JAPANESE MARKET FOR DIMENSIONAL LUMBER:

A Gravity Model Approach

by

Fumiko Otsuka

B.Sc., Tokyo University of Agriculture

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

THE FACULTY OF GRADUATE STUDIES

Department of Agricultural Economics

We accept this thesis as conforming

to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

April 1992

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Agricultural Economics

The University of British Columbia
Vancouver, Canada

Date Oct 9, 1992

DE-6 (2/88)

ABSTRACT

The research was done using both descriptive and statistical analyses to investigate the Japanese market for dimensional lumber and how this might affect the demand for wood products from British Columbia. The data was collected from various publications obtained in both Japan and Canada.

The descriptive analysis was focused on Japan's domestic forest industry and the Japanese market as lumber importer. The ownership and tenure of Japanese forest land was examined with particular focus on the role of public versus private owners. The financial health of primary operators and owners was also pursued. The level of domestic log and lumber production, prices and uses of timber are identified. Then, the interaction between the Japanese domestic market and the international market for logs and lumber was examined such as activities of major existent importers and the role of trading companies.

The statistical analysis of the demand for dimensional lumber was developed. A commodity specific gravity model was utilized to integrate factors both in the supply and demand sides assuming lumber was differentiated by countries of origin. The underlying theories of the gravity model was first examined for the appropriate specification of the empirical model. The variables were also specified based on the information from the descriptive analysis.

One conclusion was that non-price variables which indicate power relations between importer and exporter, and among exporters have a significant role in lumber trade with Japan; the variables were production capacities, absorption powers and dummy variables for each of the exporters. In contrast, price variables such as export/import prices, exchange rate have only small impacts on the trade flows. Since Japan's needs for lumber are so diversified, consumers

in Japan may choose lumber by their own purpose; prices might be the secondary factor. Finally, as the world's resource market is moving in the direction of sustainable development and resource exporting countries are tightening regulation of their resource export, Japan has been forced to adjust her trade practises.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

I would first like to thank my supervisor, Dr. G.C. van Kooten, for his assistance and guidance throughout my years of study here. Dr. Mary Bohman, a member of my thesis committee, was of particularly great help during my thesis project. As well as Dr. W. R. Wilson who gave me the opportunity to work on this project, I would like to acknowledge all the professors and instructors who advised me to the completion of this thesis. I would like to thank Wood Products Stockpile Corp. in Tokyo as well as the other individuals and organizations which provided materials which contributed to my research.

I also would like to thank the members and staff of the Department of Agricultural Economics, University of British Columbia for their help and particularly Dr. G.C. van Kooten for his financial assistance. A special thanks goes to Mrs. Kathy Shynkaryk and Ms. Retha Gestsmar, secretary, and Ms. Gwynne Sykes, librarian. I would like also to thank all my friends and colleagues who shared their ideas and time.

Finally, my deepest thanks goes to my family whose love and support have never faltered and to whom I will always be grateful.

ANALYSIS OF THE JAPANESE MARKET FOR DIMENSIONAL LUMBER: INSTITUTIONS AND FACTORS AFFECTING DEMAND

1 Introduction

1.1 Background

Exports of B.C. lumber have expanded greatly since the early 1900s, while production growth has been even more dramatic. In 1929, 47.6% of B.C. lumber was exported to foreign countries; in 1989, 80.2% was exported. B.C.'s customers have also changed through the decades. In the 1920s, the major importers were the U.S. and Asian countries such as China and Japan. During that decade, B.C. aggressively promoted its products in Asia and the U.K., and increased the volume of it shipments to these countries. However, shipments to Asia decreased during the 1930s, falling to zero in the World War II period. On the other hand, shipments to the U.K. jumped during World War II and the post-war period due to a building boom; at one time, exports to the U.K. far exceeded those to the U.S. Since the 1960s, the U.S. has become the largest importer of B.C. lumber. In 1989, the U.S. share of B.C. lumber was 44.9%, followed by Japan with a share of 21.0%.

In each case, promotion has played a great part in the expansion of B.C.'s markets and development of new markets. In the past, two major promotions of B.C. wood products to the Japanese market were held. The first promotion took place during the 1920s and, by the end of that decade, Japan developed into B.C.'s largest export market. However, due to WWII, Canada lost the Japanese market, and the U.S. took over as the major exporting country to Japan.

The second promotion took place during the 1970s. This promotion introduced 2x4 construction methods for building houses and captured the interest of the Japanese. As a result, the volume of B.C.lumber exported to Japan expanded. However, in the 1980s, the U.S. carried out a major promotion of its West Coast wood products to Japan. In 1989, the U.S. was the largest exporter of wood products. It supplied 26.3% of total wood products to Japan; however, because of Japan's strong preference for raw materials, the U.S.'s export share of dimensional lumber was 30.7%. On the other hand, despite the fact that Canada's total wood products supply share was only 11.1%, its export lumber share of 38.8% was the largest among lumber exporters. This was due to the efforts of Canadian industrial strategies that promoted exports of finished products, not raw materials.

Currently, Japan is the second largest consumer of B.C. wood products and one of the most potentially profitable markets for B.C.'s dimensional lumber. In 1989, the volume of those exports to Japan was about 10.0% of total shipments and its value was $1,051.2 million: those to the U.S. were 58.4% and $2,387.6 million. As well, British Columbia is the largest supplier of wood products for Japan. The value of exports of all wood products from Canada to Japan was $2,538.2 million, of which $1,065.8 million was for lumber. British Columbia exported 99.8% of all wood products and 98.6% of lumber from Canada to Japan.

Since the demand for B.C. wood products is determined largely by exports, it is important to achieve success in the world wood products market. Consumer oriented marketing and promotion is a key element to making gains in the world market and, consequently, it is essential to precisely analyze the market. This task requires analysis of the following factors:

- market trends,
- the various manufactured products,
- domestic industry,
- foreign suppliers,
- government and industry policies, and
- factors influencing demand for dimensional lumber.

The purpose of the proposed research is to systematically analyze the Japanese wood products market.

1.2 Research Objectives

The overall objective underlying the research proposed here is to find strategies for expanding B.C.'s dimensional lumber exports to Japan. However, this objective is rather broad. Therefore, it is proposed that an initial investigation examine institutional aspects of Japan's role in markets for dimensional lumber. In particular, the following tasks are proposed:

(1) Examine the market structure of Japanese forest and wood products industries. Proposed tasks are to:

(a) identify the current level of Japanese timber harvests, the capacity of Japanese timber production, the species of trees grown in Japan and the capacity for domestic production;

(b) investigate the quantity of timber imported, the exporting countries, the species imported and the end uses of those timber products;

(c) identify the number and size of domestic companies that produce timber and wood products;

(d) analyze the role of the domestic companies participating in the wood products trade;

(e) analyze the role of the trading houses, financial institutions and Japanese government agencies in the international markets;

(f) analyze Canada's role in Japanese markets.

(2) As far as possible, identify the underlying strategies that enable Japan to exercise a strong preference for raw materials in international markets--that is, strategies that inhibit Japanese imports of finished wood products.

(3) Investigate factors influencing the demand for fibre products in Japan. The focus will be on dimensional lumber. The research will:

(a) investigate uses made of timber products;

(b) identify factors affecting the demand for dimensional lumber in Japan; and

(c) identify trends in Japanese use of wood products.

1.3 Research Methodology

The proposed research will use both descriptive and statistical analyses to investigate the Japanese market for dimensional lumber and how this might affect the demand for wood products from British Columbia. Special attention will be paid to data that focus on the Japanese market. The data will be available from publications by:

- Bank of Japan,
- Ministry of Agriculture, Forestry and Fisheries (Economic Affairs Bureau and Forestry

Agency),

- Ministry of Finance, and

- Ministry of International Trade and Industry.

Finally, a demand function for Japanese dimensional lumber will be estimated using standard economic demand theory. The purpose is to identify factors that affect Japanese demand for wood products, specifically dimensional lumber.

1.4 Outline of Study

The outline of the study is as follows. In the next chapter, the ownership and tenure of Japanese forest lands is discussed, with particular focus on the role of public versus private owners. Also considered is the financial health of primary operators and owners, and the management of Japanese forests; for example, who is involved in management and what silvicultural activities are pursued. In that chapter, domestic log production, lumber production, prices and uses of timber are also examined. The focus of Chapter 3 is on the interaction between the Japanese domestic market and the international market for logs and lumber.

In Chapter 4, a theoretical model that is used in the subsequent statistical analysis is developed, and previous relevant research is reviewed. In Chapter 5, the empirical model and variables are specified. Data construction and its source are also addressed, and the estimation results are discussed. Chapter 6 contains the policy analysis that follows from the empirical model. Effects of variables and the interpretation of results is presented. The last chapter provides a summary of the results and conclusions, and suggestions for further research.

2 Japan's Domestic Supply and Demand for Lumber

2.1 Forest Ownership and Management

2.1.1 Land Ownership and Tenure

In Japan, forest lands account for about two thirds of the total land area, or about 24.7 million hectares. Woodlands are divided into two categories: national forests and non-national forests. National forests account for 29.7% of the total forest lands (Figure 2.1) and produced 26.2% of total timber produced in 1989.

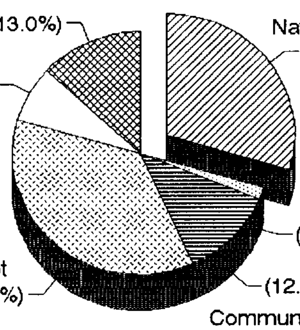

Figure 2.1 Forested Area by Types of Ownership
Source: MAFF, *Reports on Demand and Supply of Wood Products*

Most of the national forests are owned and managed by the Forestry Agency which belongs to the Ministry of Agriculture, Forestry and Fisheries (M.A.F.F.). The remaining 2.5% of national forests are owned by other government agencies such as other sections of M.A.F.F., the Ministry of Finance, and the Ministry of Health and Welfare. In many cases, the management of these forests is entrusted to the Forestry Agency.

In 1989, the area of the national forests was 7,338,000 hectares; 32.7% of the national forests are replanted forests. The major species in the replanted forests are conifer trees such as the Japanese red pine, cedar and cypress which are often referred to as conifer trees. The area replanted to conifer accounts for 97.0% of replanted forests in national forests. In contrast, old-growth forests make up 65.3% of the national forests, but non-conifer trees are the major species. Trees such as oak and beech constitute about 80.6% of the old-growth forest; the area is 3,865,000 hectares.

Ownership, management and operation of the remaining forests (70.3% of the total woodland) take various forms (Table 2.1). Non-national forests consist of three types of forests according to the owners of the woodlands: 1) forests owned by the Forest Development Corporation, which is the equivalent of a crown corporation, 2) communal forests, and 3) private forests.

Table 2.1 Types of Forest Ownership and the Owners

Types of Forest Ownership	owners
national forests	Forest Agency, other governmental agencies
non-national forests	
forests owned by corporation	Forest Development Corporation
communal forests	prefectural bodies, municipal bodies, property wards, cooperatives in local public bodies,
private forests	private woodlot owners, private companies, shrines and temples, habitual joint holdings, union bodies and cooperatives

Source : Association of Agricultural and Forestry Statistics, *Statistical Dictionary of Agriculture, Forestry and Fisheries*, 1988, Tokyo

Of those, the privately-owned forests are the most significant and occupy the largest area. The private forests represent 56.7% of total woodlands or 80.6% of non-national forests. These forests are also the major producers of timber; in 1989, 67.9% of timber in Japan was harvested on private lands, and the proportion has been increasing for several years.

The major organizations of the private forests are a large number of small owners who are often referred to as private woodlot owners. Important decisions regarding not only the method of management and operation, but also whether the forests should be operated to make profits, are made by these private woodlot owners. For example, private owners could manage their forests by themselves, they could entrust the management to a second party such as a forestry cooperative, or they could neglect their forests because they might think management is unprofitable. The same situation is applied to the other organizations that own the non-national forests. Some companies own forests simply as any other assets.

The area in private forests was 13,995,000 hectares in 1989. Out of all private forests, 42.2% are replanted forests. As with the national forests, the majority of trees in the replanted forests are conifer trees, about 98.7% by area. In contrast, in the old-grown forests, 83.3% of forests consist of non-conifer trees.

Communal forests account for 12.1% of total woodlands and 17.2% of non-national forests. These forests are owned by the following four types of organizations:

1) Prefectural bodies are institutions established by the prefectural governments,[1] such as schools and recreation centres;

---

[1]Japan consists of forty seven prefectures. These are similar to provinces, but lack the latter's legislative powers. The structure and powers of prefectural government are closer to those municipal government.

2) municipal bodies are institutions established by the municipal governments;

3) Cooperatives in local public bodies include such groups as a governmental workers' union; and

4) Property wards are areas previously owned by former municipal bodies, but since have been merged and remain as property of the new municipality.

The timber output from communal forests was only 5.6% of total log production in 1989. This is because these forests are operated as demonstration forests by the regions' forest industry or as recreation forests. Some of these forests are also maintained as water sheds for a region's water supply. Some 47.3% of communal forests are replanted forests. The age of stands in replanted forests is relatively old compared to the average age of replanted forests (Forestry Agency, 1990a).

M.A.F.F. distinguishes the forests owned by the Forest Development Corporation from the other non-national forests. The Corporation was established in order to harvest and manage difficult-to-access forest regions (Rinya Jiho, July 1988). The major activities of this corporation are: 1) silviculture in difficult-to-access forest regions, 2) building logging roads, 3) construction of water shed forests, and 4) construction of recreation forests. Therefore, log production from these forests was only 7,000 m^3 in 1989.

Ownership of non-national forests varies. In 1990, there were 2,863,327 different organizations or individuals who owned forests and/or were involved in log production. In communal forests, there are four major types of organizations involved in log production as described previously. In private forests, organizations which owned grater than 0.1 hectare are classified into six types as follows: 1) Private woodlot owners, 2) Private companies, 3) Shrines and temples, 4) Union bodies and cooperatives[2], 5) Habitual joint holdings[3], and 6) Joint holdings by individuals, companies, *et cetera*, which own forests together, with the profit divided among them.

The most important organizational form is the private woodlot owners; there were about 2,509,000 private woodlot owners in 1990 (Table 2.2). The number of private owners is 7.2% less than in 1960, although they still constitute 87.6% of all organizations and 64% of private forest area. The scale of private woodlot owners is relatively small; 57.9% of them own less than 1 hectare. However, the share of area within the total area that is owned by private woodlot owners is only 8.3%. Further, the decline in private woodlot ownership occurred primarily among small owners. In contrast, those who owned greater than 50 hectares of forest land accounted for only 0.4% of total private woodlot owners. However, they held 22.7% of the total privately-owned area, and the number of these large private woodlot owners increased each year.

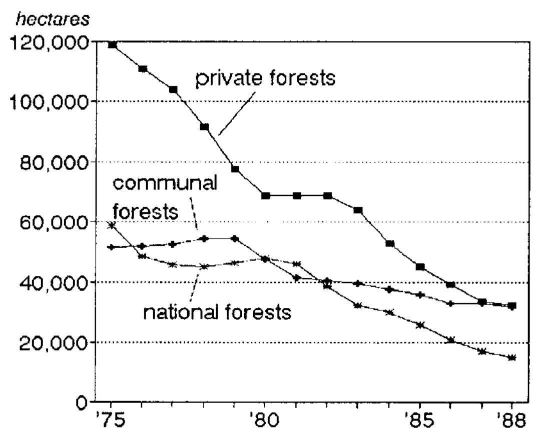

Figure 2.2 Reforestation Activity, 1975-1988
Source: Forest Agency, *White Paper*

Replantation activity by the private woodlot owners has been declining (Forestry Agency, 1990a). Many owners own replanted forests more than they own old-growth forests;

---

[2]Union bodies and cooperatives that own forests for the benefit of the particular group.

