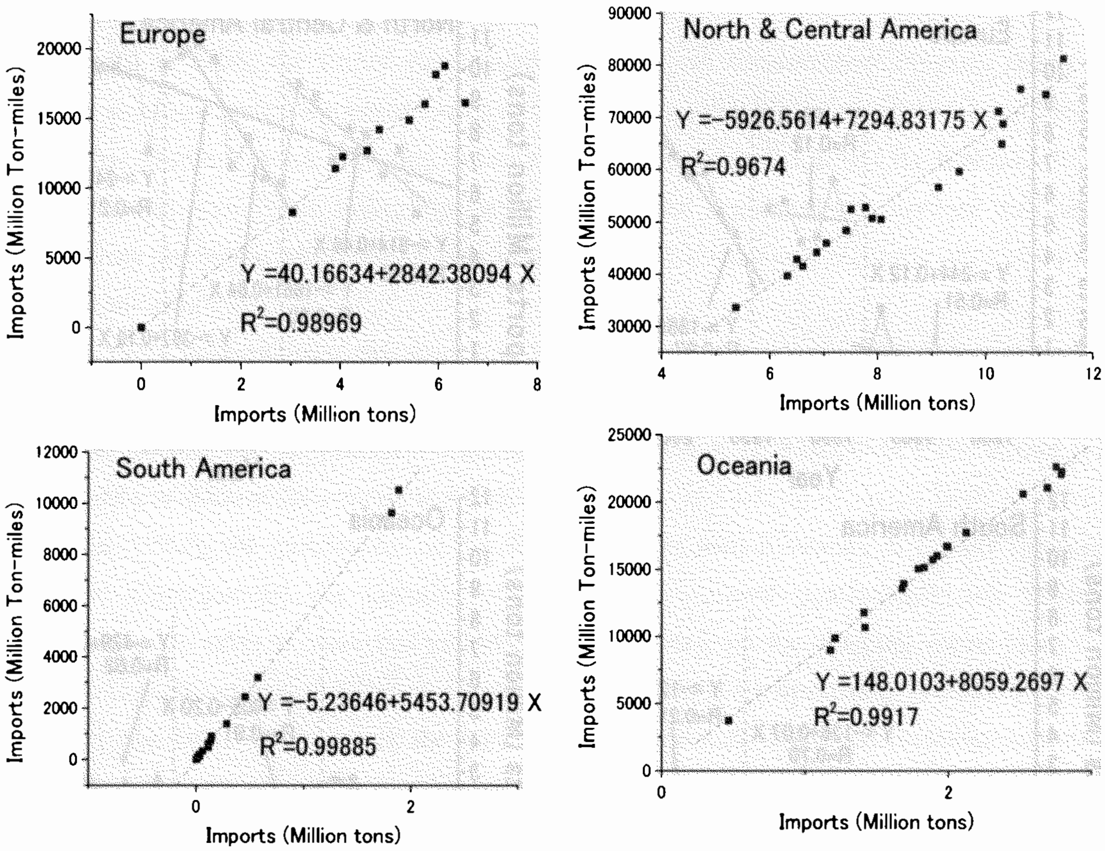

Figure 7.7 Relationships between Tons and Ton-miles

7.4.4 Prediction Result

By using 60,000 DWT grain bulk carriers and considering 10 nautical miles/hour, we make a prediction using the above model and get the results as shown in Table 7.3. In the first scenario, the number of grain bulk carriers will increase to 37, 4, 17, and 22, respectively, from North and Central America, South America, Oceania, and Europe in 2010. Therefore, it is 81 of the total necessary carrier for Africa. In the second scenario, the number of grain bulk carriers will increase to 34, 5, 17, and 22, respectively from North and Central America, South America, Oceania, and Europe in 2010. As a result, it is 78 of the total necessary carrier for Africa.

Table 7.3 Predicted Number of Bulk Carriers Needed

Year	North & Central America		South America		Oceania	Europe	Total	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2			Scenario 1	Scenario 2
2002	32	31	3	4	11	13	59	59
2004	33	32	3	4	12	15	65	64
2006	35	33	4	4	14	18	70	68
2008	36	33	4	5	16	20	75	73
2010	37	34	4	5	17	22	81	78

7.5 Emissions of CO_2 (Africa)

The same as method of Asia, we can get the result form equation 5.

$$E_{CO_2} = \sum_i \sum_j C_{CO_2} W_{ij} d_{ij} \quad (5)$$

E_{CO_2} is emission of CO_2, C_{CO_2} is incident rate of CO_2 (5.5 t- $CO_2/10^6$ ton・km). (Ship & Ocean Foundation, 2001). The results are presented in Figure 7.8. We can calculate the emissions of CO_2 using two scenarios because there are two scenarios when we prediction the maritime ton-miles.

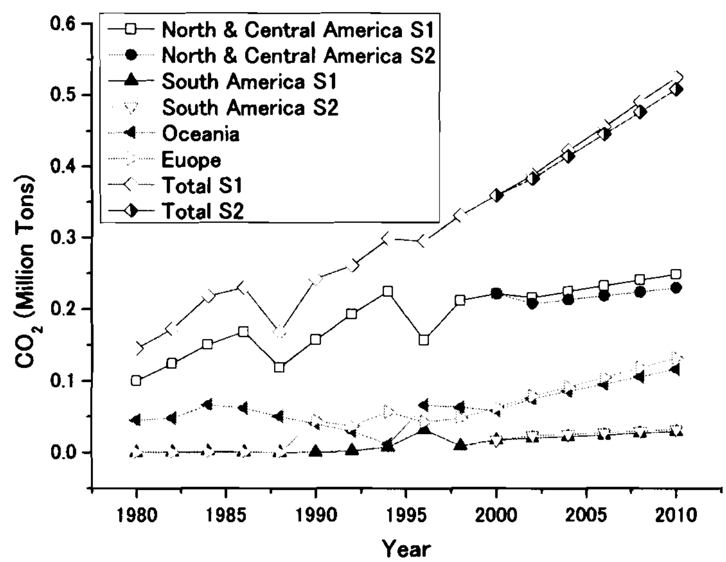

Figure 7.8 Emissions of CO_2 (Africa)

7.6 Conclusions

We summarize the results as follows:

1. We analyzed the panel data of African trade and developed an analyzing system of maritime transportation and logistics of wheat, which includes the maritime tons, ton-miles, trade value, number of bulk carriers needed and emissions of CO_2 in the maritime transportation.
2. We found that there was a competitive relationship among the EU, Canada, and the USA.
3. We also found a strong correlation between the tons and ton-miles in Africa. The information was valuable for predicting the appropriate number of required ships.
4. We created two scenarios for predicting the imports in Africa, but could not determine which scenario would actually happen in the future because the agricultural trade is greatly affected by various policies.

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Chapter 8 Comparative Research on the Trade and Bulk Carriers of Wheat and Rice for Maritime Transportation to Africa

8.1 Introduction

Wheat and rice are staples for much of the world's population. Wheat is grown worldwide; however, 90% of rice production and supply is in Asia. In the case of wheat, share of trade occupied to production is more than 20%, and that of rice is only 5%. Especially in Africa, Starvation frequently happens in many countries. The import of wheat and rice is increasing over the last 20 years.

Some related researches about wheat and rice are made by us as follows: Kubo and Purevdorj (Kubo, 2004) made a prediction about the future of rice production and consumption. Kubo and Xie (Kubo, 2006) have studied the supply and import/export of wheat in every region. Xie and Kubo (Xie, 2007) discussed the Asian maritime transportation system of wheat.

Here, the purpose of in this chapter is to make a comparative study on the trade and bulk carriers of wheat and rice for maritime transportation to Africa. In order to analyze the problem, using data from the United Nations Food and Agriculture Organization (FAO, 2001), we discuss the feature of production and supply, and trade situation of wheat and rice including trade volume and trade share. Based on the analysis of trade, we predict the number of bulk carriers for wheat and rice.

The remainder of the chapter is structured as follows. Section 8.2 presents the comparative research on the trade. Section 8.3 introduces the bulk carriers for maritime transportation followed by navigation distance, selection of import and export ports, model specifications, estimation method and results. Conclusions present in section 8.4.

8.2 Comparative Research on Trade

8.2.1 The Feature of Production and Supply

Wheat is grown worldwide; however, 90% of rice production and supply is in Asia as shown in Figure 8.1. Rice is the favored grain in Asia. The future of rice production fundamentally depends on developing countries in Asia. However, the production and supply of wheat is entirely different from that of rice.