[3]The forests are operated by local residents according to old customs with rights guaranteed by low. The original owners are temples, unions, property ward and so on.

owners, whose more than 80% of forests are replanted, reached more than one third of all private woodlot owners in all over Japan. Replanted forests accounted for 54.4% of total area owned by all private woodlot owners in 1990 and they are particularly located in Kyushu and Shikoku regions. However, the reforested area in each year has declined during the past decade (Figure 2.2). Therefore, the replanted forests are aging rapidly. The majority of replanted forests are 31 to 40 years old. This implies that replantation is not being carried out as much lately by the forest households. This is because of labour shortage and lack of fund as well as a decline in the timber harvest. Also, depression and uncertainty in the forestry industry suspend motive of reforestation.

Some 75.8% of private woodlot owners were involved in agriculture. Further, about half worked as full time employees of forestry/non-forestry establishments. In the case of private woodlot owners who were not involved in agriculture, about half were self-employed in either the forestry industry or other industries. In both cases, the percentage of full-time foresters was only 0.8% for private woodlot owners in agriculture, and 1.6% for those not in agriculture (Figure 2.3). The percentages increased as the scale of organizations became larger. Consequently, many private woodlot owners entrusted the management of their forests to second parties. In 1990, 6.1% of total private woodlot owners or 32.9% of those who owned

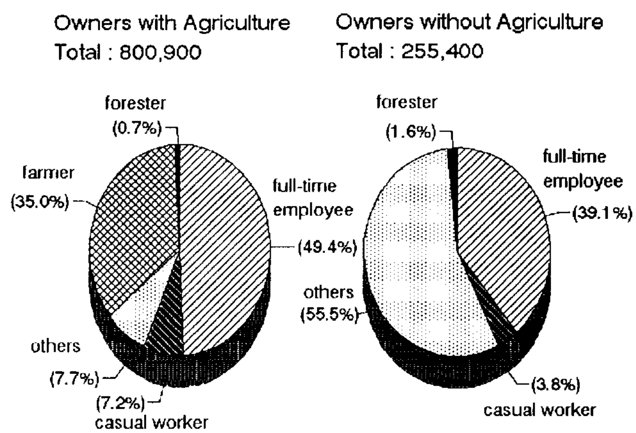

Figure 2.3 Employment Opportunities of Private Woodlot Owners
Source: MAFF, *Forestry Census 1990*

more than 100 hectares entrusted the management of their forests to others, mainly forestry cooperatives. For private woodlot owners with sizable holdings (say, 20-500 hectares), financial returns were reasonable (Figure 2.4).

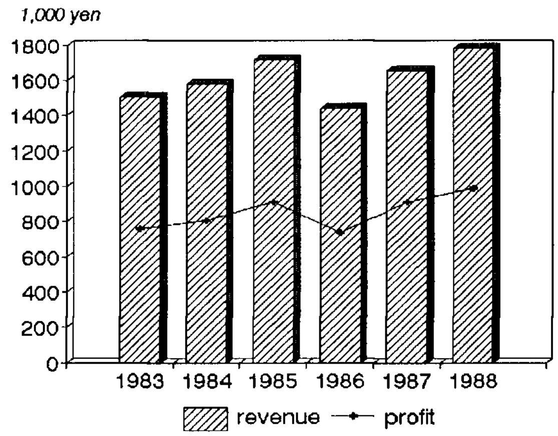

Figure 2.4 Average Revenues and Profits of Private Woodlot Owners with 20-500 Hectares, 1983-1988
Source: MAFF, *Forestry Census 1990*

Private companies are also a major organizational form in ownership of private forests. In 1990, companies numbered 43,940, or 1.5% of the total organizations involved in log production. However, the number of companies increased substantially since 1960; there were about 14 times more private companies in 1990 than in 1960. Companies owned 1,819,000 hectares in 1989; this constituted 13% of private forests or 7.4% of total woodlands. Of those companies, 66.8% were small companies that owned less than 1 hectare. However, the average area per company was 224.9 hectares, and this was higher than that of the other organizations involved in private forests (MAFF, 1990b).

Both sales activity and maintenance operation of forest companies cannot be considered proactive. In the case of those who owned more than 1 hectare (14,580 companies), only 3.6% of them carried out any silvicultural activity, either by themselves or by a second party. Thinning was done by 6.7% of the total companies by the same manner. According to a survey of forestry organizations by the Forestry Agency in 1986 (Rinya Jiho, July 1988b, pp.30-33), 69% of companies considered that there was inadequate thinning to maintain their forests; the unprofitable nature of theses activities prevented adequate maintenance. The survey also found that many forest companies were in severe financial condition; forestry expenditures exceeded forestry gross income for an average 30% of companies, regardless of the size of operation.

The number of the other organizations in private forestry such as temples has increased since 1960, although habitual joint holdings has declined (Table 2.2). Most of them were small organizations who owned less than 1 hectare. The maintenance condition of these forests is the same as that of private company forests.

In communal forests, the number of organizations also tended to increase except for cooperatives in local public bodies, which decreased by 31.5% from that in 1960. Unlike the organizations in private forests, the area each organization owns is relatively large. The major organizations are those that own more than 50 hectares. Involvement in log or timber sales and

Table 2.2 Number of Forestry Organizations Involved in Log Production

	1960	1970	1980	1990	(%)
private woodlot owners	2,705,000	2,566,000	2,531,000	2,509,000	(87.6)
private companies	3,200	11,440	28,100	43,940	(1.5)
temples & shrines	20,210	31,000	30,640	33,630	(1.2)
joint holdings	148,520	164,950	166,150	202,790	(7.1)
unions & cooperatives	2,920	6,770	9,390	11,330	(0.4)
habitual joint holdings	109,910	74,000	61,640	59,210	(2.1)
property wards	140	800	670	780	(0.0)
municipal bodies	2,420	2,500	2,520	2,470	(0.1)
cooperatives in local public bodies	190	150	150	130	(0.0)
prefectural bodies	46	46	47	47	(0.0)
TOTAL	2,992,556	2,857,656	2,830,307	2,863,327	(100.0)

Source: Statistics and Information Department, MAFF, *World Forestry Census [iv] Economies of Forestry Organization 1990* (Sekai Noringyo Census [iv] 1990) the level of forest maintenance are relatively high compared to those in private forests. This is because of the sufficient financial background of those organizations since they belong to the local governments.

2.1.2 Organization of Private Harvesting and Silviculture

There are a large number of different organizations involved in the Japanese forestry industry, but few are involved in silviculture and harvesting. In 1980, there were 24,399 establishments working as either log producers or in silviculture, or both. These establishments take various organizational forms: forestry cooperatives, other cooperatives (e.g., production forestry cooperatives), companies and individuals.[4]

Cooperatives. Forestry cooperatives are associations of forest owners. In 1987, there were 1,746 cooperatives. Membership in cooperatives totalled 1,706,000, or half of all forest owners in those regions where forestry cooperatives are active. The area accounted for by cooperative members constituted 74% of the total private forest area in these regions.

The major operation of forestry cooperatives are: 1) sales of forest products, 2) production, 3) manufacture, 4) reforestation, and 5) bulk purchase of seedlings and fertilizer. In 1987, the total value of these operations was 339.3 billion Japanese yen,[5] about twice as much as in 1975. In terms of volume, cooperatives approximately doubled their output, while

---

[4]Some of the private woodlot owners and private companies that own more than 20 hectares are also considered establishments since they are constantly involved in forestry operations.

[5]339.3 billion Yen was about $C 3.1 million--the average exchange rate between $C and Yen in 1987 was 1$C. = 109.08 Yen.

log sales increased by about one and half times. In 1987, log production was 3,981,000 m^3, while 2,899,000 m^3 was actually sold. Log production by cooperatives accounted for 17% of total log production in non-national forests. The area of replanted forests by forestry cooperatives has fallen since 1980; however, it still accounts for 80% of total replanted forests in non-national forests. This implies that forestry cooperatives play a great part in forest operations in non-national forests.

The financial condition of these forestry cooperatives has not been good in recent years. In the 1986 fiscal year, 16% of all forestry cooperatives had an average deficit of 2,879,000 Japanese yen (Rinya Jiho, July 1988a, pp.2-6). The decline in forest cooperative workers is also a serious problem. In 1987, 78% of all forestry cooperatives owned their own operational groups with a total of 52,134 workers, but the number of workers has fallen by 20% since 1981. A major problem is that many of these workers are advanced in age and the situation has not improved over the years. In 1987, 41.9% of all workers were between 50 and 59 years old, and 27.9% were over 60 years of age. In contrast, workers younger than 40 years old constituted only 11.2% of worker force. Forestry cooperatives are the core supporters of forest operations, particularly the smaller ones. Improvements to the financial and worker-age problems of forestry cooperatives would provide significant future social benefits for the forestry industry.

Log Producers. While forest organizations can be divided into various forms, such as private companies or cooperatives, they can also be divided into two categories according to their operation. One is called log producers and the other is tree planters, those involved in reforestation. In 1991, there were about 11,841 log producers (Rinya Jiho, Oct. 1991, pp.2-23). Compared to 1978, the number of log producers declined by 25%, with the decrease occurring mainly among small scale establishments. In contrast, the average size of establishment has expanded.

Individuals and private companies accounted for 65% of all log producers (Forestry Agency 1990b, p.163). Of these, full time log producers are few. The others were diversified into other sections of the forest industry such as sawmilling and lumber sales or into agriculture. Small scale log producers in particular tended to be less specialized. Forestry cooperatives made up 10% of all log producers.

As with forestry cooperatives, log producers have a serious problem with the age structure of their work force. In 1985, there were 103,000 workers among all log producers including forestry cooperatives, 26% less than the 1978 level. Of those, 59% were over 50 years old. In contrast, the proportion of workers under 49 years has declined. Among all workers, 63% were full-time employees, 30% were seasonal workers, and 6% were casual labourers.

Log producers play a significant role in the supply of domestic logs by both providing forest owners with the incentive to produce logs and brokering the logs to sawmills. Therefore, strong management skills and an adequate supply of workers are critical to a healthy logging industry in Japan.

<u>Reforestation Activity</u>. The number of private establishments (firms, cooperatives, *etc.*) involved in reforestation was about 6,300 in 1980 (MAFF, 1990b). This was about half of the 1970 level due to a decline in area and operation of replanting. About half of all those who reforested land also operated as log producers. However, unlike log producers, they tended to be small-scale establishments, and their managerial and economic foundation was relatively

weak. The major problems with building up expertise in reforestation include the small areas to be replanted, dispersion of locations to be replanted, and inactivity by forest owners who generally entrust their reforestation activities to other organizations. However, organizations that engage in reforestation are essential to communal forests, for example, because these do not have any structure to carry out forestry management.

2.1.3 Public Management of National Forests

The objectives of national forest management are: 1) to provide a continuous supply of forest products; 2) to preserve and protect nature, national forest lands and watersheds; 3) to supply recreational opportunities; and 4) to promote rural development by providing economic activities related to national forest management. It also sets up projects that provide incentives to increase participation in forest management among non-forest owners such that the non-forests owners wish to invest in silviculture. These projects are becoming more popular as people's interest in maintaining forests increases, particularly among people who live in urban areas[6]. As well as these public interests, management has a commercial aspect, namely, to create income for the National Treasury. The operations and sale of logs is carried out through the Forest Service Stations, which are local or regional bureaus of the Forestry Agency and are located all over Japan.

Supply of Logs. In 1988, the volume of harvest in national forests was 11,121,000 m^3. The amount decreased by 45% compared to the 1970 level. The national forest management

---

[6]The same system exists for non-national forests. This system is regulated by the governor of each prefecture.

supplies jobs to private establishments in the process of harvesting in order to reduce its expenditure and promote the rural economy. Of national forest timber, 55% is sold as standing timber with harvest done by private establishments that purchase the timber. The rest is sold as logs. About 40% of the log production is carried out by private establishments such as log producers and forestry cooperatives (MAFF 1990a, pp.151-152).

The timber in national forests is mainly sold by rural Forest Service Stations directly, either by auction or negotiation with buyers who are approved as forest industry personnel by the heads of Forest Service Stations. In 1988, total log sales from national forests was 4,123,000 m^3.

Financial Condition. In the 1990 fiscal year, national forests' revenue was 556.4 billion yen while expenditures on forestry operations were 576.9 billion yen, thereby creating a deficit of 20.5 billion yen after it had surplus for several years. 47% of the revenues came from long-term loans. The rest of income came from forestry operations (45%) and general account (4%). The revenues from forestry operations declined by 24.1 million yen from a year before. This is due to low prices for logs and declining harvests, and it has created severe financial problems (Forestry Agency 1986, p.104). Personnel expenses accounting for 46% of total national forest expenditures. Direct forestry income showed a loss of 71.9 billion yen in fiscal year 1989. The accumulated deficit rose to 921.3 billion yen. Debt servicing reached 36.3% of the total expenditures in 1989. At the end of the 1989 fiscal year, the total debt was 2,251.1 billion yen. This is a big burden on national forest management. Because of the huge debt, the Forestry Agency set special projects in order to improve national forest management in 1978, 1984 and 1987.

2.2 Japan's Domestic Timber Production

2.2.1 Timber Stock

Japanese timber stocks have increased in recent years, especially in areas where silviculture was practised. The total stock of timber in Japan was 2,862 million m^3 in 1986 (Forestry Agency 1990a, p.62). The average increase in the stocks or mean annual increment was 76 million m^3 for each year over the five years beginning in 1981; this was a 15% increase over 1981. However, there was not much change in the total woodland area during this period.

The stock increased particularly in the replanted forests that accounted for 40.6% or 10,200,000 hectares of total woodland in 1986--an increase of 3% over 1981. The timber stock increased from 1,050 million m^3 to 1,353 million m^3, or a 28.9% increase over the five year span. The increase in timber stock in replanted forests accounted for about 80% of the total increase during this period. Of this timber stock, cedar increased by the greatest proportion. It accounted for 59.0% of total timber stock, followed by cypress (19%) and larch (9.7%) (Figure 2.5). Cedar less than 40 years old increased the most. In other words, 44% of the total replanted forest area was occupied by cedar and 23% by cypress.

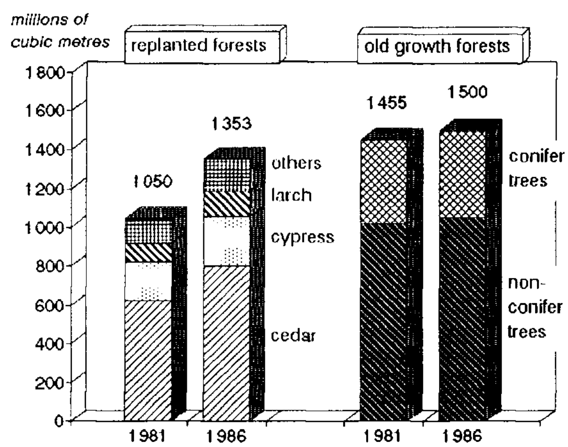

Figure 2.5 Change in Timber Stock, 1981 and 1986
Source: Forestry Agency, business data

The area of old-growth forests decreased by 2% to 13,670,000 hectares between 1981 and 1986, but the timber stock in old-growth forests increase by 5%. In

1986, the timber stock was 1,500 million m^3. Unlike replanted forests, non-conifer trees are the major species in old-growth forests, accounting for 70% of timber stock and 75% of the area of old-growth forests. Also, relatively young, naturally-regenerated trees less than 50 years old accounted for 56% of the area of mature forests.

2.2.2 Domestic Log Production

Domestic production of logs reached a peak in 1967; timber output in that year was 51.8 million m^3 (Figure 2.6). Production declined substantially between 1967 and 1975, but has levelled off since then. Log output has fluctuated between 31 and 33 million m^3 since 1982. In 1989, production was 30.15 million m^3.