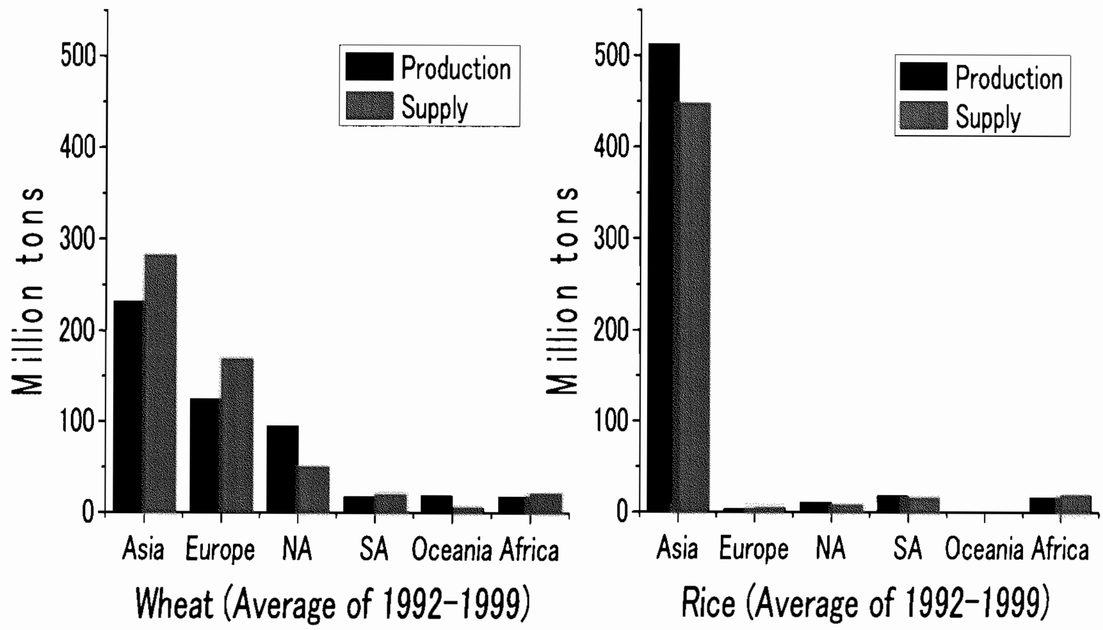

Figure 8.1 Comparisons of Production and Supply

8.2.2 Share of Trade Occupied to Production

As shown in Figure 8.2, in the case of wheat, share of trade occupied to production is more than 20%, and that of rice is only 5%. Since the share of the rice is small compared with the production, as it says well, the international market of rice is a thin market. The international price of rice tends to fluctuate sharply even if slight change of supply happens. Since the 20% of wheat production is quoted at international market, wheat should be more regarded as international merchandise than rice.

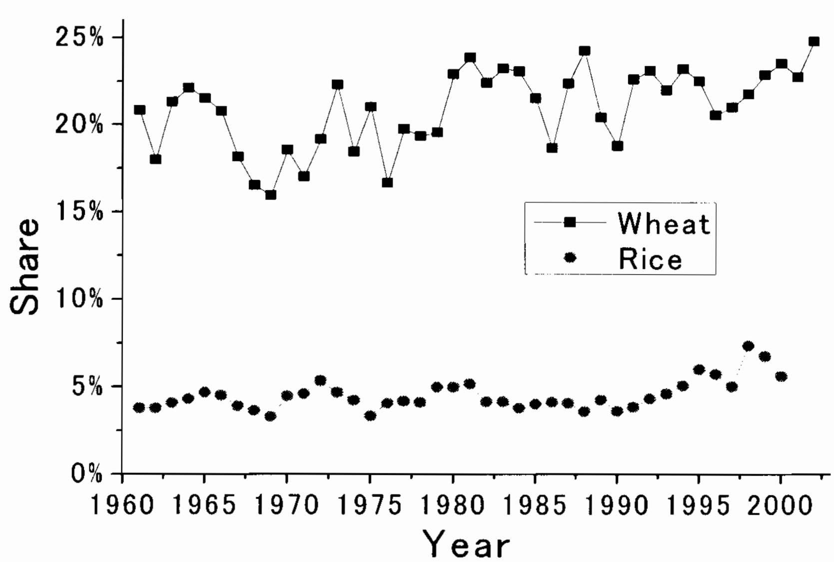

Figure 8.2 Share of Trade Occupied to Rice and Wheat Production

8.2.3 The Feature of International Price

It is the feature that the price of rice is high and change of rice price is sharply compared with wheat in Figure 8.3 because the rice consumption rate for food is higher than wheat. International market change came to arise in the rice trade after the 1970s. The import area became diversification. This change mainly originates in rapid increase of rice production in Asia after the 1970s. In the past, the rice trade has been developed within Asian countries. However, the specific gravity of Asia as an import area falls quickly, and the specific gravity of Africa is increasing heretofore. The reason of change is as follows: firstly, it is the result of Green Revolution in Asia; secondly it is also the result of African food situation is getting worse, and Africa depends on cheap rice. Although the international price of rice rose suddenly at the first half of the 1970s due to food crisis, when the 1980s came, wheat and rice prices fall sharply with enhancement of excess problem of grain.

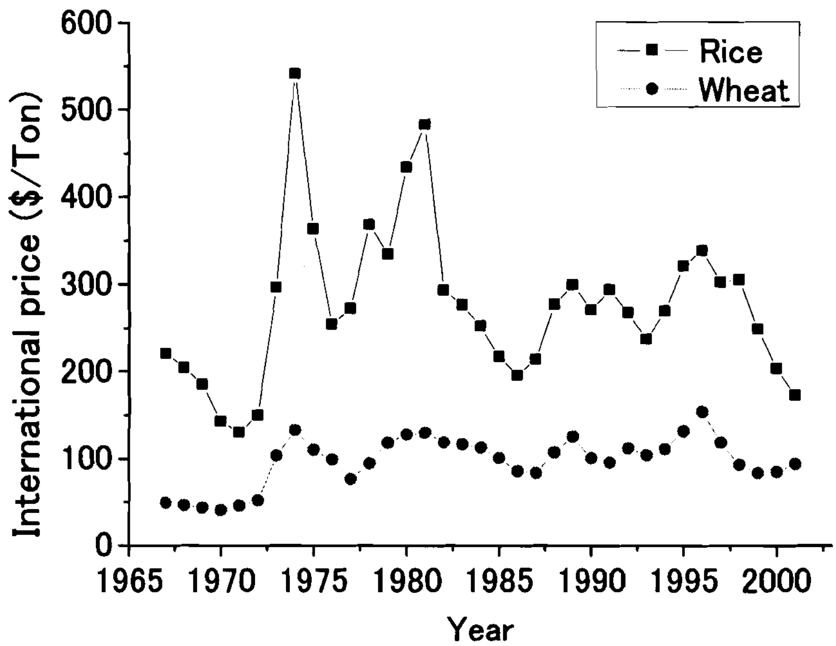

Figure 8.3 Comparisons on International Price

8.2.4 Comparison on Trade

Firstly we make a comparison on the trade volumes between wheat and rice. In the case of wheat, the volumes of imports from America, Europe and Oceania are most to Africa. The import trend of wheat is suddenly changed in Africa in Figure 8.4. In the case of rice, the volumes of imports from Asia and America are most and from Europe and Oceania are few to Africa. The import trend is generally regular in Africa in Figure 8.5.

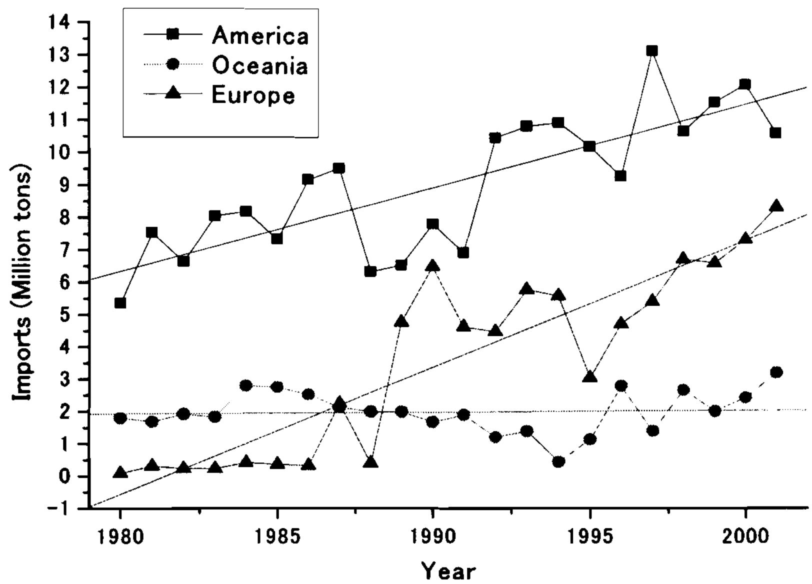

Figure 8.4 Wheat Import of Africa

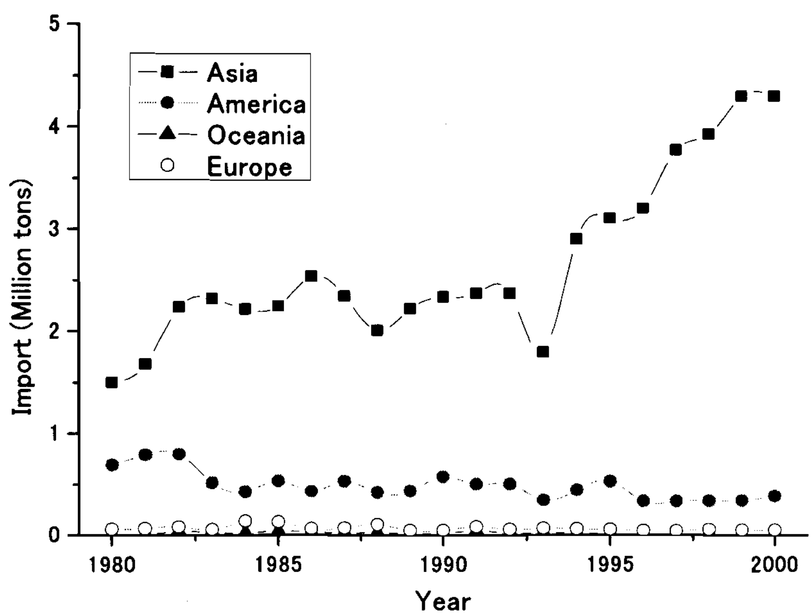

Figure 8.5 Rice Import of Africa

Secondly, we can get the residual of wheat import after we remove the trend of import by linear regression as shown in Figure 8.4. In the case of rice, using the same way, we also obtain the residual of import in Africa. Then, we discuss the relation between residual of export and international price.