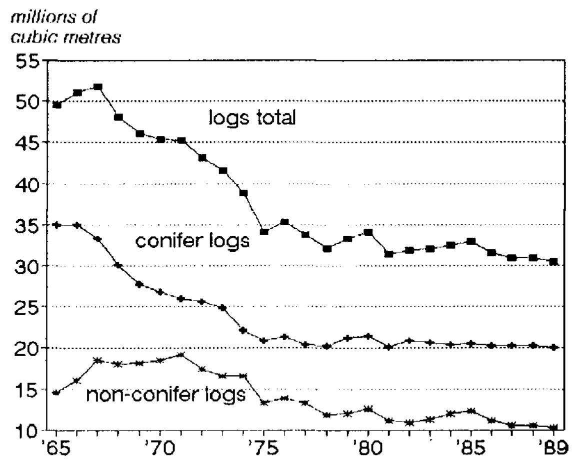

Figure 2.6 Japanese Log Production, 1965-1989
Source: MAFF, *Annual Report on Demand and Supply of Wood Products*

In the case of log production by species, output of non-conifer logs, which are often referred to as broad-leaf trees in Japan, reached a peak in 1971. Since then, output of these logs exhibited a downward trend with some fluctuations (Figure 2,6). In 1989, the production of all non-conifer logs was 10.44 million m^3, or 34.2% of total log production. The major species of non-conifer trees are beech and oak. The output of these logs has decreased dramatically compared to 1967. In particular, output of beech logs dropped to one quarter of 1967 levels, and that of oak by half over the 22 year span. As a proportion of total logs, production of oak and beech was relatively small; each constituted 1.9% of total production.

The production of conifer logs, which are referred to as needle-leaf trees, was 20.71 million m^3 in 1989, or 67.9% of the total log production. Total conifer log production declined since 1968, but has stayed quite stable since 1975; this is a trend similar to that of non-conifer logs. The change in production exhibits some difference among species (Figure 2.7). On one hand, the output of fir and hemlock spruce fell to one-fifth of 1967 levels, while production of red pine and black pine is less than half because of damage by pine bark beetles. On the other hand, the production of larch, white fir and yeso spruce exhibits the smallest decrease among conifer logs; it fell 25% over 20 years. These logs were mostly produced in northern Japan (Hokkaido). In this region, forestry organizations and establishments have endeavoured to provide effective management and promotion of larch since 1975 (Forestry Agency 1990a, p.37).

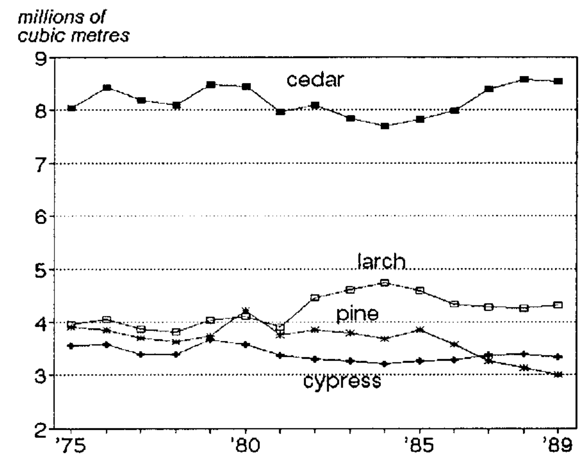

Figure 2.7 Conifer Log Production by Species, 1980-1989
Source: MAFF *Annual Reports on Demand and Supply of Wood Products*

During the last decade, log production increased for some species. The production of cedar and cypress logs increased somewhat since 1984, although the level of output is much lower than that in 1967. These are also the most popular species for lumber. In 1989, 30.0% of total log production was cedar logs, and 96.6% was used for lumber. Cypress logs account for 11.0% of total log production, with 97.3% used for lumber. The production of cedar logs increased particularly in south-western Japan, mainly the Shikoku and Kyushu regions. This is because forests which were replanted after the war are almost ready to harvest in this area as trees grow relatively fast. However, logs have been relatively small in these regions because production to date is the result of thinning, not clear cutting.

More than half of conifer logs are middle-sized--14 to 28 cm in diameter, regardless of species. Of these logs, average grade sawlogs, particularly of cedar and hemlock spruce, are the main competitors of North American hemlock, mainly square dimensional lumber (Japan Timber Union's Association 1990 p.15, p.33).

In the case of log output by purpose, 60.8% of total log production in 1989 was for lumber; pulp and wood chips, and other purposes, accounted for 35.7% and 3.5%, respectively (Figure 2.8). In 1968, 33.57 million m^3 of logs were manufactured into lumber, or 64.8% of total production. After 1984, however, output maintained a range of 18 to 19 million m^3 per year, with 60% for lumber. Logs that were manufactured into pulp and wood chips decreased as the total output of logs decreased, but the *ratio* of logs used for pulp and wood chips increased from 27.4% in 1968 to 37.2% in 1984, and, after 1987, the ratio was between 35 and 36 percent.

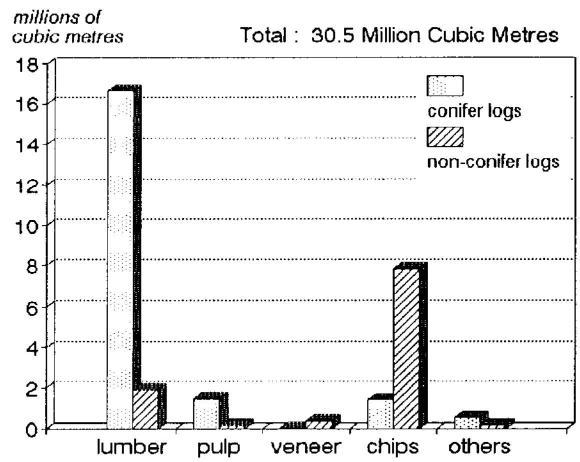

Figure 2.8 Japanese Log Production by End Use, 1989
Source: MAFF *Annual Reports on Demand and Supply of Wood Products*

The quantity of logs that were manufactured into lumber was 18.55 million m^3 in 1989 with 89.7% being conifer logs. Cedar logs accounted for 44.4% of the total logs manufactured into lumber. The second most popular species for lumber was cypress; in 1989, 17.5% of the total logs for lumber were cypress logs. However, the production of cypress logs for lumber decreased slightly between 1988 and 1989. In contrast, larch logs became a more popular species. Larch logs account for 9.7% of the total logs for lumber, with production of larch logs for lumber increasing 4.5% between 1988 and 1989.

2.2.3 Domestic Log Production Costs

Total value of log production varies by species. Domestic log prices for various species over the period 1971-1990 are provided in Figure 2.9. Prices reached their peak in 1980. Then, they fell rapidly due to a large decrease in number of housing starts, until it recovered in 1987. The prices of Japanese logs depend not only on their production costs but also on other factors. Mostly, the change of domestic log prices followed that of imported log prices except that the latter fluctuate more. The prices of imported logs were influenced by the policies of exporting countries (economic and political factors), and exchange rates. Also, an increase in non-forestry related factors such as the condition of other resources creates instability of Japanese log prices.

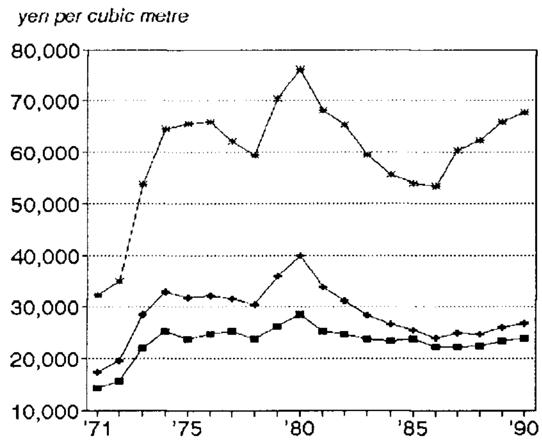

Figure 2.9 Domestic Log Prices, 1971-1990
Source: MAFF, *Price of Timber*

During the last five years, the price difference between domestic cedar logs and North

American hemlock logs decreased; the increase in cedar price was held low in order to compete with North American hemlock (Forestry Agency, 1990b pp.89-94). The price of cypress continues to increase since supply is decreasing due to a labour shortage. Also, the prices of some old-growth non-conifer logs such as oak are rising since there are no good substitutes.

According to a study of standing timber values by the Forestry Agency (1990b pp.165-168; Rinya Jiho, Oct 1991, pp.35-39), the stumpage price or fee for cypress (41,885 yen/m^3 in 1988) was highest among four major species--cedar, cypress, pine and larch (Figure 2.10). It made up 74.6% of total value of cypress log production. In contrast, that of larch accounted for 40.0%; its stumpage value of 4,685 yen/m^3 was the lowest of the four species. The reason for producing expensive cypress logs is obviously attributable to its high demand, and this is indicated by its high stumpage values. Cypress is preferred by Japanese builders for traditional Japanese house construction.

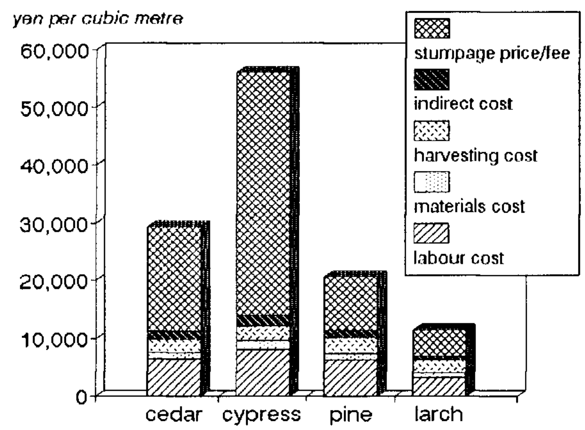

Figure 2.10 Cost of Log Production, 1990
Source: MAFF, *Study of Standing Timber*

In addition to stumpage fees, log values are determined by the costs of harvesting and collection (transportation), labour, machinery, materials for processing of logs, and overhead. However, it is clear from Figure 2.10 that the major component in log costs is the stumpage fees collected by the property owner. Given that stumpage fees are a large component of log value, one would expect more silvicultural effort than appears to be the case, as discussed above.

2.3 Domestic Sawmilling industry

2.3.1 The Position of Sawmilling Industry in Japan

The Japanese sawmilling industry is the core of the Japanese forest industry as a supplier of materials for traditional Japanese house construction. Because of the high rate of housing construction, during 1987-1989, the sawmilling industry has increased its total value of shipments. However, the economic position of the sawmilling industry, and the wood manufacturing industry, which excludes furniture manufacturing and pulp and paper milling, is relatively low compared to the other manufacturing industries. The total value of shipments from wood industry is one of the lowest among twenty-two manufacturing industries classified by the Ministry of International Trade and Industry: the value was only 1.6% of total value of all manufacturing industries in 1988. Comparisons of some economic figures among the some of the other manufacturing industries is represented in Table 2.3.

The sawmilling industry not only has small output in terms of value added compared to

Table 2.3 Comparison of Economics of Some Manufacturing Industries in Japan, 1988

	number of establish-ments	number of workers	salary of workers (mil.¥)	costs of materials (mil.¥)	value of shipments (mil.¥)	value added (mil.¥)
Wood Industry	34,405	288,669	720,378	2,700,682	4,387,951	1,615,167
Sawmills	15,105	129,157	306,136	1,168,418	1,866,939	674,107
WoodChips	820	8,102	21,733	107,573	166,245	55,190
Plywood	1,527	40,965	130,646	661,302	990,004	305,328
Furniture	42,240	277,157	692,188	1,992,333	3,704,474	1,667,722
Pulp & Paper	16,565	290,681	1,007,830	4,719,169	7,859,838	2,842,098
Pulp Mills	17	1,523	8,275	38,354	70,734	28,888

Source : Research and Statistics Department, Minister's Secretariar, MITI, *Census of Manufactures 1988*, June 1990 the other manufacturing industries, but it also has a weak structure in terms of its operation. Figures that illustrate the condition of the operation are generally lower than those of the average level of all manufacturing industries, except for the last couple of years (Figure 2.11)[7] . These figures imply that the instability of the sawmilling industry is caused by the small scale of operation and its poor financial position (Japanese Timber Union's Association 1990, p.23). An investigation of medium and small size enterprises done by MITI (1990) showed that about 75% of all sawmills were operated by small establishments with workers of less than nine. Half of all establishments were individuals and the rest were companies; more than half of these companies had capital assets of less than five million yen. The weak financial conditions create instability in the sawmilling industry.

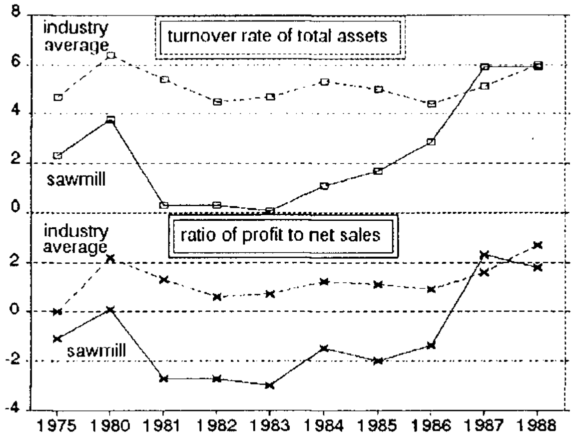

Figure 2.11 Comparison of Management Indices: Sawmill Industry and Industry Average, 1975, 1980-1988
Source: SMEA, *Management Indices of Medium and Small Size Business*

2.3.2 Number of Sawmills and the Scale of Operation

As was mentioned in the previous section, the demand for lumber has increased since 1987, and it brought a relatively high level of returns to the sawmilling industry. However, the number of sawmills has continuously declined by more than 30% over the past two decades, and

---

[7]Turnover rate of total assets = return / total assets,
Ratio of profit to net sales = profit / net sales

total employees has declined by more than half. In 1968, when the number of mills peaked, there were 25,130 sawmills in Japan with about 272,400 employees; this declined to 17,275 sawmills with 129,000 employees by 1989 (Figure 2.12). In contrast, power usage per mill has increased by about 90% from 36.9 Kw to 76.1 Kw. In terms of size of power usage, in 1989, more than 70% of total sawmills were those with power usage of less than 75 Kw. However, these small mills account for less than 30% of total volume of logs consumed and lumber produced.

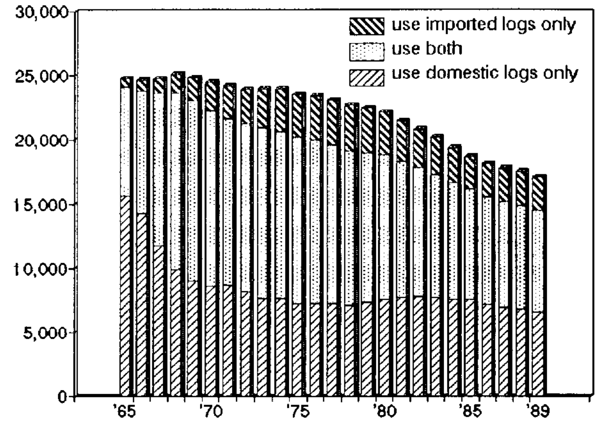

Figure 2.12 Change in Number of Sawmills, 1965-1989
Source: MAFF, *Annual Reports on Demand and Supply of Wood Products*

The major suppliers of logs to the sawmilling industry used to be the Japanese domestic industry. In 1960, only 10.0% of logs consumed were imported. However, the proportion increased to 43.8% in 1968, and 58.3% in 1989 (Figure 2.13). As a result, the number of sawmills that relied on domestic logs has decreased. Many Japanese mills are capable of processing a variety of species from different countries. Since North America is the largest log supplier, more than half of all sawmills in Japan are involved in processing North American lumber. However, this

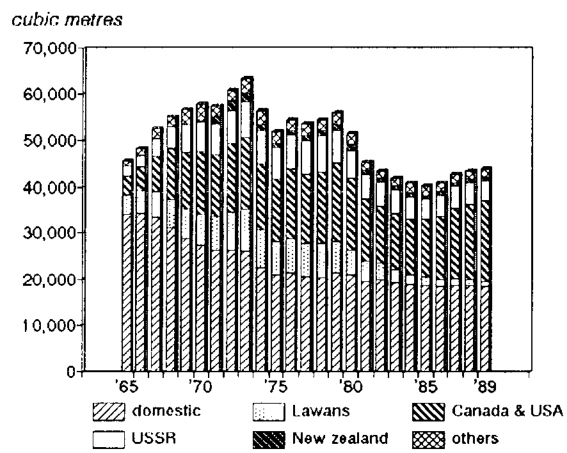

Figure 2.13 Origin of Logs Consumed by Japanese Sawmilling Industry, 1965-1989
Source: MAFF, *Annual Reports on Demand and Supply of Wood Products*

diversity in processing various species of logs slows improvement in equipment productivity (output to power usage ratio), as well as leading to a low operating ratio (Japanese Timber Union's Association 1990,pp.8-9). Equipment productivity decreased by 40% over two decades, while labour productivity increased by about 60% and power usage per worker increased three times.