We take America for example, in the case of wheat, as shown in Figure 8.6, by our discussing using the Cross Correlations, we find the correlation coefficient between residual of import and international price is weak. In the case of rice, Figure 8.7 shows the change of residual of import and international rice price. The correlation coefficient between residual of lag 1 and price of rice is the strongest. So, that price of rice affects the residual of import is stronger than wheat.

Another, there is different result in Oceania. In the case of wheat, the correlation coefficient between residual of lag -2 and price is the strongest as shown in Figure 8.6. It can be explained that the residual of lag -2 bring about the change of the wheat price. In the case of rice the relation between residual of import and price is the strongest as shown in the Figure 8.7. So the change of residual is with the change of price in the same year.

In Europe, In the case of wheat, we also find the international price bring about some effects on the residual of export. In the case of rice, since cross-correlation exceeds confidence limit (95% confidence limit), the international price greatly affect residual of import.

In Asia, we also find the international rice price bring about some effects on the residual of import. But the CCF doesn't exceed the confidence limit. We can't compare with wheat because the wheat import from Asia is not included.

By the above analysis, we find that speculation exists in different market of wheat and rice.

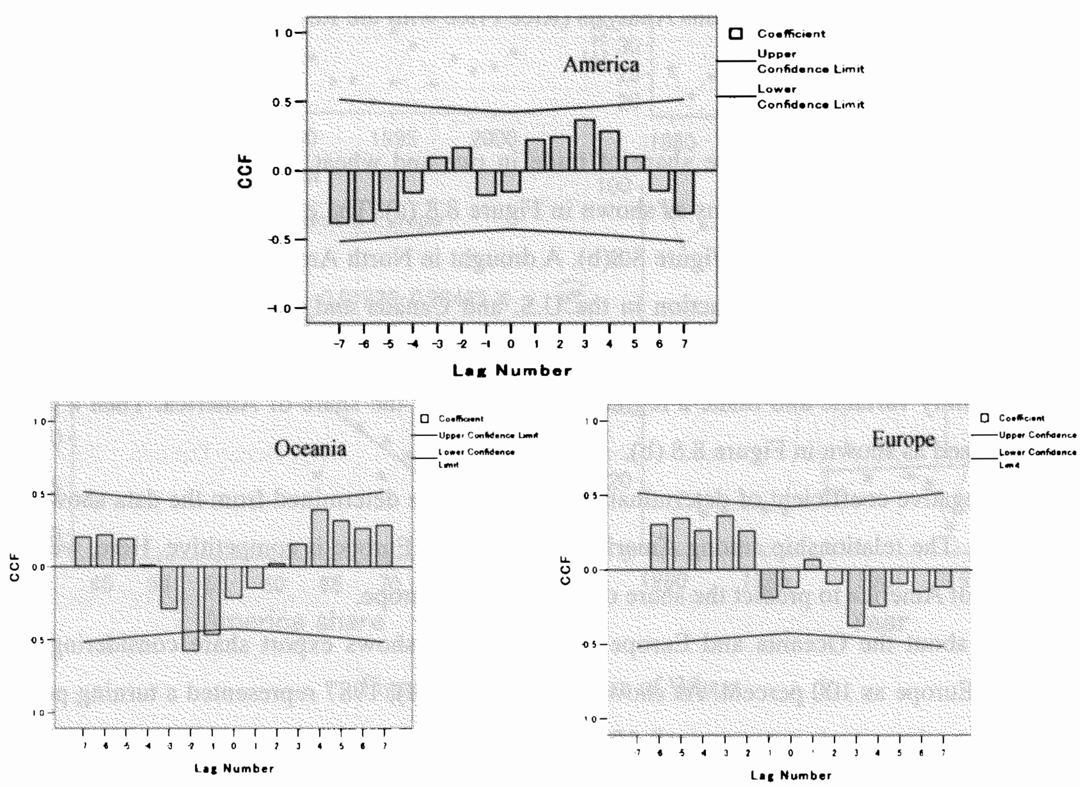

Figure 8.6 Cross-correlations Analysis (Wheat Price with the Residual of Import)

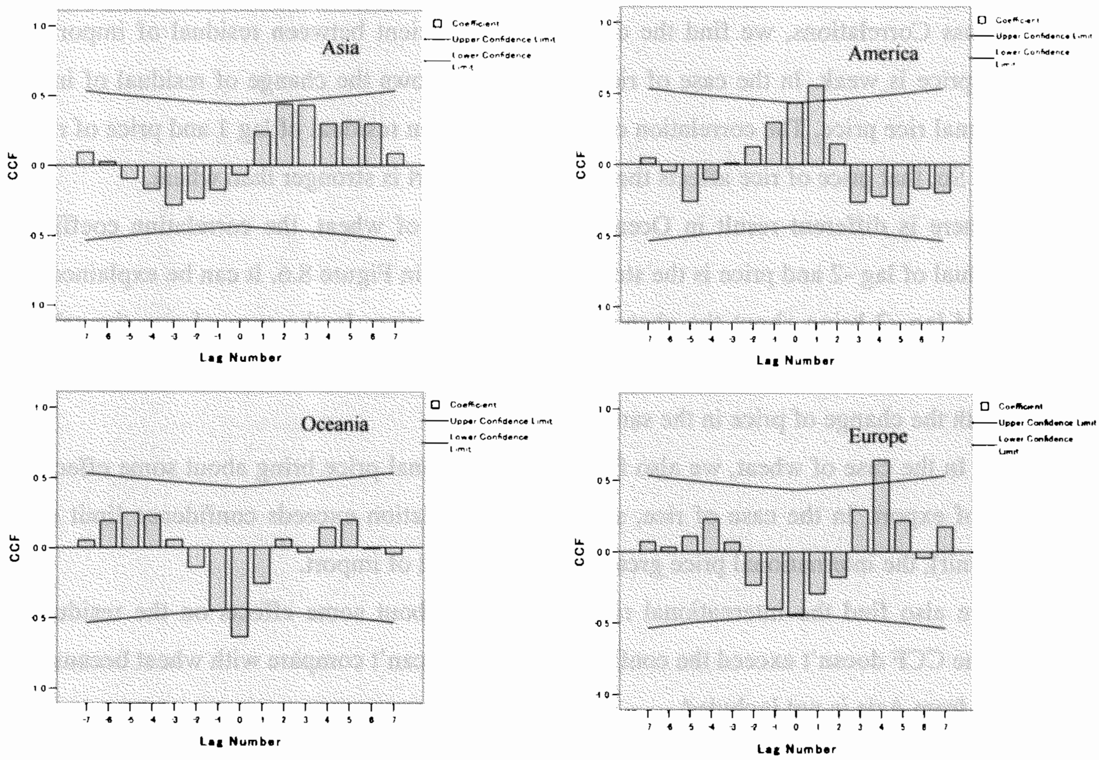

Figure 8.7 Cross-correlations Analysis (Rice Price with the Residual of Import)

8.2.5 Comparison of Trade Share

Following is a comparison of the share of trade in rice and wheat. In the case of wheat, we analyze the share of the three regions as shown in Figure 8.8 (a). The export share from America, Oceania, and Europe are shown in Figure 8.8(b). A drought in North America in 1988 resulted in a significant decrease in wheat production in the U.S. and Canada and, in turn, in a reduction of shipments to Africa. Considering the recovery period of America, we regard the years from 1989 to 1991 as a dummy variable and make a regression analysis for the share of America. Then a good result is obtained as shown in Figure 8.8 (b).

A strong negative coefficient of determination (-0.94) can be determined from the data shown in Figure 8.8 (c). The relationship among America, Oceania, and Europe is competitive. Here, we can use the share of America to predict the share of Oceania and Europe.