Sawmills in Japan can be classified into five categories depending on their location and kinds of logs they consume, as presented in Table 2.4. The number of sawmills is decreasing particularly those that consume mainly domestic logs; sawmills tend to be small. Sawmills that process imported logs and are large operations are also decreasing, but at a slower rate. The recent decline in sawmill numbers is accompanied by a decrease in employees. The decrease is not only because of labour-saving but also labour shortage in terms of both quality and quantity. The economic boom after 1989 resulted in a labour shortage for all industries in Japan. Since most sawmills do not have a strong financial balance sheet, the influence is severe. Also, many employees are advanced in age. Moreover, complaints about the noises from sawmills is another reason for the closing down of firms.

2.3.3 Japanese Lumber Production and Its Utilization

Japanese lumber production in 1989 was 30,481,000 m^3 which recovered a little from the low production during the previous decade. The production of lumber takes place in all prefectures in Japan. Hokkaido, the largest producing region among forty-seven prefectures, produces about 10% of total lumber. Hokkaido, as well as Akita and Mie Prefectures uses mainly domestic logs. The other major producing regions, such as Hiroshima and Wakayama

Table 2.4 Classification of Sawmills in Japan

location	producing districts	trading districts	trading districts	consuming districts	near ports
origin of logs	domestic-national & private forests	domestic-private forests	imported-N. America & USSR	imported-N.America & S. Sea	imported-N.America, USSR & N.Z.
suppliers	producers, markets	markets	whole-salers	whole-salers	trading companies
size of logs	middle to large	small to middle	middle to large	half-finished	middle to large
volume of input per year (m^3)	less than 4,000	less than 8,000	less than 10,000	less than 3,000	grater than 15,000
variety of species,	many	a little	many	many	a little
amounts of each input	a little	large	a little	a little	large
buyers	consumers	markets	wholesalers	consumers	wholesalers

Source: Japan Lumber Association, *The Current Conditions and The Analysis of Sawmills*, march 1990

Prefectures, utilize imported logs. In 1989, twenty-five prefectures produced sufficient lumber to meet local demand. In contrast, the remaining prefectures, including Tokyo and Osaka, could not produce enough lumber to meet demand. Metropolitan Tokyo demands more than ten times as much Japanese lumber as produced within the area.

The shipments of Japanese lumber were 30,563,000 m^3 in 1989 (Figure 2.14). Of those, 78.5% were for housing construction. The rest were for boxes and packages (9.7%), for furniture (4.9%) and for other uses (6.9%). The shipments for each utilization tended to decrease as the total shipments of Japanese lumber decreased. However, it is clear that the trend of Japanese lumber shipments and demand heavily depend on the trend of housing construction.

Although three-fourth of the lumber processed in Japan is used for housing construction, utilization is quite different, depending on the origin of the logs (Figure 2.15). The majority of logs from South Asia are hardwood logs, and nearly half of the Japanese processed lumber is utilized for housing construction. On the contrary, the majority of logs from New Zealand are softwoods. However, the lumber is mainly used for packaging and boxes. Logs from North America and the former Soviet Union are also mainly softwoods, but they are utilized for housing construction, and as is lumber processed from domestic logs.

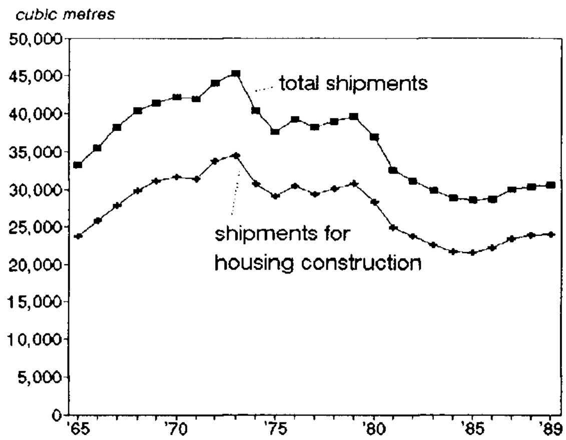

Figure 2.14 Shipments of Lumber in Japan, 1965-1689
Source: MAFF, *Annual Reports on Demand and Supply of Wood Products*

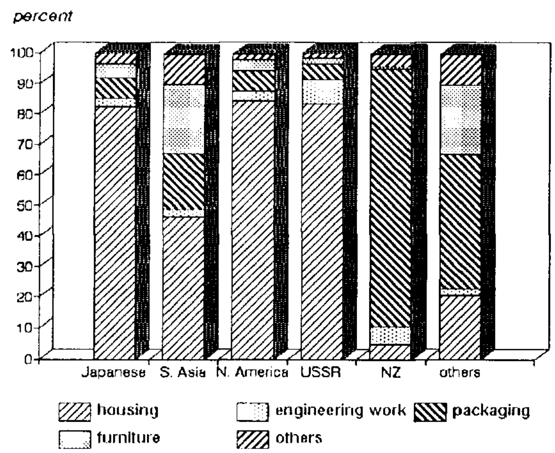

Figure 2.15 Utilization of Japanese Processed lumber by Origin of logs,1989
Source: MAFF, *Annual Reports on Demand and Supply of Wood Products*

2.4 Japan's Housing Construction

As mentioned in the previous chapter, demand for lumber depends on housing construction. Shipments of lumber can be analyzed as the sum of the variable quantity of lumber used for housing construction plus the relatively constant amount of lumber for other utilizations (see Figure 2.15). Therefore, in order to analyze demand for lumber, it is essential to evaluate factors influencing housing construction. Demand for lumber reached its peak in 1973 (67.5 million m^3). Since then, the demand continuously dropped until 1985 when demand was 44.5 million m^3. It gradually recovered to 55.3 million m^3 in 1990 (Forestry Agency, 1990b).

In 1973, the number of new housing construction was 1,905,112, with a total floor area of 138.8 million m^2.[8] Then it exhibited a decreasing trend and reached the bottom of 1,136,797 new houses with floor area of 98.2 million m^2 in 1983. In 1990, it recovered to 1,665,367 houses with 134.5 million m^2. Housing construction accounts for about 50% of all building construction in terms of its floor area. In the case of wood structures, 90% of all such buildings are for residential houses. The proportion of wood buildings has declined continuously, while the number of high rise dwellings has increased. Most wooden houses are less than two-stories, with only 0.6% of wooden buildings being three-storey or higher. The proportion of wood used in residential houses also has dropped. In 1973, the wood rate for residential houses was 58.8%. It declined to 42.4% in 1990. The decrease particularly occurred among new construction for non-owned houses, constituting about 60% of all new houses. In Japan, houses are categorized into 4 types; owned, rented, issued houses[9], and

[8]All figures concerning housing construction are obtained from *Monthly of Construction Statistics*. Years are the fiscal year.

[9]Issued houses are, for example, those that companies supply their employees.

houses for sale[10]. The proportion of wood used in construction is particularly low among rented houses and issued houses. In 1990, 71% of all houses was non-owned houses including those for sale. Of those, the wood rate was 38% on average. However, the wood rate of owned houses remains around 80%.

In terms of floor area, owned houses still constitute about 50% of new floor area. This is because the average size of owned houses has increased each year, while that of rentals has decreased. The average floor area for each category is 136.8 m^2 for owned houses, 45.1 m^2 for rental houses, 71.3 m^2 for issued houses, and 83.7 m^2 for houses for sale in 1990. The large floor area of owned houses reflects the recent trend of housing construction. High quality, highly personalized houses are preferred by those who build their own houses. House owners' decisions about overall style of houses are significant since more people are involved in planning and designing their own houses and gardens. Therefore, rebuilt houses are quite common. House builders have a variety of choices over construction methods and materials. Also, new construction methods are introduced even from abroad and are available to builders, such as North American style 2x4 construction methods. However, because of high land value, floor area for rented houses became smaller, and wood content declined. These are mainly apartment houses that have a high demand as family size falls.

The factors that may affect trend of housing construction are: the change in family structure (e.g., more single people); changes in living style towards a more western one; advance technology and various construction methods; urbanization; and so on. The change in

---

[10]Potential owners have no influence on planning houses for sale, while owned houses reflect the preference of owners.

tastes has a significant role for the demand for imported timber. Since various new construction methods are introduced from overseas (mainly North American style 2x4 methods), house builders chose new methods more often. These require particular materials, and are more likely to need foreign timber. For example, prefabricated houses utilize only 5% of Japanese timber. However, the rest of foreign-origin lumber still can be processed in Japan. The 2x4 methods, which became quite popular in the last decade, require only foreign timber. Particularly, the standard is based on those in the originating countries. Most of the 2x4 lumber is processed overseas and shipped to Japan. Moreover, Japanese orthodox houses, which traditionally use only Japanese timber, are now using imported timber; North American hemlock and Douglas fir account for an average 45% of all lumber required. Demand for imported timber has consequently been rising.

Although various construction methods are available in Japan, the traditional post and beam method dominates. Carpenters examine lumber on the basis of its knot, warp and dryness. Then they decide how or where the lumber should be used, and cut for the use. However, since the number of skilled carpenters has declined, both construction companies and sawmills developed a "pre-cut" method to prepare lumber for traditional construction. The lumber is cut in the factories according to the plan of individual houses, then is assembled at the destination spot. In this way, it is possible to supplement the shortage of skilled carpenters, improve and standardize the quality of houses, shorten the construction period, and cut construction costs. Some factories have introduced computer networks that connect the drawing of houses to the finished lumber (including cost calculation); these computer systems are CAD (Computer-Aided Design) and CAM (Computer-Aided Manufacturing). In 1989, the number of the factories was about 350 (Forestry Agency 1990b, pp.138-149), and this is expected to increase. The aforementioned methods are widely utilized by large national construction companies and middle-size regional companies. However, an increase in pre-cut methods implies importing more half-finished lumber, but not dimensional lumber.

3 Imports of Logs and Lumber

3.1 Introduction

The Forest Agency suggests using the *Report of Supply and Demand of Wood Products* by MAFF to examine the structure or share of kinds of wood products in the market (1990, p.9). In the report, quantities of supply and demand of all kinds of finished wood products are converted into the volume equivalent of logs.

Japan's self-sufficiency for all wood products radically declined during the 1960s. According to the *Report of Supply and Demand of Wood Products*, in 1960, the supply share of imported wood products was only 13.3%, that of imported logs 12.1%, and that of lumber only 0.56%. However, by the end of that decade, the share of imported wood products increased by more than half (Figure 3.1). In 1969, the supply share of all imported wood products was 51.0%. In particular, the supply share of imported logs was 45.4%, while that of lumber was 4.5%. Since then, the share increased rather gradually until 1979. In the 1980s, because of increasing restrictions on exports of raw materials by producing countries, the supply share of imported logs dropped and

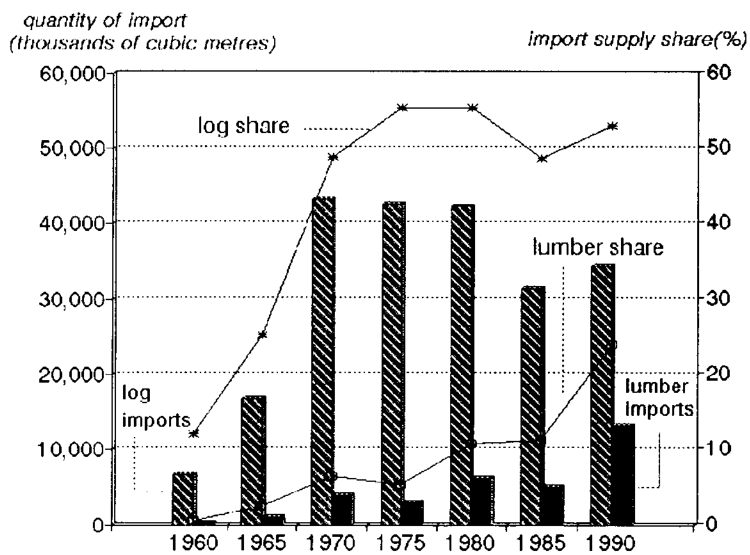

Figure 3.1 Quantity of Import Supply and Supply Share of Imported Logs and Lumber
Source: Forestry Agency, *Demand and Supply of Timber*

fluctuated around 50%. As well, the share of all wood products decreased. However, an increase in imported lumber and other finished wood products in the late 1980s pushed supply share of imported wood products up again. In 1990, total supply of all wood products was 114,880,000 m^3, and 73.5%, or 84,430,000 m^3, was imported. This supply share was higher than at any in the past. Supply of logs was 64,733 m^3, of which 53.1% was imported. The supply share of imported lumber was 24.0%.

As well as changes in the supply share of imported wood products, the structure of imported wood products also changed. In 1960, 88.5% of total imported wood products were logs. Lumber accounted for only 2.8% of total imported wood products. However, as was mentioned previously, the regulation of the export of raw materials and subsequent promotion of the export of finished products by producing countries changed the structure of imported wood products. Also, imports of wood chips increased rapidly. In 1990, the ratio of logs to all imported wood products dropped to 40.7%. In contrast, that of lumber increased to 15.7%, and wood chips to 23.6%.

The trends of imports of individual wood products is analyzed by using *Imports of Commodity* published by the Ministry of Finance. Imports of wood products have steadily increased along with the imports supply share. The imports of both logs and lumber, however, dropped in 1974, right after the peak of demand for lumber. Again, the quantity of imported logs dropped in 1981 due to the restriction of log exports from South Asia, one of the major suppliers. Since then, the import of logs remained around 30,000 m^3. Imports of lumber also fell in 1981 because of a sudden decrease in demand. Imports have steadily increased since then. Imports of lumber are more than 50 times as much as in 1960, while that of logs in 1990 was slightly less than five times that in 1960.

3.2 Changes on imports by origin

In 1990, the total volume of both imports logs and lumber was 37.0 million m^3, with a value of 983.7 billion yen. The quantity was 10% less than the year before. Japan imported logs and lumber from 67 countries all over the world; logs are imported from 48 countries, 13 countries less than in 1989, and lumber from 62 countries, also 13 less than the year before.