Especially about the Oceania and Europe, Figure 8.8 (d) shows export share considering the Oceania and Europe as 100 percent. As shown in Figure 8.8 (d), 1987 represented a turning point; Oceania was an important exporter until 1986, but Europe became the most important exporter after 1987. A competitive relationship also exists between Oceania and Europe. In 1986, the U.S. began to apply the Export Enhancement Program (EEP) to wheat against the wheat exports of the E.U. because the E.U. used agricultural subsidies to expand its exports. Australia was not price-competitive with wheat, and, as a result, exports from Oceania decreased gradually after 1986. Thus, the agricultural policies of the U.S. and the E.U. are also reflected in the wheat trade with Africa. The trend of export share from Europe and Oceania is steady since 1989. Here, we make a regression analysis for two areas. The result of regression is not significant because the P-value (0.685) is bigger than 0.05, only an average tendency can be seen. So, the steady trends in Europe and Oceania are expected to continue.

More rice is grown in Asia and America, and, for that reason, the two areas are analyzed. The exports from Asia are increasing gradually, and those from America are steadily decreasing, as shown in Figure 8.9. We can obtain the trend of the future trade share because a good fit can be achieved using the least squares program.

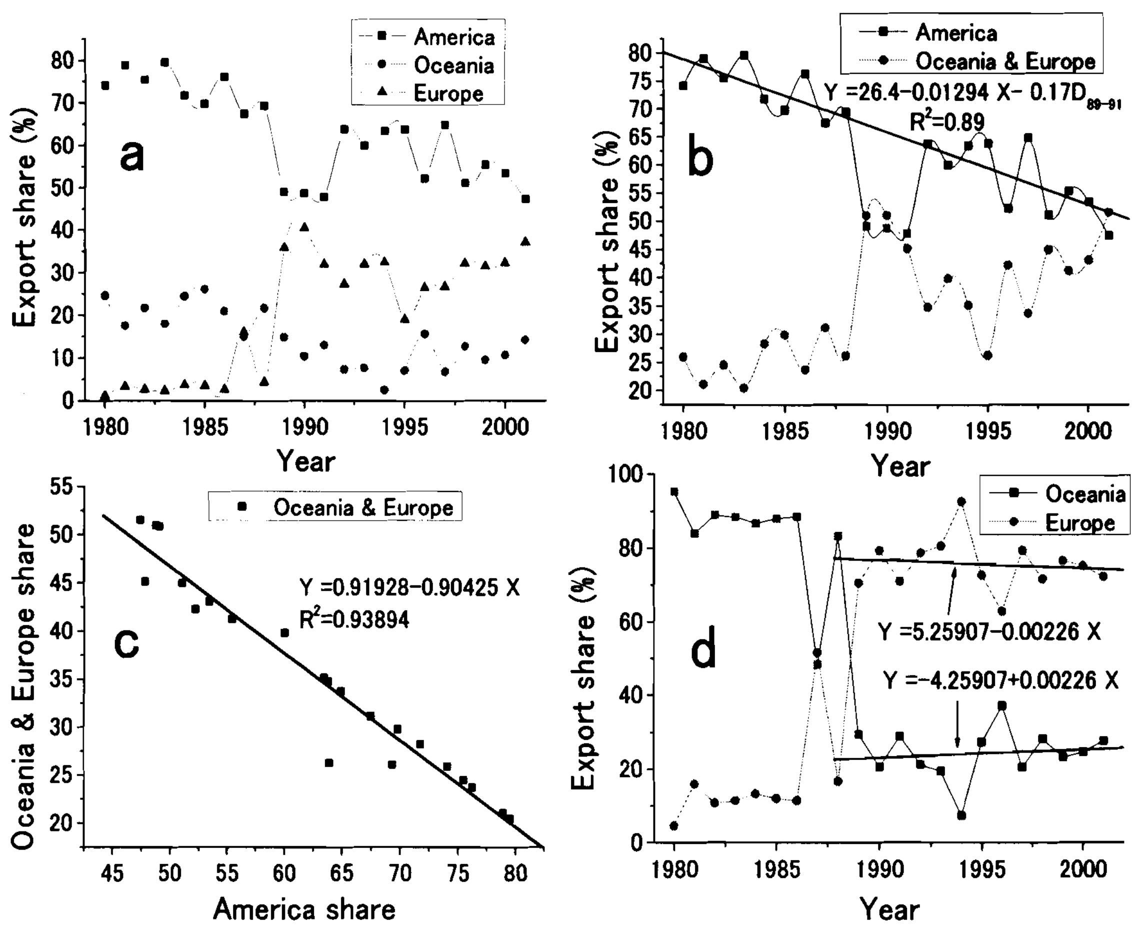

Figure 8.8 Export Share of Wheat

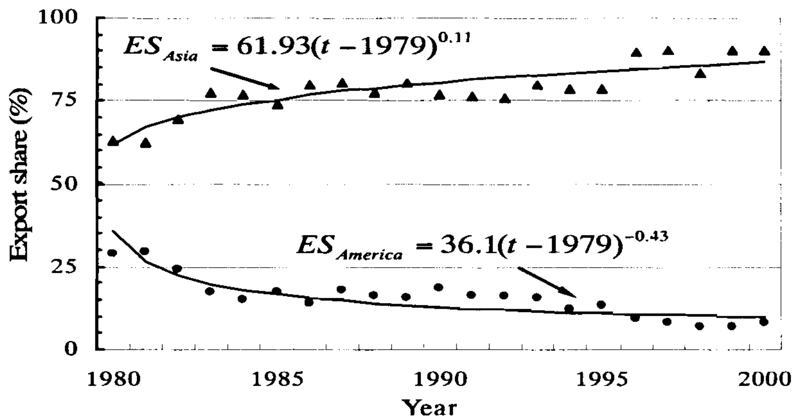

Figure 8.9 Export Share of Rice

8.3 Comparison of Bulk Carriers for Maritime Transportation

8.3.1 Navigation Distance and Selection of Import and Export Ports

We can get the shortest navigation distance and make a selection for the import and export ports using the same way as the wheat. By discussing, as a result, Table 8.1 shows the list of selected ports. Using the selected ports, we obtained the shortest route between the exporting and importing ports.

Table 8.1 List of Selected Ports

Wheat		Rice	
Exporting ports	Importing ports	Exporting ports	Importing ports
Bourgas	Abidjan Algiers Assab	Bombay	Algers Abidjan
Buenos Aires	Alexandria Banjul	Buenos Aires	Alexandria Banghazi
Constantza	Cotonou Casablanca	Dalian	Banjul Bissau
Gdynia	Dakar Djibouti	Karachi	Cape Town Casablanca
Klaipeda	Dar es Salaam East	Krung Thep	Conakry Cotonou Dakar
Koper	London Freetown	Montevideo	Dar es Salaam
Manzanillo	Lobito Lome Douala	New Orleans	Djibouti Douala Durban
Montevideo	Libreville Lagos	Osaka	Freetown Libreville
New Orleans	Tripoli Maputo	Rangoon	Lobito Lome Malabo
Novorossiysk	Monrovia Mogadishu	Sai Gon	Maputo Massawa Matadi
Odessa	Mindelo Matadi		Mogadishu Mombasa
Riga	Mombasa Nouadhibou		Monrovia Nouadhibou
Rotterdam	Walvis Bay Pointe		Pointe Noire Port Harcourt
Sydney	Noire Port Louis		Port Louis Port Sudan
Vancouver	Port Sudan Takoradi		Takoradi Taomasina Tunis
	Tunis Toamasina		Walvis Bay

8.3.2 Model Specifications for Forecasting the Required Bulk Carriers

After making a port selection for import and export and calculating the transport distance of wheat and rice by using the O-D data, we built a model to predict how many ships are necessary for maritime transportation of wheat and rice for Africa. The model is as follows:

$$D_{ij} = \frac{d_{ij}}{v \times 24} \times 2 + D_{ED} + D_{LU} \quad (1)$$

$$N_{ij} = \frac{365 \times 0.95}{D_{ij}} \quad (2)$$

$$TS_{ij} = \frac{W_{ij}}{DWT \times N_{ij}} = \frac{W_{ij}d_{ij} + W_{ij} \times 72v}{DWT \times 4161v} = \frac{W_{ij}d_{ij} + W_{ij}A}{B} \quad (3)$$

Here, the navigation days of a vessel are considered as 95% of 365. A=72v, B=DWT×4161v; i: exporter; j: importer. D_{ij} is the number of days required for a round trip from i to j; d_{ij} is the distance from i to j (miles); v is the speed of the grain bulk carrier (miles/hour); D_{ED} is the number of days required for entering and departing ports in one round trip (3 days); D_{LU} is the number of days required for loading and unloading in ports in one round trip (3 days); N_{ij} is the number of annual voyages of i and j; TS_{ij} is the number of ships for i and j; W_{ij} is the trade from i to j (tons); DWT is the dead weight tonnage of a grain bulk carrier. Based on this model, the required number of grain bulk carriers can be predicted from the maritime tons and maritime ton-miles.