Imported logs and lumber are usually divided into 4 or 5 categories depending on their origin. These are North American Timber, South Sea Timber, North Sea Timber, New Zealand Timber and sometimes Chile Timber (Figure 3.2).[1] The exporting countries and the major species in each of the categories are described in Table 3.1. Of the imported timber, South Sea Logs are mainly used for veneer; in contrast, those from North America, Russia, and N.Z. are chiefly utilized for lumber. However, of those sawlogs, North

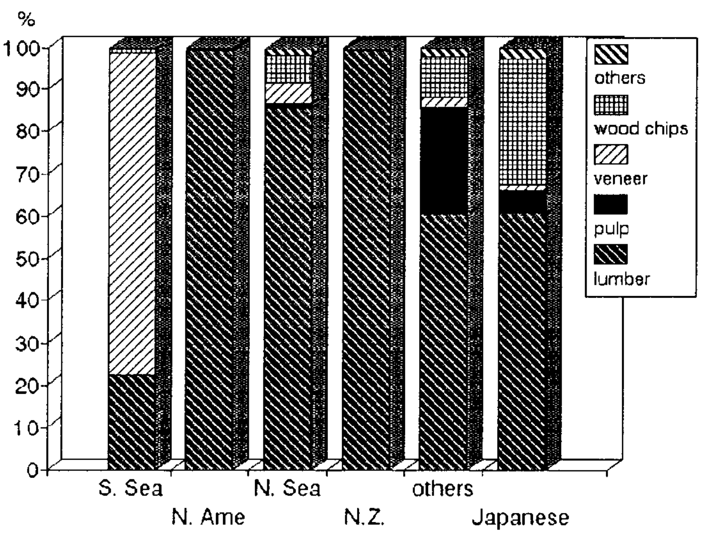

Figure 3.2 End Use of Imported Logs and Domestic Logs
Source: MAFF, Statistics and Information Dept., *Reports on Demand and Supply of Timber*

[1]The categories are according to the *Statistic Dictionary of Agriculture, Forestry, and Fisheries* (Association of Agricultural and Forestry Statistics 1985, p.241). "Timber" implies both logs and lumber.

Table 3.1 Exporting Countries and the Major Species in Five Imported Timber Categories

Categories American Timber	South Sea Timber	North Sea Timber	New Zealand Timber	Chili Timber
Countries				
USA (California, Oregon, Washington, Alaska) Canada (British Columbia)	Philippine Indonesia Malaysia Papua New Guinea Singapore Solomon Islands Brunei	USSR (east coast, Sakhalin)	New Zealand	Chili
Major Species				
pine	lawan	red pine	pine	pine
sitka spruce	red mernati	yezo spruce		
fir	white meranti	white fir		
spruce	keruing	larch		
larch	teak	oak		
white cedar	ramin	beech		
yellow cedar	oak	cotton wood		
hemlock	beech			
red cedar	kwarin			
douglas fir				
oak				
beech				
cotton wood				

Source: Ministry of Finance, *Imports of commodity by Country, Dec. 1990*

American and North Sea Timber are direct substitutes since lumber from these sawlogs are mainly used for housing construction (see Chapter 2.3 sawmill industry).

South Sea Timber used to be a major import in the Japanese market. In 1960, 71.6% of all imported logs and lumber were South Sea Timber. However, South Sea Timber has continuously lost its market share. In 1990, the market share dropped to 32.7%. This is because of a large increase in the supply of other timber, particularly North American Timber. Although South Sea Timber lost its market share, the quantity of both imported logs and lumber increased until 1973, a peak in lumber demand. However, imports of its logs have continuously declined since then (Figure 3.4). In contrast, imports of South Sea lumber have been increasing since 1975 (Figure 3.4). This is because exporting countries employed policies to promote their forest manufacturing industry and embargo exporting logs. At present, the countries that prohibit the export of some or all kinds of logs are Malaysia, which accounts for about 90% of South Sea Timber, Indonesia, which was the main exporter until the late 1970s, the Philippines, and Papua New Guinea. Recently, Indonesia and the Philippines also restricted the export of some finished wood products owing to the protection of their rain forests. Future imports of South Sea Timber could decrease since the movement for preservation of natural resources and the environment has become more popular all over the world (Forest Agency 1990, pp.44-48).

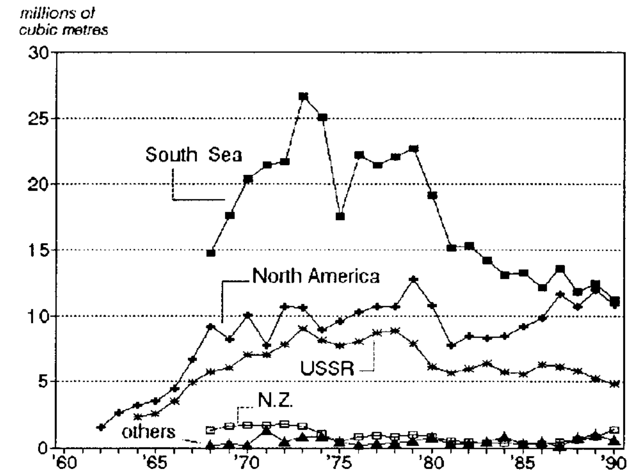

Figure 3.3 Quantity of Imported Logs, 1960-1990
Source: MF, *Foreign Trade Statistics*

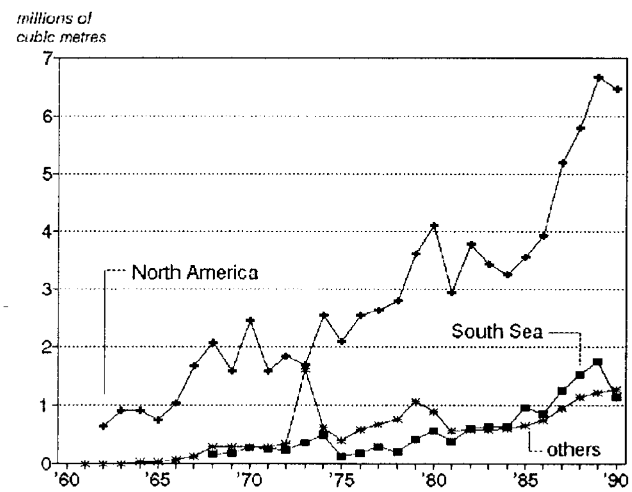

Figure 3.4 Quantity of Imported Lumber, 1960-1990
Source: MF, *Foreign Trade Statistics*

Imports of North American Timber have increased by a large amount since 1960. In

1960, 533,000 m^3 of both logs and lumber were imported by Japan. That was only 11.5% of the total imported logs and lumber. While total imports increased, the supply share of imported North American Timber expanded. In 1990, North America Timber accounted for 10,857,000 m^3 of logs or 37.6% of total imported logs next to South Sea Timber, and 6,471 m^3 of lumber which was 79.8% of total imported lumber. Of North American timber, the share of imports from Canada has increased (Figure 3.5). In 1975, 10% of total North American Timber was imported from Canada; in 1990, the Canadian share had increased to 24.2%.

Since Canada has restricted the export of its logs for decades, most North American logs were imported from the U.S., while 57% of lumber was imported from Canada. The decrease in Canada's log exports to Japan led to an increase in the U.S.'s log exports since they are direct substitutes for each other. Since April 1989, Canada has employed an export fee on logs for companies owning sawmills (Random Length Publications, May 10, 1990). The export fee has also applied to independent loggers since January 1990. The effect was rather obvious. Between 1988 and 1989, log imports from the U.S. increased by 16.4%, while those from Canada decreased by 26.9%. In 1990, total log imports from North America declined by a further 8.85% since the demand for lumber declined; imports from Canada declined by 42.3% in contrast to those from the U.S. which declined by 6.1%. However, the

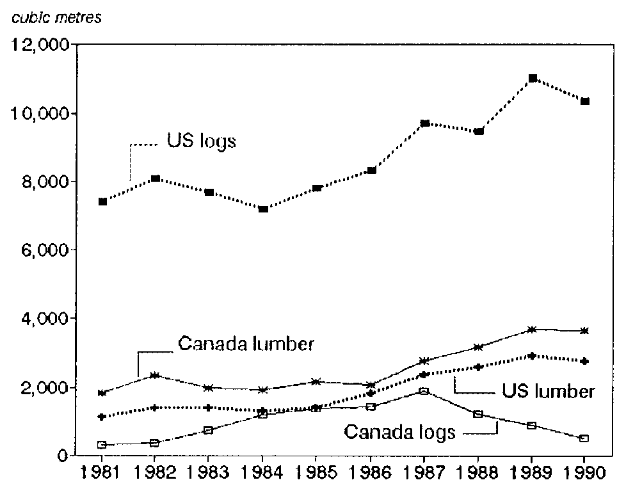

Figure 3.5 Change of the Import of North American Timber, 1980-1990
Source: MF, *Foreign Trade Statistics*

export fee on logs contributed to increased lumber exports from Canada to Japan. Between 1988 and 1989, lumber imports from Canada increased by 16.8%. In 1990, although total lumber imports from North America declined by 7.5% from 1989, those from Canada declined by only 1.0%.

The U.S. has banned export of logs from federal forests even though the practice is not so restrictive. However, in August 1990, the U.S. registered an Act to enforce restrictions on exports of logs from public forests, which was pushed by the Northwest Independent Forest Manufacturers (NIFM) and environmental groups to protect the sanctuary of the spotted owl. The *Forest Resources Conservation and Shortage Relief Act of 1990* includes the following: 1) a ban on the exports of unprocessed materials from federal forests, 2) a restriction on the indirect-export of the raw materials from federal forests, and 3) a restriction on raw materials exports from state forests. The Japanese Forestry Agency predicts that log imports from the U.S. will decrease by 15 to 20% of the 1990 level, or 1.5 to 2.0 million m^3 (Wood Products Stockpile Corp. Nov. 1990). The details of the decreases are: 1) 50% of log exports to Japan from Washington State forests, mostly Douglas fir; 2) 100% of those from Oregon and California State forests whose major species are Douglas fir and white fir; respectively, and 3) 30% of all indirect exports. Moreover, there is some movement to restrict log exports from private forests. Therefore, imports of North American logs will likely show a declining trend in the future.

The former USSR[2] or Russia is another major supplier of timber and is a direct

---

[2]The USSR was reorganized as the Commonwealth Independent States (CIS) in 1991. Since the major sourcing area of the USSR timber was Far East region and Sakhalin, the negotiation that Japan had between the USSR was transferred to the Republic of Russia.

competitor of North American Timber in the Japanese market. The import of logs from the former USSR showed a declining trend in the last decade (Figure 3.3). This was not due to a restrictions on the exports of raw materials, but as a result of a slow growth rate of timber supply caused by the shortage of labour, out-of date machinery, a strong demand for timber in the former USSR, and an increase in timber exports to the Peoples Republic of China (Forest Agency, 1990 pp.50-51). In contrast, imports of lumber from the former USSR have increased over the last decade (Figure 3.4). In 1990, Japan imported 4,865,000 m^3 of logs and 267,000 m^3 of lumber from the former USSR.

Imports of Soviet timber, often referred to as North Sea Timber in Japan, are operated by negotiation between two countries in which the quantity and the exchange rate for the year are also determined. However, the practise is done under uncertain circumstances. Particularly, many problems are seen in the process of shipping caused by insufficient facilities, irrational operation, and so on. Difficulty in accessing necessary information in the former USSR, and inadequate quality management are other factors that create unstable timber supply from the former USSR. Because of this instability, the supply of Soviet timber decreased between 1985 and 1989, even though the Japanese demand for lumber increased. Consequently, the market share of North Sea Timber was taken by other timber, particularly from North America. In 1985, the market share of North Sea Timber was 18.8%, but it decreased to 13.6% in 1990. In contrast, that of North American Timber increased from 39.7% to 45.9% during the same period.

The major tree species from New Zealand is radiata pine. Even though almost all of it is manufactured into lumber, this is not a direct competitor of North American Timber because final utilization of lumber is for packaging and boxes, not housing construction. The import of New Zealand Timber increased since 1987 as the import of those logs increased (Figure 3.3). Between 1989 and 1990, while all other timber imports declined due to decreased demand for lumber, only imports of New Zealand Timber increased. In 1990, New Zealand exported 1,373,000 m^3 of logs and 208,000 m^3 of lumber to Japan. Those quantities were nearly twice as much as the year before. The reasons for the increase in log imports are relatively high stumpage fees or costs, which bring profitable log sales, and inactive investment in the domestic wood manufacturing industry. Moreover, the New Zealand government is selling its national forest assets, and radiata pine, which accounts for over 95% of the replanted forest area, is being harvested. These factors also support an increase in log imports from New Zealand.

Imports of Chile Timber have increased over the last three years. The main species is radiata pine which is the same as New Zealand Timber. Unlike New Zealand, Chile exports more lumber than logs. In 1990, Japan imported 413,000 m^3 of logs and 415,000 m^3 of lumber, that is, the ratio of logs and lumber was almost 1 to 1, while that for New Zealand was 6 to 1.

Japan also imported logs and lumber from various other countries as indicated in Table 3.2. Asian countries exported various species of logs and lumber from both conifer and non-conifer trees. The Republic of Korea (South Korea) exported hemlock and Douglas fir lumber. This lumber is counted as North American Timber since its lumber is also used for housing construction. Although the amount imported was small--3% of North American hemlock and 1% of North American Douglas fir exports in 1990, exports to Japan have been increasing year by year. However, South Korea's roundwood production, which includes production of sawlogs, veneer logs and so on, in 1989 was 6,803,000 m^3 which was insignificant compared

Table 3.2 Exporting Countries and the Major Species of Imported Logs and Lumber Other Than Five Major Categories, 1990

Regions Asia	Africa	Europe	C. America S. America	Oceania
Countries				
Taiwan	South Africa	Norway*	Guatemala*	Australia
North Korea	Madagascar	Sweden*	Honduras*	Vanuatu
R. Korea	Gabon	Finland*	Mexico	Fiji*
China	Conga	Denmark	Panama	
Vietnam	Cameroon	Belgium	Belize**	
Cambodia	Tanzania	Netherlands	Brazil	
Laos	Mozambique	W. Germany	Argentina	
Thailand	Zaire	France	Paraguay	
India	Ivory Coast	UK*	Venezuela	
Myanmar	Zimbabwe	Greece**	Peru*	
Mariana (US)	Ghana*	Spain*	Bolivia*	
Mongol*		Yugoslavia*	Nicaragua*	
Hong Kong*		Italy*	Ecuador*	
Sri Lanka*				
Turkey*				
Major Species				
pines	okoume	pines	kwarin	ramin
fir	obeche	douglas fir	paulownia	kwarin
spruce	sapello	oak		
white cedar	tiama	beech		
yellow cedar	mansonia			
teak	kwarin			
oak				
paulownia				
kwarin				

* lumber only
** logs only
Source: Ministry of Finance, *Imports of Commodity by Country*, Dec. 1990

to roundwood production by the U.S. (533,168,000 m^3) or Canada (176,976,000 m^3). Therefore, South Korea cannot be replaced with the U.S. and Canada as a major timber supplier to the Japanese market. The reason for an increase in imports from South Korea is considered risk diversifying strategy on the part of Japan.

African countries export mainly tropical non-conifer trees. European countries export both conifer and non-conifer trees. Countries in Central and South America and Oceania export pine and various non-conifer trees. These non-conifer trees are usually manufactured into furniture and interior decoration. In any case, logs and lumber imported from those countries--that is, other than the countries in the 5 major categories--accounted for only 1.1% of total imported logs and 4.5% of total imported lumber in 1990.

Additional information concerning the countries that export logs and/or lumber to Japan and these species is provided in Table 3.2.

3.3 Importers of Logs and Lumber: Trading Companies

Imports of logs and lumber to Japan mostly depend on trading companies. There are about 300 traders that import either logs or lumber, or both. The traders can be classified into the following categories: 1) diversified trading companies that import not only wood products but also other kinds of products from all over the world; 2) companies that specialize in wood products including some sawmill associations, forestry associations and construction companies; and 3) joint ventures between the exporting countries and Japan. The objective of these companies is to pursue stable sources of supply.