8.3.3 Estimation Method and Results

First, we discuss the estimation method. When we predict the maritime tons, we consider the volume of import as the volume of maritime transportation. We can estimate the import in the future by the trade share trend because a good fit can be applied using the least squares program after obtaining the shortage of Africa. The estimated equations are as follows:

Table 8.2 Estimated Equations

Wheat	Rice
$P_{Africa} = 0.29t - 569.6 \quad R^2 = 0.81$ (4)	$P_{Africa} = 0.31t - 596.3 \; R^2 = 0.90$ (21)
$S_{Africa} = 0.07POP - 8.7 \quad R^2 = 0.99$ (5)	$S_{Africa} = 0.04POP - 4.9 \; R^2 = 0.98$ (22)
$DEF_{Africa} = P_{Africa} - S_{Africa}$ (6)	$DEF_{Africa} = P_{Africa} - S_{Africa}$ (23)
$ES_{America} = 26.4 - 0.01294t - 0.17D_{89-91} \quad R^2 = 0.89$ (7)	$ES_{Asia} = 61.93(t-1979)^{0.11} \; R^2 = 0.76$ (24)
$ES_{Europe\&Oceania} = 0.91928 - 0.90425ES_{America} \quad R^2 = 0.94$ (8)	$ES_{Africa} = 36.1(t-1979)^{-0.43} \; R^2 = 0.71$ (25)
$ES_{Europe} = 5.25907 - 0.00226t$ (9)	$W_{Asia} = DEF_{Africa} \cdot ES_{Asia} / 100$ (26)
$ES_{Oceania} = -4.25907 + 0.00226t$ (10)	$W_{America} = DEF_{Africa} \cdot ES_{America} / 100$ (27)
$W_{America} = DEF_{Africa} \cdot ES_{America} / 100$ (11)	$Wd_{Asia} = 7693 \cdot W_{Asia} (i = 1 \sim 7) \; R^2 = 0.9619$ (28)
$W_{Europe} = DEF_{Africa} \cdot ES_{Europe\&Oceania} \cdot ES_{Europe} / 100$ (12)	$Wd_{America} = 6041 \cdot W_{America} (i = 8 \sim 10) \; R^2 = 0.9968$ (29)
$W_{Oceania} = DEF_{Africa} \cdot ES_{Europe\&Oceania} \cdot ES_{Oceania} / 100$ (13)	$TS_{Asia \to Africa} = \frac{1}{B} \sum_{i=1}^{7} \left(\sum_{j=1}^{35} W_{ij} d_{ij} + A \sum_{j=1}^{35} W_{ij} \right)$ (30)
$Wd_{America} = -5825 + 7219W_{America} \quad R^2 = 0.9825$ (14)	$TS_{America \to Africa} = \frac{1}{B} \sum_{i=8}^{10} \left(\sum_{j=1}^{35} W_{ij} d_{ij} + B \sum_{j=1}^{35} W_{ij} \right)$ (31)
$Wd_{Europe} = 40 + 2842W_{Europe} \quad R^2 = 0.98969$ (15)	$TS_{Africa} = TS_{Asia \to Africa} + TS_{America \to Africa}$ (32)
$Wd_{Oceania} = 148 + 8059W_{Oceania} \quad R^2 = 0.9917$ (16)	
$TS_{Europe \to Africa} = \frac{1}{B} \sum_{i=1}^{9} \left(\sum_{j=1}^{49} W_{ij} d_{ij} + A \sum_{j=1}^{49} W_{ij} \right)$ (17)	
$TS_{America \to Africa} = \frac{1}{B} \sum_{i=10}^{14} \left(\sum_{j=1}^{49} W_{ij} d_{ij} + A \sum_{j=1}^{49} W_{ij} \right)$ (18)	
$TS_{Oceania \to Africa} = \frac{1}{B} \sum_{i=15}^{15} \left(\sum_{j=1}^{49} W_{ij} d_{ij} + A \sum_{j=1}^{49} W_{ij} \right)$ (19)	
$TS_{Africa} = TS_{Europe \to Africa} + TS_{America \to Africa} + TS_{Oceania \to Africa}$ (20)	

Here, P: production; S: supply; t: year; POP: population (UN 2004) in Africa. DEF_{Africa} is the deficit volume in Africa. ES is the export shares (%), W is the export volume, and Wd is the transportation distance.

When we predict the maritime ton-miles, we analyze the relationship between the transportation ton and ton-miles in Figure 8.10 In the case of wheat, the coefficient of determination is more than 0.98 in Figure 8.10 (a-c), and, in the case of rice, the coefficient of determination is more than 0.96 in Figure 8.10 (d); therefore, strong correlations can be seen.

Because all conditions of prediction are satisfied, we make a long-time forecast until 2020. By using 60,000 DWT grain bulk carriers and considering the speed as the 10 nautical miles/hour, we make a case study. The required number of grain bulk carriers can be predicted from these equations by the extrapolation of regression analysis. The predicted results are shown in Table 8.3.

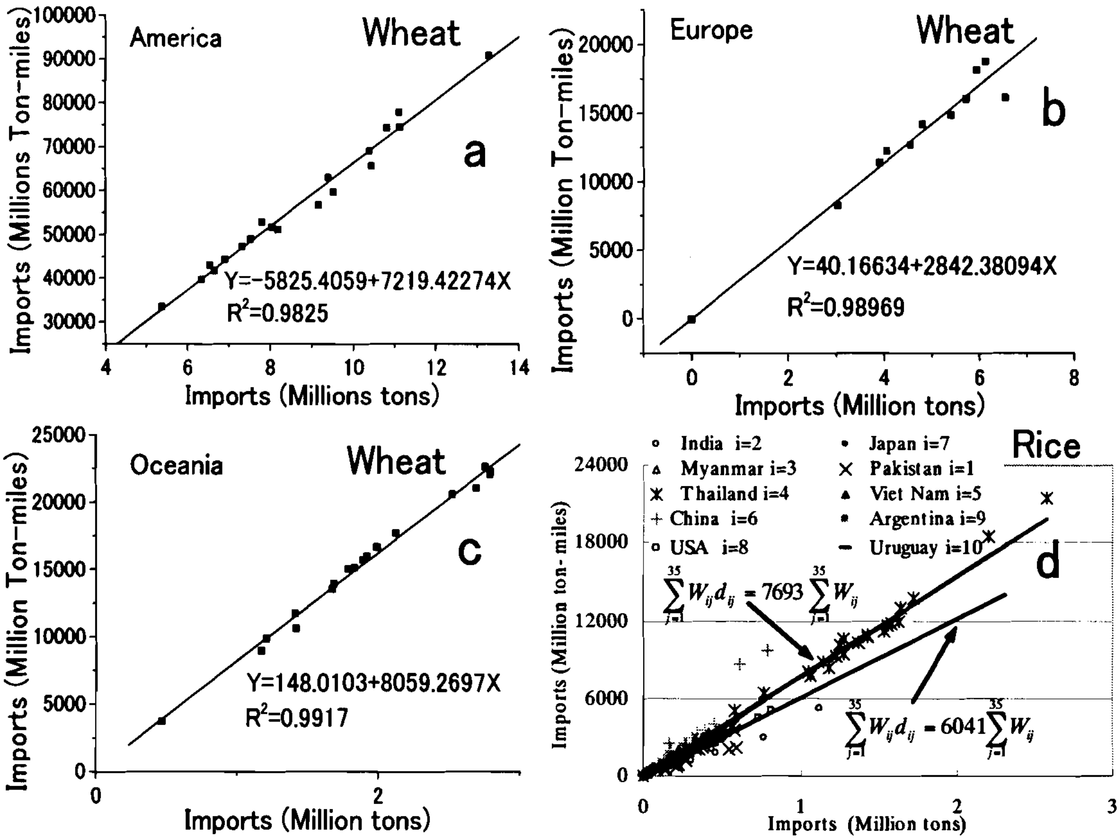

Figure 8.10 Relationship between Transportation Tons and Ton-miles

Table 8.3 Predicted Number of Bulk Carriers Needed

	Wheat				Rice		
Year	America	Oceania	Europe	Total	Asia	America	Total
2005	47	15	17	79	20	2	22
2010	46	21	21	89	26	2	28
2015	45	28	27	99	31	2	33
2020	41	36	33	109	39	2	41

8.4 Conclusions

The results are summarized as follows:

1. The production and supply of wheat is worldwide; rice is the favored grain in Asia.
2. The international market of rice is thin market.
3. The import trend of wheat has suddenly changed; on the other hand, the import trend of rice is generally regular in Africa.
4. We use a different method to predict the imports of wheat and rice for Africa because their trade features are different. In particular, regarding wheat, trade is greatly affected by various policies.
5. A model is built to estimate the number of bulk carriers for wheat and rice in Africa.
6. We find a strong correlation between the maritime transportation tons and ton-miles. Little change in the importers and exporters is seen.
7. Since change of wheat trade significantly depends on agricultural policy, prediction of wheat trade is more difficult than rice. And the change of the number of bulk carriers for wheat is larger than that for rice.

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Chapter 9 Conclusions

Wheat is the principal food for about half of the world's population. In recent years, it is well known that the trade volume of wheat has occupied half of the grain trade volume. Therefore, research on wheat is very important. Especially in Asia and Africa, the present agricultural condition is dangerous. Starvation frequently happens in many countries. The cause of starvation is often considered to be the explosive growth of the population in these countries. However, climatic aberration, civil war, the depression of national economies, and the failure of economic policy in the world economy system are also important factors. In other words, the cause is composed of various complex factors, such as natural, social, and political factors. As a result, food shortages are very serious for people.

As an important chain of global business activities, maritime transportation is strongly influenced by world economy and global trade. However, little research has been done on the maritime transportation of grain in the world.

In this study, from the viewpoints of cargo creation and environmental problem, we analyze the maritime transportation and logistics systems of wheat including maritime Ton, Ton-Miles, trade value, number of bulk carriers needed and emissions of CO_2 in the transportation using the trade flow data. We believe that this research is very useful for the maritime transportation of wheat in the future. The major findings obtained are summarized as follows.

In chapter 3, we analyze the population predictions, population changes and population growth rate according to the UN's data. The factor of population increasing is clearly shown. We found that:

1. A steep increase in the global population is expected, mostly in Asia and Africa.
2. An important point is that the change of population in Africa will exceed the change of Asia and become No.1 after 2030.
3. The population growth rate will decrease in every region; the negative growth rate in Europe is significant.
4. The cause of population explosion comes from the decline of death rate.

In chapter 4, we examine the production, supply of wheat on the basis of the continental method and analyze the factors that affect the production and supply. Using the continental method, we can obtain the volumes of wheat shortage, surplus wheat shortage. After discussing the relations between the import, shortage and volume of maritime transportation, the requirements for maritime transportation of wheat are investigated and estimated in the future. We found that:

1. Until now, although country-by-country predictions are often researched, they are hard to be

estimated. In this chapter, we deal with the wheat problem by the continental method and good continent-by-continent results were obtained. The accuracy of the model and the reliability of the results were high.

2. Using populations or years as a variable, a high correlation is obtained, especially in the shortage areas; therefore, it is possible to estimate wheat production and supply.
3. A continental presumed model of wheat production and supply with food shortages was built.
4. Sufficient wheat to support the growing population can be secured.
5. We deduced a new method to estimate the maritime transportation of the future. In other words, we discovered a high correlation between the shortage and the import volume. Therefore, the shortage can be used to estimate the maritime transportation.

Chapter 5 proposes a trade flow analysis of wheat. First of all, we conduct the trade flow data of across section using programming. Secondly, we analyze the Asian wheat's import by panel data. Finally, the share analysis of the international wheat export market is discussed. We found that:

1. A negative correlation among surplus areas is obtained for the market share of wheat.
2. Using the program EXCEL VBA, we build the OD tables in the Asia and Africa.
3. By the panel data analyses, we find that the import of wheat dependents on the population and GDP of Asian countries.

In chapter 6, the maritime transportation and logistics systems of wheat are analyzed for Asia. Firstly we analyze the Asian trade condition of wheat. Secondly from the import condition of Asia, we can make a decision which port can be used as importing ports and exporting ports based on investigating wheat exporting ports of others' countries and wheat importing ports of Asian countries. So the navigation distance between the exporting ports and importing ports can be calculated. Finally, we analyze the maritime transportation and logistics systems of wheat in Asia including maritime Ton, Ton-Miles, trade value, number of bulk carriers needed and emissions of CO_2 in the transportation. In addition, the effect coming from the international price of wheat is analyzed by Cross-correlations. We found that:

1. We analyzed the panel data of Asian trade and developed an analyzing system for maritime transportation and logistics of Asia including maritime Ton, Ton-Miles, trade value, number of bulk carriers needed and emissions of CO_2 in the maritime transportation.
2. We find the coefficient of determination is high between the ports' depths and the DWT of bulk carriers.
3. A strong correlation between the tons and ton-miles can be concluded. The information was valuable for predicting the appropriate number of required ships.
4. The model was built to estimate the number of grain bulk carriers needed for wheat.

5. The international price greatly effects the change of export share's residual by cross correlation.
6. The speculation exists in the wheat marketing.

In chapter 7, we analyze maritime transportation and logistics systems of wheat to Africa from maritime Ton, Ton-Miles, trade value, number of bulk carriers needed and emissions of CO_2 in the transportation. After an analysis of the wheat transportation, we find that the agricultural policies greatly affect the wheat transportation to Africa. Then, using two scenarios, we predict how many ships are necessary for the maritime transportation of wheat to Africa in the future. We found that:

1. We analyzed the panel data of African trade and developed an analyzing system of the maritime transportation and logistics of wheat, which includes the maritime tons, ton-miles, trade value, number of bulk carriers needed and emissions of CO_2 in the maritime transportation.
2. We found that there was a competitive relationship among the EU, Canada, and the USA.
3. We also found a strong correlation between the tons and ton-miles in Africa. The information was valuable for predicting the appropriate number of required ships.
4. We created two scenarios for predicting the imports in Africa, but could not determine which scenario would actually happen in the future because the agricultural trade is greatly affected by various policies.

In chapter 8, a comparative study is undertaken on maritime trade of wheat and rice destined for Africa. For comparison, firstly, the feature of production and supply becomes clear. Secondly, trade feature is also discussed. Moreover, we show that agricultural policies significantly affect the transportation of wheat to Africa. On the other hand, we show that the export of rice to Africa is a regular trend. Finally, based on the comparison of trade, we predict the number of maritime bulk carriers of wheat and rice for Africa. In addition, the effect coming from the international price of wheat and rice is also discussed. We found that:

1. The production and supply of wheat is worldwide; rice is the favored grain in Asia.
2. The international market of rice is thin market.
3. The import trend of wheat has suddenly changed; on the other hand, the import trend of rice is generally regular in Africa.
4. We use a different method to predict the imports of wheat and rice for Africa because their trade features are different. In particular, regarding wheat, trade is greatly affected by various policies.
5. A model is built to estimate the number of bulk carriers for wheat and rice in Africa.
6. We find a strong correlation between the maritime transportation tons and ton-miles. Little

change in the importers and exporters is seen.

7. Since change of wheat trade significantly depends on agricultural policy, prediction of wheat trade is more difficult than rice. And the change of the number of bulk carriers for wheat is larger than that for rice.

Subject of Future Investigation

In modern society, we must respond collectively to the challenges of climate change, globalization and bioenergy, etc. In the future investigation, as shown in Figure 9.1, we could employ some approach (such as social engineering, economic engineering and management engineering, etc.) to deal with decision-making, forecasting and causal relationship among the environment, food and logistics so as to build the Environment-conscious Maritime Transportation and Logistics Systems of Food.

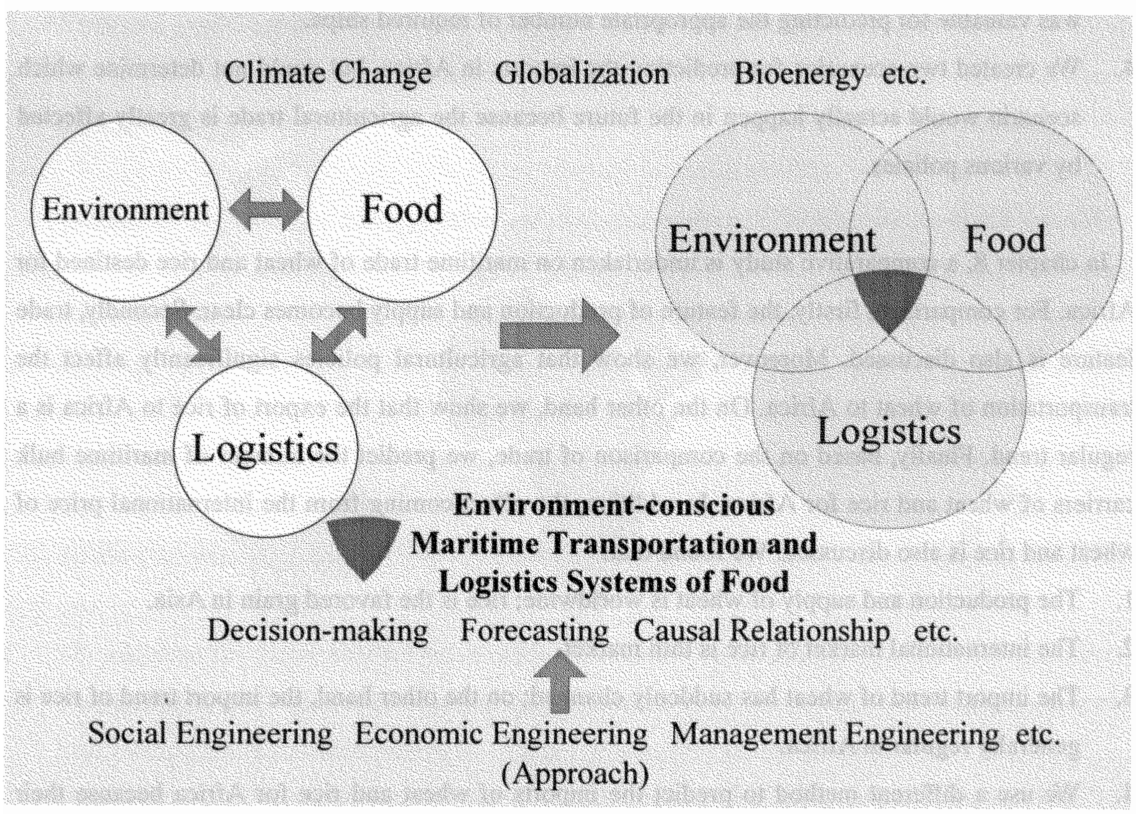

Figure 9.1 Subject of Future Investigation

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List of Publications (With Referee)

Journal articles

① Kubo, M, and Xie, Jingci. 2006. "A Continental Method for Estimating the Supply and Import/Export of Wheat" Journal of Food Distribution Research 37(3). P12-28.