There are few non-Japanese companies among them, such as MacMillan Bloedel. Of Japanese companies, many are large diversified trading companies that often have a strong influence on prices and policies in the Japanese market; they may even influence industrial policy decisions by the Japanese government. In the case of log imports, the ten largest trading companies are actually these powerful trading companies or their subsidiaries, such as Mitsubishi and Sumitomo. In 1989, 49.0% of total imported logs were traded by the top eight companies. Also seven out of the eight largest lumber importers, which held 44.1% of total lumber imports in 1989, were those diversified trading companies or their subsidiaries which specialize in wood products. MacMillan Bloedel was the only non-Japanese company considered as a large importer; it ranked as the sixth largest importer of total lumber and the second largest importer of North American lumber in 1989.

As mentioned previously, supply of imported logs and lumber to the Japanese market mainly depends on the large companies. However, these companies do not have the strong market power they had previously because many more trading companies are now involved in trading. Particularly in the case of trading South Sea Timber and North American Timber, the concentration ratio of the four largest companies, for example, is not high (Table 3.3). However, in the exporting countries, a small number of large companies have some market power over production and shipments of logs and lumber. Consequently, this market power starts to have some influence in the Japanese market (Forest Agency 1990, p.112).

In contrast, the concentration ratio for North Sea lumber, New Zealand Timber and Chile Timber for the four top companies are considerably higher since there are not so many companies involved in the trade. Imports of N.Z. lumber heavily depend on one company (62.2%) which specialized in trading between Japan and N.Z.. Also, imports of both logs and lumber from Chile heavily depend on a single company (controlling 75.3% and 43.5% of logs and lumber, respectively); the company is one of the largest house building companies in Japan, specializing in the traditional pillar and beam method of construction. This implies existence

Table 3.3 Concentration Ratio: Major Traders of Imported Logs and Lumber, 1989

	South Sea	North American	North Sea	N.Z.	Chili	Total
Concentration ratio						
LOGS						
4	29.6%	35.8%	29.2%	66.7%	99.4%	31.1%
8	50.1%	56.2%	48.8%	97.6%	--	49.0%
12	60.1%	71.3%	64.0%	--	--	61.3%
16	68.4%	80.8%	73.2%	--	--	67.3%
20	74.9%	86.4%	79.3%	--	--	71.6%
LUMBER						
4	52.6%	26.2%	63.3%	90.0%	75.9%	24.9%
8	50.2%	47.5%	83.0%	99.6%	92.8%	44.1%
12	60.6%	61.7%	93.1%	--	98.1%	58.5%
16	68.5%	69.6%	98.3%	--	--	65.3%
20	74.1%	75.2%	--	--	--	70.5%

largest Eight Companies

ALL LOGS	ALL LUMBER
1 Nichimen	1 Mitsubishi
2 Nisho Iwai	2 Nisho Iwai
3 Marubeni	3 Itochu
4 Sumitomo	4 Nichimen
5 Itochu	5 Marubeni
6 Yuasa	6 MacMillan Bloedel
7 Mitsubishi	7 Sumitomo Ringyo
8 Tomen	8 Sumitomo Lumber

Source : Wood Products Stockpile Corp. Japan, Business Data 1989

of some market power in the market for logs and lumber in these categories. Therefore, it can be concluded that some market power exists in the supply of any kind of imported logs and lumber to the Japanese domestic market.

3.4 Competitiveness of Imported Lumber in the Japanese Market

In 1975, the total supply of foreign-origin lumber to the Japanese domestic market was 37,450,000 m^3, with 6.5% imported as lumber from the original countries. The rest was processed in Japan. The ratio of imported lumber had increased to 23.9% in 1989. Particularly, the proportion for South Sea Timber has increased from 2.3% in 1975 to 47.5% in 1989. That of North American Timber has also changed. It rose from 17.4% to 35.4% during the same period (Japanese Timber Union's Association 1990 pp.18-19). The increase in foreign-origin lumber induced the changes in Japanese domestic sawmilling industry discussed in the previous chapter. An increase of imported lumber in Japanese domestic market implies a decrease in the market for domestic sawmilling industry. The advantages of foreign-origin lumber are analyzed from the supply system of domestic timber and imported timber, and a comparison of lumber producing costs in importing countries and Japan.

3.4.1 Comparisons of Supply System

The analyses of supply system was presented by the Forest Agency (1990, pp.110-118) and Wood Products Stockpile Corp. (1987). The supply system differs between domestic logs and imported logs. The supply system of domestic logs is provided in Figure 3.6.[3] The major characteristics of the system were as follows.

1) Because of the large number of small land owners, the size of trades is small and there are many varieties of logs in each trade.
2) Sawmills which process domestic logs are relatively small.
3) Distribution channels are sawlog markets and lumber markets, rather than wholesalers where the logs are sold by auction or bid. There were 460 sawlog markets and 257 lumber markets in 1984.

---

[3]The percents represent the quantity ratio of each player in the flow when the outputs or inputs are 100% in 1984.

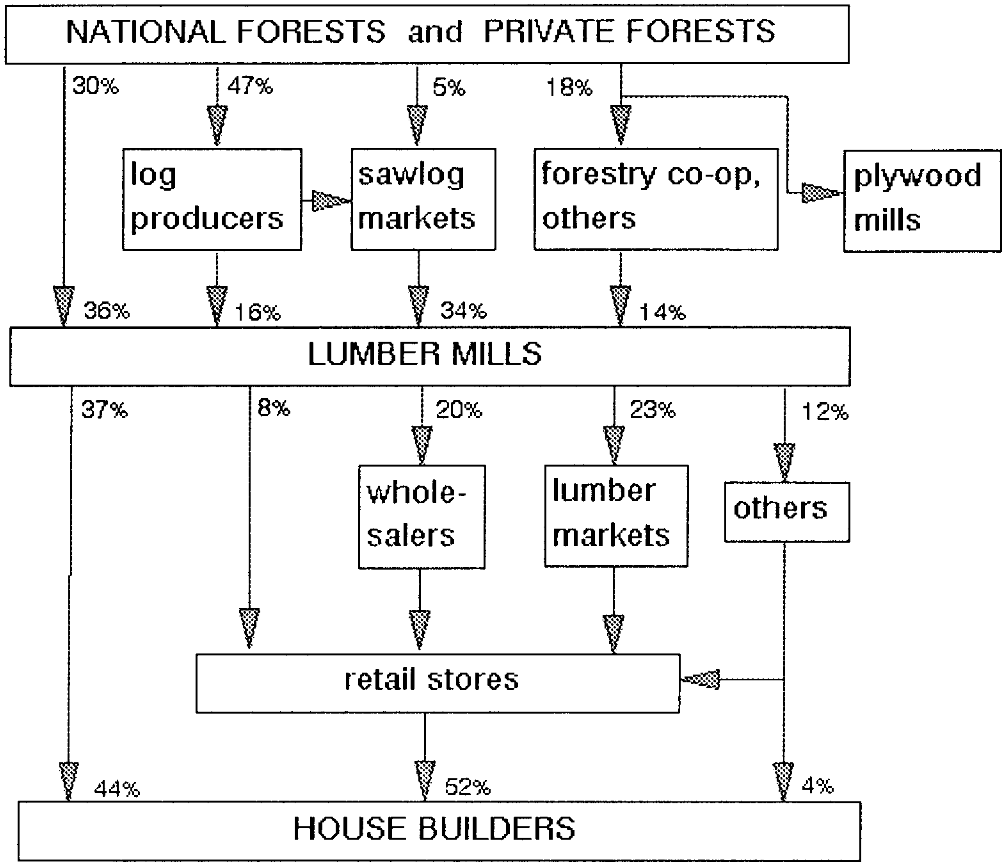

Figure 3.6 Flow of Domestic Logs Source: *Reports on Timber Flow*

4) The majority of house builders using domestic logs are individual carpenters and national construction companies that often entrust their jobs to individual carpenters. Since they purchase lumber for each house, the amount of each sale is small. Some construction companies start to have their own constructional sections in order to rationalize their material consumption system. Moreover, diversification of construction methods prevent them from getting jobs since most of individual carpenters's skill is limited to traditional construction methods. Also, difficulties in rationalizing their markets (e.g. advertising) creates less competitiveness in the housing construction market. The number of individual carpenters to decline.

All these conditions lead ineffective supply system of domestic logs such as high transportation costs and inefficient marketing and are obstacles to promote domestic lumber.

The supply system of imported logs is provided in Figure 3.7. The major characteristics are as follows.

1) Imported logs are supplied to the Japanese domestic market by a relatively small number of large trading companies. There is some degree of market power as was mentioned in the previous section.

2) Logs are distributed by mainly wholesalers to middle consumers, or lumber mills.

3) The scale of each trade is relatively large, and each trade contains the same species and

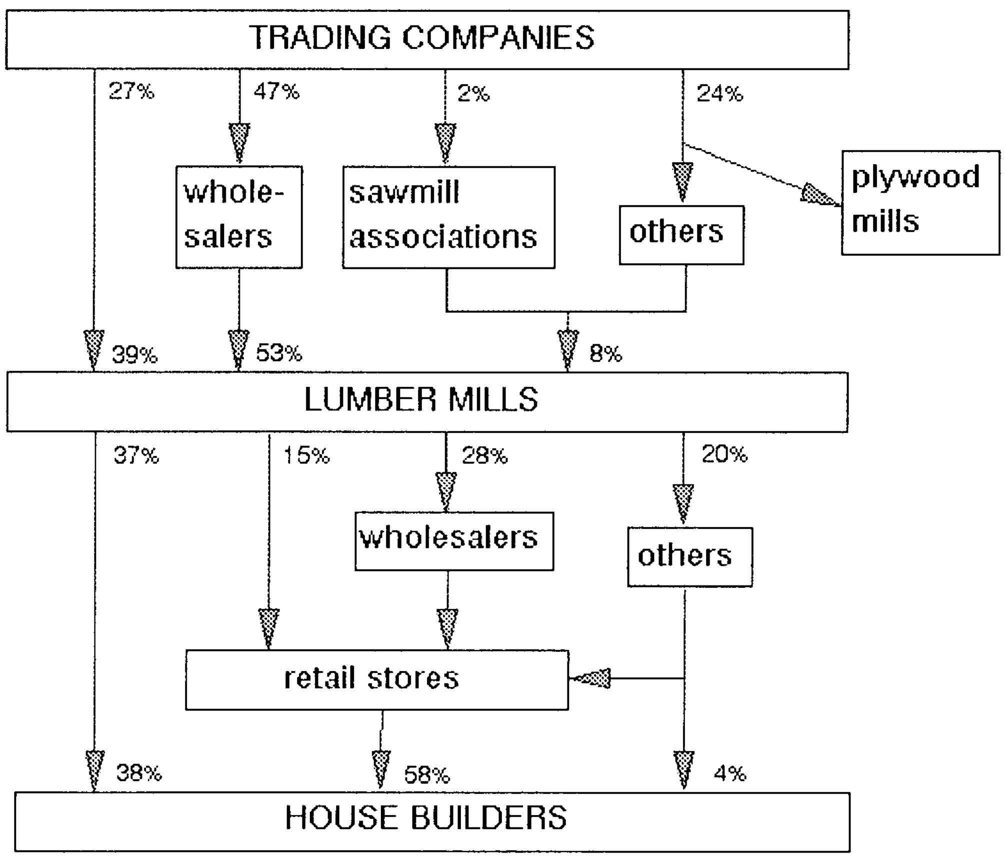

Figure 3.7 Flow of Imported Logs Source: MAFF, *Reports on Timber Flow*

even quality of logs.

4) Logs are processed in relatively large sawmills.

5) Fifty-eight percent of the processed lumber is distributed by retail stores through wholesalers. These retail stores and wholesalers usually deal not only in processed lumber but also domestic logs and imported lumber. The distributors have changed over the past several decades; more than half of foreign-origin lumber was directly distributed by sawmills to house builders in 1972.

6) The major consumer of foreign-origin lumber was middle- to large-size, regional construction companies. They specialize in a particular region and promote aggressively to meet the needs of the region. They often have their own constructional section and consume large amount of materials.

Overall, the system is quite rational in terms of physical distribution and transfer of the title.

3.4.2 Comparisons of Production Cost

Cost comparisons for three kinds of lumber, particularly for posts, are presented at Table 3.4 (Japanese Lumber Association 1990, pp.32-33). The comparisons are for hemlock lumber processed in North America which is the major species of North American Timber exported for to Japanese market, hemlock lumber processed in Japan, and middle-size Japanese cedar lumber which is strong substitution of North American hemlock lumber. Since direct processing costs are

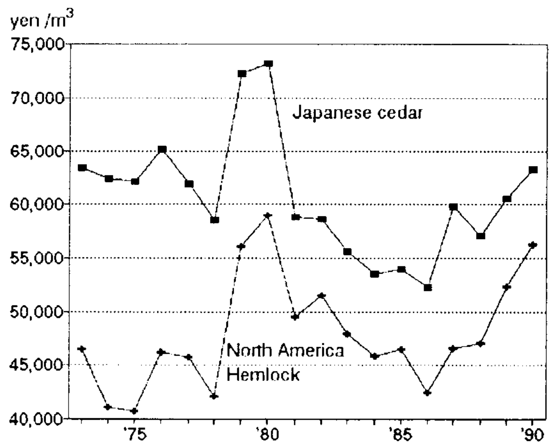

Figure 3.8 Prices of Imported and Japanese Lumber, 1973-1990
Source: MAFF, *Price of Timber*

Table 3.4 Cost Comparisons for North American Lumber Processing

costs description	imported lumber (hemlock)[1]	processed in Japan (hemlock)[2]	processed in Japan (cedar)[3]
raw materials	24,800	36,200	40,000
direct labour	3,600	5,400	7,500
fuel,electricity	1,400	2,500	2,000
sub total	29,800	44,100	13,500
depreciation	2,100	1,200	1,000
transportation	10,300	1,800	1,500
operation	3,200	3,300	3,800
chips revenue	- 2,400	- 2,000	- 1,000
TOTAL	43,000	48,400	54,800

Source: MAFF, Forestry and Forest Products Research Institute
notes for sawmills:
1) North America West Coast. Process for Japan.
2) Shizuoka Pref.. Specialized in North American logs. Production: 150m^3/day.
3) Shizuoka Pref.. Mainly process Japanese logs. Production: 15m^3/day.
notes: Exchange rate US$ 1 = 130 yen.
Costs are at March 1990.

much higher in Japan, total production costs of imported lumber are lower than those processed in Japan even though the transportation cost is taken into account. Consequently, the price of imported lumber is much lower than that of Japanese lumber (Figure. 3.8). The price of lumber in the Japanese market is led by imported lumber. Therefore, Japanese sawmills are struggling to cut their production costs; some sawmills are actually forced to process at shut-down point. However, these conditions create good opportunities to promote imported lumber. The number of North American sawmills focused on the Japanese market increased in the U.S. North Coast region and B.C.. They process a finished products variety of finished products, such as a custom cut lumber and Kiln Dry Lumber.

3.5 Prospect of Log and Lumber Imports and the Policy

As mentioned in section 2, log imports from the U.S. were restricted in August 1990. The reaction of the Japanese forest industry was rather calm. There are several reasons that the embargo would not affect the Japanese market, at least in the short term (Wood Products Stockpile Corp., Nov. 1990).

1) There was a large stock of North American logs at the end of July 1990.
2) Appreciation of the Yen in August 1990 brought some loss for trading companies.
3) The influence of the embargo on exports of the U.S. logs will not likely appear until late 1991.
4) Housing construction is expected to fall in 1991 because of high interest rates in Japan.
5) A decrease in log imports from state forests in the U.S. can be covered by logs from private forests.
6) These is a labour shortage in the sawmill industry in Japan.

There are some considerable changes in the structure of the North American Timber supply. The vice-director of the construction material department in the trading company "Marubeni" analyzed the influence as follows (Wood Products Stockpile Corp., Nov. 1990):

> "Imports of manufactured materials must increase. The circulation of lumber in Japan will change such as to sell to the house builder directly excluding wholesalers, or to sell only to wholesalers who can maintain a stable supply system."

Also, the Japanese sawmill industry association mentioned the possibility of a change in the demand structure of lumber. The board of governors of the Japanese North American Timber Sawmill Association answered in interview as follows:

> "If the imports of North American logs decreases, the demand for North American lumber itself would decrease. Nowadays, the construction of non-wood houses has been increasing. Also, there are a lot of substitutes for North American lumber such as

> laminated lumber. Only high quality trees such as douglas fir would be necessary to decorate the laminated lumber. If the prices of these materials rise, other materials such as compound plywood or non-wood material will be substituted for lumber."

Interest rates in the U.S. and Canada are declining in 1991. As a result, housing construction in both countries is starting to increase. This implies an increased demand for lumber in both countries. Since the two countries are practising sustainable harvests of timber, the supply of logs to Japan should decrease. Therefore, an increase in lumber exports is inevitable.

4 Theoretical Considerations

Estimation of empirical models provide the parameters which reveal the relationship between more than two economic phenomena. Estimation is a process of econometrics. The main objective of econometrics is to provide empirical verification of the economic theory. Therefore it is essential that every econometric model be supported by economic theory. Lack of theoretical consistency leads to a mis-specification of the empirical model to mis-specify. Consequently, the results of the estimation are inaccurate. In this study, a gravity model is employed for estimation of an empirical model. In order to provide consistent results, all relevant microeconomic theory of gravity models is examined.

4.1 Theory of Gravity Models

A gravity model is a reduced form of simultaneous supply and demand systems. Examining consumer's preferences and behaviour, and deriving demand systems is a fundamental task for appropriate application of the gravity model. Another task is analyzing how rational firms maximize their profit, and then develop the ensuing supply system. Finally, how theses two systems are linked should be examined carefully. Good analyses of microeconomic theory that is related to gravity models are presented by Layard and Walters (1987), Deaton and Muellbauer (1983), Birchenhall and Grout (1984), Varian (1984), and Okuno and Suzumura (1984).

Preference and Utility

Consumer's tastes are often represented by utility functions. Consumer's preference are rationalized by some ordering and reasonable assumptions. They are called axioms of choice, and are recognised as a precondition for the existence of utility functions. Formally, the following six axioms are defined; completeness, transitivity, reflexivity, continuity, local nonsatiation and strict convexity. The first three axioms define an ordering of preference. Completeness implies that any set of two bundles can be compared.[1] Transitivity says, if A is at least as good as B, and B is at least as good as C, then A is at least as good as C.[2] Reflexivity means that each bundle is at least as good as itself. The last three axioms are assumptions to support the ordering. Continuity says if (A) is a set of bundles in which any bundle X is at least as good as a bundle Y, and (B) is a set of bundles in which X is no better than Y, then (A) and (B) are closed. It follows that, if (A) and (B) are a strict preference relation, then (A) and (B) are open sets.[3] Local nonsatiation indicates that there exists at least one bundle which is always preferred to others. The last assumption is that if (A) is a set of bundles which is at least as good as Y, then (A) is a convex set. That is, indifference curves are convex to the origin. All these axioms are reflected in utility functions.

Consumer Behaviour

A consumer's preferences are defined in the previous section. A consumer can choose any bundle. However, possibilities exist completely independent of a consumer's choice. This

---

[1]When this is not true, for example, two bundles are equally preferred or indifferent.

[2]In the real world, it is possible to prefer C to A although A is preferred to B and B is preferred to C.

[3]There exists a strong counter ordering called lexicographic ordering. This is a set of discontinuous preferences and is ruled out for convenience.

is frequently presented as limitation of choice. For example, consumers have to carry out their consumption plan within the possibility frontier; in other words, a consumer's physical choice for the commodities is constrained by their budget. A rational consumer is assumed to maximize his or her satisfaction subject to the limitation. The problem of standard utility maximization can be written:

$$\text{Maximize } \mathbf{u}(\mathbf{x}_i) \text{ subject to } \Sigma\, \mathbf{p}_i\mathbf{q}_i = \mathbf{y}$$

where $\mathbf{y}$ is total expenditure, and $\mathbf{p}_i$ and $\mathbf{y}$ are positive. The solution of this problem is the system of Marshallian demand functions which is written:

$$\mathbf{x}_i = \mathbf{x}_i(\mathbf{y},\mathbf{p})$$

Marshallian demand functions have two properties; (1) Adding up requires that the total value of Marshallian demands are equal to total expenditure. It follows that the weighted average of income elasticities is unity where the weights are the relative shares of each good. (2) Homogeneity says that the Marshallian demands are homogeneous of degree zero in prices and total expenditure.

Theory of the Firm

Economic profit is defined as the difference between the total revenue and the total costs. The firm is assumed to maximize its profit. This problem is constrained by two factors. One is technological constraints concerning a feasible production set. The other is market constraints, or a firm's market opportunities for selling outputs and buying inputs. In the gravity model, each firm is assumed to be a price-taker with one input which is differentiated by importers of the commodity.

The set of feasible production plans--possible combinations of inputs and outputs--is called the production possibility set for the firm. This set represents the technological possibilities which the firm faces. For example, when technology is defined as a production function $\mathbf{q} = \mathbf{f}(\mathbf{x})$, the production possibility set is defined as $\mathbf{q} - \mathbf{f}(\mathbf{x}) = \mathbf{T}(\mathbf{q}, \mathbf{x}) = \mathbf{0}$. Three main properties of this set are monotonicity or free disposal, convexity and weak regularity. The production possibility set is a closed nonempty set. Some important topics that are related to technology and can be derived from production functions are the technical rate of substitution and returns to scale.

The short-run profit maximization problem for a competitive firm with single input can be written as:

$$\pi(\mathbf{p},\mathbf{w}) = \text{maximize } \mathbf{pf}(\mathbf{x}) - \mathbf{wx}$$

where $\mathbf{p}$ is output price, $\mathbf{f}(\mathbf{x}) = \mathbf{q}$ is output, $\mathbf{w}$ is input factor price, and $\mathbf{x}$ is the amount of the input. The first-order conditions for the profit maximization problem are:

$$\mathbf{p} = \mathbf{f}'(\mathbf{x})\mathbf{w} = \textbf{marginal cost}$$

This gives the supply function for output. Another expression

$$\mathbf{w} = \mathbf{pf}'(\mathbf{x}) = \textbf{value of the marginal product}$$

is the demand for the input.

General Equilibrium

General equilibrium analyzes the behaviour of all individual decision-making units and of all individual markets simultaneously. When consumption and production are brought together, existence of equilibrium is the critical point, particularly whether there is an equilibrium price and whether the equilibrium is unique. According to Walras' Law,[4] if there are markets, that have excess demand (import) of any good (say X because of the relatively low price of good X to good Y), there should be other markets that have excess supply (export). When the relative price in the first group of markets rise, the excess demand will decline, and there must be some relative price for which excess demand is zero. This is a point of equilibrium. Since a rise in relative price always decreases excess demand for X in the former markets, and decreases excess supply in the other markets symmetrically, there should be a unique equilibrium.

4.2 Functional Form

The theory of a gravity model was standardized by Linnemann (1966) as a reduced form from a partial equilibrium model of export supply and import demand systems. According to Linnemann, trade flows are explained by the following three kinds of factors: 1) economic factors influencing the supply from exporting countries, 2) economic factors influencing the demand of importing countries, and 3) natural and artificial factors that attract and/or resist trade flows. However, Bergstrand (1985) claimed that Linnemann's formulation lacked strong theoretical foundations, especially omitting some price variables.

A detailed microeconomic foundation was given to the gravity model by Anderson (1979) and Bergstrand (1985, 1989). Bergstrand specified the following equation for bilateral gross aggregate trade flows (1985):

---

[4]The sum of positive excess demands and absolute value of the sum of negative excess demands must be equal.

$$PX_{ij} = \beta_0 Y_i^{\beta_1} Y_j^{\beta_2} D_{ij}^{\beta_3} A_{ij}^{\beta_4} u_{ij} \tag{4.1}$$

where $\mathbf{PX_{ij}}$ is the value of the flow of the commodity under investigation from exporting country $\mathbf{i}$ to importing country $\mathbf{j}$; $\mathbf{Y_i}$ and $\mathbf{Y_j}$ are values of nominal GDP in $\mathbf{i}$ and $\mathbf{j}$, respectively; $\mathbf{D_{ij}}$ is the distance between $\mathbf{i}$ and $\mathbf{j}$ as a natural resistance to trade flows; $\mathbf{A_{ij}}$ is any other factors attracting and/or resisting trade flows in commodity X between $\mathbf{i}$ and $\mathbf{j}$; and $\mathbf{u_{ij}}$ is the random error term. Bergstrand derived equation (1) from a general equilibrium framework. He first derived import demand equations by maximizing the constant elasticity of substitution (CES) utility function subject to income constraints, and supply equations by maximizing the constant elasticity of transformation (CET) production function. He assumed CES between domestic and imported goods, as well as among imported goods from individual countries in the demand system. The CET between domestic and exporting goods, and among exporting goods to individual countries was also assumed.

Koo (1991) constructed commodity specific gravity model by simplifying Bergstrand's specification. Unlike Bergstrand, Koo assumed the CES and the CET only among the world markets using the same utility and profit maximization behaviour. In other words, the single commodity is assumed to be differentiated by country of origin. Another difference of the between Koo's gravity model specification and that of Bergstrand is that, Koo used quantity of trade as a dependent variable while Bergstrand used value of trade as a dependent variable. A formulation of the gravity model similar to that of commodity specific gravity mode is provided below.

Two-Stage Budgeting

Utility maximization among differentiated goods is supported theoretically by two-stage budgeting. A good review of two-stage budgeting is presented by Deaton and Muellbauer (1980, 1983). The key concept of two-stage budgeting is separability of preferences which allows one to generate within group budgeting independent of other groups. Under two-stage budgeting, a consumer allocates the total budget in two stages; in the first stage the total budget is allocated to broad groups of goods, and then to individual goods in the second stage. Because of separability of preferences, information is required only for each stage in order to allocate budget. Therefore, at the second stage, group expenditure and prices within the group are sufficient to express the so-called Marshallian subgroup demand function. The subgroup demand functions have the same properties as demand functions since they are derived from ordinary maximization of utility.

Consumer's Utility Maximization: Import Demand System

Consumer theory is the key concept to derive import demand functions. Each importing country **j** is assumed to maximize the identical CES utility function,

$$U_j = (X_{1j}^{\theta_j} + X_{2j}^{\theta_j} + \cdots + X_{Nj}^{\theta_j})^{1/\theta} = (\sum_{k=1}^{N} X_{kj}^{\theta_j})^{1/\theta} \qquad j=1,\ldots,M \quad j \neq k \tag{4.2}$$

where $\mathbf{X_{kj}}$ is the quantity of the aggregate good imported from country **k** to **j**; and $\theta_j = (\sigma_j\text{-}1)/\sigma_j$ where σ_j is the CES among imported goods; and N and M are the number of exporting and importing countries, respectively. Consumption expenditures are constrained by income on an aggregate level:

$$Y_j=\sum_{k=1}^{N}\overline{P}_{kj}X_{kj}, \qquad where \qquad \overline{P}_{kj}=\frac{P_{kj}T_{kj}C_{kj}}{E_{kj}} \tag{4.3}$$

where $\mathbf{P_{kj}}$ is the unit value of the commodity imported from **k** and sold in **j** in **k**'s currency; $\mathbf{T_{kj}}$ is $\mathbf{1+t_{kj}}$, where $\mathbf{t_{kj}}$ is **j**'s import tariff rates on the commodity from **k**; $\mathbf{C_{kj}}$ is the transport cost rate derived as **i**'s c.i.f. divided by **j**'s f.o.b.; and $\mathbf{E_{kj}}$ is the spot exchange rate of **j**'s currency in term of **k**'s currency. Maximizing equation (2) subject to (3) by forms Lagrangian function yields the following import demand equations:

$$X_{ij}^{d}=Y_jP_{ij}^{-\sigma_j}T_{ij}^{-\sigma_j}C_{ij}^{-\sigma_j}E_{ij}^{\sigma_j}(\sum_{k=1}^{N}\overline{P}_{kj}^{1-\sigma_j})^{-1} \qquad i=1,..N, \quad j=1,...M, \quad i\neq j \tag{4.4}$$

where $\mathbf{X_{ij}^{d}}$ is the quantity of trade flow between an importing country **j** and an exporting **i** among all exporting countries represented as **k**.

Firms' Profit Maximization: Export Supply System

The export supply equation is derived from the firms' profit maximization behaviour. The firms in exporting country **i** are assumed to produce differentiated products for the world market, and to maximize the following profit function:

$$\pi_i=\sum_{k=1}^{M}P_{ik}X_{ik}-W_iR_i \qquad i=1,\ ...,\ N, \quad i\neq k \tag{4.5}$$

where $\mathbf{P_{ik}}$ is the unit value of the commodity exported by country **i** and paid by country **k**; $\mathbf{X_{ik}}$ is the quantity of the commodity from **i** to **k**; $\mathbf{W_i}$ is the unit value of $\mathbf{R_i}$ in **i**'s currency, and $\mathbf{R_i}$ is the amount of single resource used to produce the commodity in a given year in country **i**. $\mathbf{R_i}$ in each country is allocated according to the following CET production function:

$$R_i=(\sum_{k=1}^{M}X_{ik}^{\phi_i})^{1/\phi_i} \qquad i=1,\ ...,\ N \tag{4.6}$$

where $\phi_i = (1+\gamma_i)/\gamma_i$ and γ_i is the CET among exporters. This also implies a two-stage decision to allocate income to produce the commodity for each country that imports the commodity from **i**, so that producing country **i**'s income is constrained by

$$Y_i = W_i R_i \qquad i=1,\ldots,N \tag{4.7}$$

Substituting equation (4.6) into(4.5), maximizing the resulting equation, and then applying (4.7) yields the following export supply equations:

$$X_{ij}^{s} = Y_i P_{ij}^{\gamma_i} \left(\sum_{k=1}^{M} P_{ik}^{1+\gamma_i}\right)^{-1} \qquad i=1,\ldots N \quad j=1,\ldots M \quad i \neq j \tag{4.8}$$

where $\mathbf{X}_{ij}^{s}$ is the quantity traded from an exporting country **i** to an importing country **j** among all importing countries **k**.

General Equilibrium Condition

Assume general equilibrium conditions such that supply and demand are simultaneously in equilibrium, that is:

$$X_{ij} = X_{ij}^{d} = X_{ij}^{s} \tag{4.9}$$

where $\mathbf{X}_{ij}$ is the equilibrium quantity traded from **i** to **j**. Since the gravity equation is the reduced form of equations (4.4) and (4.8), it is derived as follows from (4.9):

$$X_{ij} = Y_i^{\sigma_j \delta_{ij}} Y_j^{\gamma_i \delta_{ij}} T_{ij}^{-\gamma_i \sigma_j \delta_{ij}} C_{ij}^{-\gamma_i \sigma_j \delta_{ij}} E_{ij}^{\gamma_i \sigma_j \delta_{ij}} \left(\sum_{k=1}^{M} P_{ik}^{1+\gamma_i}\right)^{-\sigma_j \delta_{ij}} \left(\sum_{k=1}^{N} \overline{P}_{kj}^{1-\sigma_j}\right)^{-\gamma_i \delta_{ij}} \tag{4.10}$$

$$\text{where} \quad \delta_{ij} = 1/(\sigma_j + \gamma_i) \qquad i=1,\ldots.N, \quad j=1,\ldots.M$$

4.3 Review of Previous Studies

Most studies analyzing flows and policies of lumber trade used spatial models developed by Samuelson (1952), and Takayama and Judge (1964). W. McKillop (1973) structurally analyzed the effects of the U.S.'s restrictions on the export of logs from Federal lands to Japan which were imposed in 1968. In order to segregate factors influencing the trade flows, three demand equations and three supply equations were constructed. These simultaneous linear equation models enabled the linking of three markets, Japan, the U.S. and Canada, and two commodities, logs and lumber. The results suggested the inelasticity of Japan's import demand for North American logs and lumber.