② Xie, Jingci, and Kubo, M. 2007. "A Continental Method for Estimating Wheat Production, Supply and Maritime Transportation" Journal of Food Distribution Research 38(1). P182-195.

③ Xie, Jingci, and Kubo, M. 2007. "Research on Wheat Maritime Transportation System in Asia" Journal of Logistics and Shipping Economics.No.41.P105-114. (In Japanese).

④ Xie, Jingci, and Kubo, M. 2008. "Comparative Research on the Trade and Bulk Carriers of Wheat and Rice for Maritime Transportation to Africa" Journal of Japan Institute of Navigation, No. 118, P237-243.

⑤ Xie, Jingci, and Kubo, M. 2008. "A Forecasting Model of Required Number of Wheat Bulk Carriers for Africa" Ocean Economics Review of China, (In press).

Conference papers

⑥ Kubo, M, and Xie, Jingci. 2006. "A Continental Method for Estimating the Volumes of Maritime Transportation of Wheat." International Association of Maritime Economists Annual Conference Proceedings. CD-ROM. July.

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Appendix A

O-D Cross Section Data Program (Using EXCEL Visual Basic for Applications)

```
Public Sub CreateOD_Data()

'定数及び変数を定義する
Const FirstYear = "1980"
Const LastYear = "1998"
Const SpecialStr = "Country,Item,Element"
Const MaxColumn = 30
Const MaxRow = 300
Const FromCountryColNO = 1  'ゼロから始まる
Const ToCountryColNO = 4    'ゼロから始まる
Const FirstYearColNO = 7    'ゼロから始まる

Dim FromCountry(), ToCountry() As String
Dim iRow, iCol, i, iCount, iYear As Integer
Dim MaxFromCountry, MaxToCountry As String
Dim OD_Data As Long
Dim IsExist As Boolean


'すべての出発国と目的国を取得する
Sheets("Asia and Africa O-D data").Select
With Range("A1")

    ReDim FromCountry(MaxRow), ToCountry(MaxRow)

    '出発国を取得
    iCount = 0
    For iRow = 0 To MaxRow

        IsExist = False
        For i = 0 To MaxRow
            If FromCountry(i) = Trim(.Offset(iRow, FromCountryColNO).Value) Then
```

```
            IsExist = True
        End If
    Next i

    If IsExist = False _
       And Trim(.Offset(iRow, FromCountryColNO).Value) <> "" _
       And InStr(1, SpecialStr, Trim(.Offset(iRow, FromCountryColNO).Value)) = 0 Then
        FromCountry(iCount) = Trim(.Offset(iRow, FromCountryColNO).Value)
        iCount = iCount + 1
    End If

Next iRow

MaxFromCountry = iCount - 1

'目的国を取得
iCount = 0
For iRow = 0 To MaxRow

    IsExist = False
    For i = 0 To MaxRow
        If ToCountry(i) = Trim(.Offset(iRow, ToCountryColNO).Value) Then
            IsExist = True
        End If
    Next i

    If IsExist = False _
       And Trim(.Offset(iRow, ToCountryColNO).Value) <> "" _
       And InStr(1, SpecialStr, Trim(.Offset(iRow, ToCountryColNO).Value)) = 0 Then
        ToCountry(iCount) = Trim(.Offset(iRow, ToCountryColNO).Value)
        iCount = iCount + 1
    End If

Next iRow

MaxToCountry = iCount - 1
```

```
End With

'年ごとに OD データを作成する
For iYear = CInt(FirstYear) To CInt(LastYear)

    'OD データ保存用のデータシートを作成する
    Sheets.Add
    ActiveSheet.Name = CStr(iYear)

    '出発国と目的国をシートに書き込み
    With Sheets(CStr(iYear)).Range("A1")
        '出発国をシートに書き込み
        For i = 0 To MaxFromCountry
            .Offset(i + 1, 0).Value = FromCountry(i)
        Next i

        '目的国をシートに書き込み
        For i = 0 To MaxToCountry
            .Offset(0, i + 1).Value = ToCountry(i)
        Next i
    End With

    'OD データを検索して、シートへ記入する
    With Sheets(CStr(iYear)).Range("A1")
        For iRow = 0 To MaxFromCountry
            For iCol = 0 To MaxToCountry
                strOD_Data = ""
                OD_Data = 0

                'OD データを検索する
                For i = 0 To MaxRow
                    DoEvents
                    If Sheets("Asia O-D data").Range("A1").Offset(i,
FromCountryColNO).Value = FromCountry(iRow) _
                    And Sheets("Asia O-D data").Range("A1").Offset(i,
```

```
ToCountryColNO).Value = ToCountry(iCol) Then
                        If Not Sheets("Asia O-D data").Range("A1").Offset(i, FirstYearColNO + iYear - CInt(FirstYear)).Value = "" Then
                            OD_Data = OD_Data + CLng(Sheets("Asia O-D data").Range("A1").Offset(i, FirstYearColNO + iYear - CInt(FirstYear)).Value)
                            strOD_Data = CStr(OD_Data)
                        End If
                    End If
                Next i

                'OD データをシートへ書き込み
                If Not strOD_Data = "" Then
                    OD_Data = CLng(strOD_Data)
                    .Offset(iRow + 1, iCol + 1).Value = OD_Data
                Else
                    .Offset(iRow + 1, iCol + 1).Value = "-"
                End If

            Next iCol
        Next iRow
    End With

Next iYear

End Sub
```

Appendix B

Distance Table between Imports and Exports Port (Asia)

D	Country	Afghanistan	Azerbaijan,	Bahrain	Bangladesh	Bhutan	Cambodia	China	Cyprus	Georgia	India	Indonesia	Iran, Islam	Iraq	Israel	Japan	Jordan	Kazakhstan	Korea, Dem	Korea, Repub	Kuwait	Kyrgyzstan
O	ports	Karachi	Batumi	Mina Sulman	Chittagong	Chittagong	Phnom penh	Dalian	Limassol	Batumi	Bombay	Surabaya	BANDAR	Basrah	Haifa	Osaka	Aqaba	NOVORO	Chongjin	Busan	Kuwait	karachi
Country	ports	Afghanistan	Azerbaijan,	Bahrain	Bangladesh	Bhutan	Cambodia	China	Cyprus	Georgia	India	Indonesia	Iran, Islam	Iraq	Israel	Japan	Jordan	Kazakhstan	Korea, Dem	Korea, Repub	Kuwait	Kyrgyzstan
EU (15) Excl.Intra-Trade	Rotterdam	6097 *1	3747 *1	6351 *1	7970 *1		8966 *1	10819 *1	3249 *2	3747 *2	6298 *1	8876 *1	6057 *1	6551 *1	3361 *2	10925 *1	3609 *1	3617 *2	11156 *1	10725 *1	6500 *1	6097 *1
Australia	Sydney	6441		7216	5510		4425	4829			5984	3381	6920	7416	8415 *1	4314	8091		4885	4457	7365	
Canada	Vancouver	9823	10710 *3		8426	8426	6746	4974	10212 *3		9367	7067	10310	10009	10324 *3	4432	10572 *1		4455	4481	10757	
United States of America	New Orleans	9301 *1			11174 *1	11174 *1		10026 *3	6453 *2	6951 *2	9502 *1	11625 *3	9261 *1	9755 *1	6565 *2	9413 *3	6813 *1			9533 *1	9704 *1	9301 *1
Hungary	koper		1734		5986 *1			8835 *1	1246		4314 *1	6892 *1	4073 *1	4567 *1	1359		1625 *1			8741 *1		
Lithuania	Klaipeda		4615 *2																			
Russian Federation	NOVOROSSIYSK								1148	249					1272					8693 *1		
Ukraine	Odessa		565						1034	565	4152 *1				1158		1463 *1		9027 *1	8579 *1		
Argentina	Buenos Aires				9185 *4			11426 *5	7177 *2	7675 *3	8247 *4	9211 *4	8342 *4	8836 *4	7289 *2		7537 *1			11002 *5	8785 *4	
Bulgaria	Bourgas				5608 *1				818													
Mexico	Manzanillo				10229																	
Panama	Balboa				10972 *1															8041		
Romania	Constantza				5678 *1				888	588					1012							
Poland	Gdynia							11632 *1							4174 *2					11538 *1		
Romania	Constantza							8527 *1									1317 *1			8433 *1		
Uruguay	Montevideo							11329 *5														
Brazil	santos															11436 *4						
Peru	Callao															8684						
Bulgaria	Bourgas																1247 *1			8363 *1		
Slovenia	koper																			8741 *1		
Colombia	Barranquilla																					
Norway	Stavanger																					
Croatia	Rijeka																					
Paraguay	Montevideo																					

D	Country	Lebanon	Malaysia	Mongolia	Myanmar	Nepal	Oman	Pakistan	Philippines	Qatar	Saudi Ara	Singapore	Sri Lanka	Syrian Arab	Tajikistan	Thailand	Turkey	Turkmenis	United Arab	Uzbekistan	Viet Nam	Yemen
O	ports	Beirut	Penang	dalian	yangon/rangoo	Chittagong	Port sultan q	karachi	Manila	Doha	Jeddah	Singapore	Colombo	tartous	karachi	Bangkok	Istanbul	karachi	KHOR FA	karachi	SaiGon/Hu	Aden
Country	ports	Lebanon	Malaysia	Mongolia	Myanmar	Nepal	Oman	Pakistan	Philippines	Qatar	Saudi Ara	Singapore	Sri Lanka	Syrian Arab	Tajikistan	Thailand	Turkey	Turkmeni	United Arab	Uzbekistan	Viet Nam	Yemen
EU (15) Excl.Intra-Trade	Rotterdam	3365 *2	7964 *1	10819 *1	7926 *1	7970 *1		6097 *1	9541 *1		3978 *1	8251 *1	6730 *1	3369 *2	6097 *1		3161 *2	6097 *1	5971 *1	6097 *1	8849 *1	4648 *1
Australia	Sydney	8474 *1	4390		5119	5510	6687	6441	3696	7141	7548	4041	5134	8523 *1		4594	9032 *1		6837		4114	6875
Canada	Vancouver	10328 *3	7306			8426	10084	9823	5831		10941 *1	6955	8507	10332 *3		6970	10124 *3		10234	9823	6427	10561
United States of America	New Orleans	6569 *2	11168 *1	10026 *3		11174 *1	9025 *1	9301 *1	10794 *3	9480 *1	7182 *1	11455 *1	9934 *1	6573 *2	9301 *1	11980 *3	6365 *2	9301 *1	9175 *1	9301 *1	11437 *3	7852 *1
Hungary	koper	1363						4113 *1									1148			4113 *1		2664 *1
Lithuania	Klaipeda																					
Russian Federation	NOVOROSSIYSK																456					
Ukraine	Odessa	1152	5818 *1					3951 *1	7395 *1								342	3951 *1				
Argentina	Buenos Aires	7293 *1	8963 *4					8327 *4			7906 *1	9245 *4	8021 *4	7297 *1		10004 *4	7089 *2		8256 *4			7587 *4
Bulgaria	Bourgas																					
Mexico	Manzanillo																					
Panama	Balboa																					
Romania	Constantza																196					
Poland	Gdynia		8777 *1								4791 *1											5461 *1
Romania	Constantza	1006						3805 *1														
Uruguay	Montevideo																6992 *2					
Brazil	santos																					
Peru	Callao																					
Bulgaria	Bourgas							3735 *1						922			126					
Slovenia	koper																	4113 *1				
Colombia	Barranquilla							8763 *1														
Norway	Stavanger							6480 *1														
Croatia	Rijeka																1112					
Paraguay	Montevideo																6992 *2					

(Note):*1:Via Suez, *2:Via Gibraltar, *3:Via Panama, *4:Via Good Hope, *5:Via Magellan

Appendix C

Distance Table between Imports and Exports Port (Africa)

D	Country	Algeria	Angola	Benin	Botswana	Burkina Fas	Burundi	Cameroon	Cape Verde	Central Africa	Chad	Congo, Dem Re	Congo, Repu	C?te d'Ivoire	Djibouti	Egypt	Eritrea	Ethiopia	Ethiopia, Forme	Gabon	Gambia	Ghana	Kenya	Lesotho	Liberia	Libyan Arab Jamahiriya
O	ports	Algiers	Lobito	cotonou	Walvis Bay	Takoradi	Dar es Salaam	Douala	Mindelo	Douala	Douala	Matadi	Pointe Noire	Abidjan	Djibouti	Alexandria	Assab	Djibouti	Djibouti	Libreville	Banjul	Takoradi	Mombasa	East London	Monrovia	Tripoli
Country	ports	Algeria	Angola	Benin	Botswana	Burkina Fas	Burundi	Cameroon	Cape Verde	Central Africa	Chad	Congo, Dem Re	Congo, Repu	C?te d'Ivoire	Djibouti	Egypt	Eritrea	Ethiopia	Ethiopia, Forme	Gabon	Gambia	Ghana	Kenya	Lesotho	Liberia	Libyan Arab Jamahiriya
EU (15) Excl.In	Rotterdam	1773 *2	5110	4112	5545	3861	6353 *1	4550	2565	4550	4550	4924	4791	3730	4620 *1	3159 *2	4517 *1	4620 *1	4620 *1	4545		3861	6215 *1	6686 *4		2435 *2
Argentina	Buenos Aires	5701 *2	4117	4254	3808			4501	3782			4338			7699 *4	7087 *2						4016	6157 *4		3699	6363 *2
Australia	Sydney				7368 *4	9259 *4										8402 *1		6987	6987				6474	6194		9233 *1
Canada	Vancouver	8736 *3	9826 *3	8973 *3	10038 *3	8722 *3		9403 *3			9403 *3	9740 *3		8591 *3	10673	10122 *3	10699	10673	10673	9407 *3		8722 *3	10928	10935 *4		9398 *3
United States of	New Orleans	4977 *2	6622	5699	6899	5448	9557 *1	6129			6129	6507	6377	5317	7824 *1	6363 *2	7721 *1	7824 *1	7824 *1	6124	4376		9419 *1	7823 *4	4858	5639 *2
Hungary	koper	1236														1187										912
Mexico	Manzanillo	4424 *2																								
Romania	Constantza	1580																					3923 *1			1144
Ukraine	Odessa	1726														1064										
Poland	Gdynia		5923																							
Bulgaria	Bourgas																									
Latvia	Riga																									
Russian Federat	NOVOROSSIYSK																									
Uruguay	Montevideo																									
Lithuania	Klaipeda																									

D		Madagascar	Malawi	Mali	Mauritania	Mauritius	Morocco	Mozambique	Namibia	Niger	Nigeria	Rwanda	Senegal	Sierra Leone	Somalia	South Afric	Sudan	Swaziland	Tanzania, Unite	Togo	Tunisia	Uganda	Zambia	Zimbabwe
O		toamasina	Dar es Salaam	Dakar	Nouadhibou	Port Louis	Casablanca	Maputo	Walvis Bay	cotonou	Lagos	Dar es Salaam	Dakar	Freetown	Mogadishu	East London	Port Sudan	Maputo	Dar es Salaam	lome	Tunis	Mombasa	Dar es Salaam	Maputo
Country	ports	Madagascar	Malawi	Mali	Mauritania	Mauritius	Morocco	Mozambique	Namibia	Niger	Nigeria	Rwanda	Senegal	Sierra Leone	Somalia	South Afric	Sudan	Swaziland	Tanzania, Unite	Togo	Tunisia	Uganda	Zambia	Zimbabwe
EU (15) Excl.In	Rotterdam	6818 *1	6353 *1	2582	2224	6961 *1	1386	7211 *4	5545	4112	4171	6353 *1	2582	3070	5712 *1	6686 *4	4036 *1	7211 *4	6353 *1	4059	2155 *2	6215 *1	6353 *1	7211 *4
Argentina	Buenos Aires				4171	5078	5149	4726 *4			4304		3859	3706		4201 *4	7964 *1		5998 *1		6083 *2		5998 *4	4726 *4
Australia	Sydney	5520	6392				10346 *1	6116	7368 *4		9229 *4				6410	6194	7509		6392		9406 *1	6474	6392	6116
Canada	Vancouver			7688 *3	7710 *3		8329 *3	11460 *4		8973 *3	9032 *3	10973	7688 *3		10533	10935 *4	10999 *1	11460 *4	10973	8920 *3	9118 *3	10928	10973	11460 *4
United States of	New Orleans	9364 *4	9557 *3	4304	4246	9575 *4	4498	8348 *4	6899	5699	5758	9557 *1	4304	4672	8916 *1	7823 *4	7240 *1	8348 *4	9557 *1	5646	5359 *2	9419 *1	9557 *1	8348 *4
Hungary	koper						1831 *2			4679 *2				3633 *2			2052 *1	5574 *1			917			
Mexico	Manzanillo																				6836 *3			
Romania	Constantza						2183 *2				5090 *2						1744 *1				1238			
Ukraine	Odessa																				1384			
Poland	Gdynia						2199										4849 *1							
Bulgaria	Bourgas						2113 *2																	
Latvia	Riga						2406																	
Russian Federat	NOVOROSSIYSK						2443 *2																	
Uruguay	Montevideo						5052														5986 *2			
Lithuania	Klaipeda																				3023 *2			

(Note):*1:Via Suez, *2:Via Gibraltar, *3:Via Panama, *4:Via Good Hope, *5:Via Magellan