The simultaneous linear equation model was also used to analyze the demand behaviour for timber in the Japanese market by Mori (1981). He employed the economic model using both domestic and imported supply and demand equation and the equilibrium conditions to reveal an aggregate supply and demand relationship in the Japanese market. The results were satisfactory; his model captured the actual movements.

The impact of the U.S.'s export embargo on logs was also examined by Wiseman and Sedjo (1981). They focused on softwood logs exported from the Pacific Coast Region of the US, and analyzed the effects of the log-export embargo under two levels of feedback in the lumber market from the point view of exporters. Wiseman and Sedjo used a partial equilibrium model introducing Marshallian derived demand theory. The models enabled the analysis of both log and lumber markets simultaneously; the movements in the primary (log) market were directly reflected in the final product lumber) market. He suggested an export embargo on logs would improve the region's lumber market but deteriorate the log market.

Boyd and Krutilla analyzed the impact of the US trade policies on Canadian softwood lumber (1987). Their spatial equilibrium model, which employed the so-called reactive programming (RP) method, examined the various flows of lumber and constructed linear demand functions for each of 39 demand regions and linear supply functions for each of 34 supply regions in North America. The sum of the net economic welfare was maximized using a quadratic functional form. They calculated values of loss or gain caused by the trade policies for the various elasticities of Canadian export supply.

A gravity model was used to analyze the world trade for wood products by Nagy et al. (1983). They first computed unweighted averages of shares in the total world trade for time series data for each of the trade flows in order to incorporate both time-series and cross-sectional effects. They then chose trade flows such that the shares were bigger than 0.005%. Using cross-sectional data, he constructed log linear gravity equations for each of 12 wood products including conifer and non-conifer logs. A remarkable point of this model is the dependent variable; share of world trade (percent) derived as the quantity of one flow divided by the quantity of world trade. The models consisted of the following variables; 1) a dummy variable for those flows with shares of more than 1% as attraction for the flows, 2) the distance between the exporting countries and importing countries as natural resistance for the flows, 3) the population of both the exporting and importing countries as consumption capacity of the housing markets, and 4) the GDP of both the exporting and importing countries as domestic production capacity. From the results, he remarked that GDP and population may not affect the trade flows. However, the attractive and resistant factors seemed to be more influential in flows of wood products.

A commodity specific gravity model was developed by Koo, Karemera and Taylor to analyze meat trade policies. The model used pooled time series and cross-sectional data which they considered most appropriate for agricultural commodities since they are highly influenced by nature. Like traditional gravity models, a log-linear functional form was estimated using the so-called *covariance model* or *least squares dummy variables model*. The commodity specific gravity model enabled them to incorporate 29 variables. These were distance, GDP, population, grazing land area, export and import prices, inflation rates, exchange rates, trade polices such as Long Term Agreement and producer subsidies, dummy variables for economic unions such as the EC, dummy variables for extant diseases, and technology. The results strongly supported the hypotheses of both traditional gravity models and commodity specific gravity models.

5 Estimation of Empirical Model

5.1 Empirical Gravity Model

The commodity specific gravity model for a perfectly competitive market was derived in the previous chapter and can be restated as follows:

$$X_{ij}=\alpha_0 Y_i^{\alpha_1} Y_j^{\alpha_2} C_{ij}^{\alpha_3} T_{ij}^{\alpha_4} P_i^{\alpha_5} P_j^{\alpha_6} E_{ij}^{\alpha_7} A_{ij}^{\alpha_8} u_{ij} \qquad i=1,...N,\ j=1,...M \tag{5.1}$$

where: **X_{ij}** is the quantity of the commodity X traded from country i to country j;
Y represents the respective incomes of the countries;
C_{ij} is transport cost rate derived as i's c.i.f. divided by j's f.o.b.;
T_{ij} is j's tariff on the commodity imported from i;
P is the price of the commodity at the import or export port in the respective countries;
E_{ij} is the spot exchange rate of j's currency in terms of i's currency;
A_{ij} is any other factor(s) either inducing or resisting the trade; and
u_{ij} is the random error term.

The empirical model for softwood lumber trade to Japan in this analysis is based on Koo's commodity specific gravity model since this model can incorporate various variables such as trade policies and economic indicators. The empirical model for analyzing Japan's lumber trade is constructed as follow:

$$Q_{ij}=\beta_0 PROD_i^{\beta_1} PROD_j^{\beta_2} PGDP_i^{\beta_3} PGDP_j^{\beta_4} D_{ij}^{\beta_5} T_{ij}^{\beta_6} Pex_i^{\beta_7} Pim_j^{\beta_8} E_{ij}^{\beta_9} RM_{ij}^{\beta_{10}} Q_{ij,t-1}^{\beta_{11}} u_{ij} \qquad i=1,....6 \tag{5.2}$$

where: **j** denotes a single importer, Japan;
i denotes exporting countries as in the conventional model;
Q_{ij} is the quantity of lumber traded from country **i** to country **j**;
PROD stands for the quantity of roundwood production in the respective countries;
PGDP refers to per capita gross domestic products in the respective countries;
D_{ij} represent both distance between exporting country i and Japan and ocean freight indices;
T_{ij} is the weighted average of Japan's tariff on softwood lumber from country i;
Pex_i is the export price of lumber;

$\mathbf{Pim_j}$ is the import price of lumber at the port in Japan;
$\mathbf{E_{ij}}$ is the spot exchange rate of j's currency in terms of i's currency;
$\mathbf{RM_{ij}}$ is the value of raw material trade from country i to Japan;
$\mathbf{Q_{ij,t-1}}$ is the quantity traded in the previous year; and
$\mathbf{u_{ij}}$ is the error term.

In this analysis, there is a single importing country, Japan. This is because the focus of this study is the demand for imported softwood lumber in the Japanese market. Exporting countries are Canada, the United States, the USSR, New Zealand, Korea, and Chile since they are the major exporters of softwood lumber to Japan and their average trade shares for last 10 years are greater than 1.0%.

Unlike conventional gravity models, both exporting and importing countries' production of roundwood is included instead of gross domestic products (GDP) to measure domestic supply power since production of lumber is heavily related to production of natural resources. Roundwood production includes production of sawlogs, veneer logs, pulpwood, other industrial wood and fuelwood. This measures domestic production power. As production power increases, the exporter ships more lumber overseas. Less production power induces the import of more lumber for a importing country. The coefficients for roundwood production in both exporting and importing countries are expected to be positive and negative, respectively. Per capita GDP is used in this model to indicate domestic purchasing power. When the purchasing power rises in the exporting country, more lumber is purchased domestically and less lumber is exported. When it rises in importing country, more lumber is imported. The expected signs of per capita GDP are negative for exporter and positive for importer.

Distances are used in place of transportation costs in conventional models. This might be appropriate for the conventional models since they use only cross-sectional data in a given year. However, the empirical model uses both cross-sectional and time series data. Transportation costs are most unlikely constant over 15 years and assuming that they are creates some difficulty for estimation. Therefore, distances are multiplies by the ocean freight indices in order to provide a better representation of transportation costs. Since transportation costs are trade barriers, the coefficient is expected to be negative. Japan employs import tariffs on S-P-F (spruce, pine and fir) lumber and larch lumber; the rates range from 4.8% to 10%. Since Japan's tariffs are an artificial trade barrier, the expected sign is also negative.

Export and Import prices of softwood lumber are also included in this analysis. The sign for export price is expected to be negative and for importer price, it depends on substitutability among imported goods. If the elasticity of substitution of importable goods is less than one, the coefficient should have a positive sign. Exchange rates are defined in exporters' currencies (e.g., $/Yen). An appreciation of an importer's currency should induce imports. The expected coefficient is positive.

Table 5.1 Summary of Variables

name of variable	abbreviation	expected sign
exporter's roundwood production	$PROD_i$	+
importer's roundwood production	$PROD_j$	-
exporter's per capita GDP	$PGDP_i$	-
importer's per capita GDP	$PGDP_j$	+
distance	D_{ij}	-
tariff	T_j	-
export price	Pex_i	-
import price	Pim_j	?
exchange rate	E_{ij}	+
value of raw material imports	RM_{ij}	+
lagged dependent variable	Q_{t-1}	+

Some variables which indicate historical trade relations between each softwood lumber exporting country and Japan are included. The value of raw material trade from each country to Japan represents favourable trading partners. The raw materials include textile materials, metal, ores materials and other raw materials such as natural rubber and timber. The sign is expected to be positive. The lagged dependent variable is also included. Franceson, Kornak and Nagy (1983, p.49) suggested, in particular, that trade flows for a given year are closely related to trade flows of the previous year. A consumer's consumption habit does not change quickly. The sign is expected to be positive. Table 5.1 summarize the expected sings of all variables.

5.2 Data Used in Study

Most studies using traditional gravity models employ only cross-sectional data. In this analysis, both cross-section and time series data are incorporated. The time series data are available between 1976 to 1989 for all cross section units. Since the objective is to analyze demand for lumber in the Japanese market, most of the variables were constructed from the point view of the Japanese market.

Data on the dependent variable, the quantity of softwood lumber traded, were computed by adding the quantities of all softwood, sawnwood and manufactured lumber obtained from December issues of the corresponding year of *Japan Export and Import: Imports of Commodity by Country*. The classification of exported and imported goods was changed in 1988, but it was assumed that there were no significant differences between figures before and after 1988 for timber.

The quantities of roundwood production were obtained from various issues of *FAO Yearbook, Forest Product*. As was mentioned previously, roundwood includes those used for various purposes. per capita gross domestic products (GDP) was taken from the International Monetary Fund's (IMF) various issues of monthly *International Financial Statistics* and was divided by population obtained from the same source. For the USSR, net material product (NMP) was used as a surrogate for GDP and was obtained from various issue of *The USSR in Figures*. Population for the USSR was also taken from this source. The most recent figures were taken from *A Study of the Soviet Economy* published by the IMF. For the purpose of international comparisons, each country's per capita GDP was expressed in US dollars at average spot exchange rates for each year.

Distance is the geographical distance between the main importing port and exporting port for each cross sectional unit. These were calculated from the *World Atlas* published by Time Publication Ltd. based on distance provided on the maps. Lloyd's Ship Manager Freight Indices for dry cargo and trip charter were taken from *Shipping Statistics* published by the Institute of Shipping Economics and Logistics. Japan's tariffs vary depending on the species and sizes of the lumber and whether the exporting country is developed country. The tariff rates were calculated as the weighted average for each year; the total values of tariffs for each exporting country are divided by the respective countries' total value of exports. The values are taken from various issues of *Japan Export and Import: Imports of Commodity by Country* published by the Japan Tariff Association. There are no tariffs for developing countries such as Korea and Chile.

Import prices were also taken from the same publication and are in Japanese yen. Import prices were computed by dividing the total value of softwood lumber imports from each country by the quantity. The prices were deflated by wholesale price indices (WPI) for respective countries obtained from IMF's *International Financial Statistics*. WPI, and not CPI, was also used by Mori (1981) to deflate the prices since lumber is not directly consumed by home owners as is; lumber is the primary commodity of houses. Export prices were calculated by dividing each exporters total value of exports by the quantity and the data were obtained from *Yearbook of Forest Products*, unit values of conifer sawnwood exports shown in US dollars published by Food and Agricultural Organization.

Exchange rates were also obtained from *International Financial Statistics*. Exchange rates were defined as the importer's currency in terms of the exporting countries' currencies and were market rates. For the USSR, the exchange rates were obtained from *A Study of the Soviet Economy* published by IMF.

Value of raw material trade was obtained from various issues of *Japan Monthly Summary of Trade* in which the values are shown in Japanese yen. The values were deflated by Japan's CPI. CPIs were obtained from *International Financial statistics*, IMF.

5.3 Estimation Procedure

Since the data for this empirical model contains both cross-sectional and time series data, an assessment of adequate estimation procedures was done. The model should be the one which will "adequately allow for differences in behaviour over cross-sectional units as well as any differences in behaviour over time for a given cross-sectional unit" (Judge, et al, 1985). (See Judge, et al 1985, Chapter 12 and 13, Kmenta 1986, Chapter 12, and Hsiao 1986).

First it is necessary is to examine the structure of a single-equation model. A *k*-variable linear equation can generally take the following form:

$$Y_{it}=\beta_{0it}+\beta_{1it}X_{1it}+\beta_{2it}X_{2it}+\cdots+\beta_{kit}X_{kit}+e_{it} \qquad i=1,\ldots N, \quad t=1,\ldots T \tag{5.3}$$

where **i** refers to a cross-sectional unit (in this study each exporting country), and **t** refers to a time series for a given cross-sectional unit. The number of total observation will be N times T. For the generalized linear regression model, the assumption is made such that $E[e_{it}]=o$, and $E[e^2_{it}]=\sigma^2$. However, in practise, there are five possibilities to specify the behaviour of the disturbance.

1) <u>All coefficients are constant</u>. With this specification, all individual countries are forced to have the same coefficients over time. The model can be estimated by ordinary least squares correcting usually either i) cross-sectional heteroskedasticity and timewise auto regression, or ii) in addition to i), also cross-sectional, mutual correlation (Kmenta 1986, pp.618-625).[5]

2) <u>Slope coefficients are constant, and the intercept varies only over cross-sectional units</u>. This means regression lines for each countries are parallel. With this model, Judge, <u>et al</u>. (1985) require an additional specification, namely, that the intercept term in equation 5.3 is considered to consist of two parts: the mean intercept($\bar{\beta}_0$) and the individual effects or deviation from the mean for the **i**th country(μ_i), such that $\beta_{0i} = \bar{\beta}_0 + \mu_i$. Hsiao(1986) and Kmenta(1986) use a different specification--the residual is composed of two parts, e_i and μ_i, and each unit has its own intercept $\bar{\delta}$. In both cases, an additional assumption for this specification is whether μ_i is fixed or random. If μ_i is fixed, it is included as part of intercept and the least square dummy

[5]SHAZAM can calculate the model using the same specification as Kmenta.

variable model (LSDV) or the covariance model should be used. The estimator is known as a "within" estimator and is based on variation over time around a countries' averages. If μ_i is random, the error components model should be used. This can be expressed as a weighted average of a "within" estimator and a "between" estimator which is based on countries' variation of averages over time. Both estimators feature no correlation of the disturbances over time.

3) Slope coefficients are constant and the intercept varies both over cross-sectional and time units. The regression lines are parallel for both the countries and time periods with this model specification. The same additional assumption will be applied; that is, whether μ_i and λ_i, associated with time series, are random or fixed. The LSDV or the covariance model is used for fixed effects and the error components model for the other.

4) All coefficients vary only over cross-sectional units. Under this model the different behaviour over countries are reflected in both the intercept and slope coefficients. There are separate regression lines for each country. The model is further classified as a random model or fixed model. The fixed model is a seemingly unrelated regression (SUR) model developed by Zellner (1962). The model is based on the idea that the disturbance for the country is correlated with the disturbance in some other country. Different coefficients are estimated for each country. The random-coefficient model is commonly called the Swamy random coefficient model after its proposer (1970). This model, unlike the SUR model, estimates a single coefficient for all cross-sectional units. This model assumes that the disturbances across countries are heteroskedastic but uncorrelated.

5) All coefficients vary over cross-sectional units and time units. In most cases, random coefficients are assumed in this category. All coefficients have a component specific to each

country and a given time period. The common procedure for this is the Hsiao random coefficient model (1975).

In order to determine which model should be used, homogeneity of the intercept is first considered. The model specification test also examines whether the model, including its variables, are properly specified. The likelihood ratio (LR) test for specification against a restricted model is employed (Kmenta 1986, p.491). The computed LR value of 24.97, which exceeds the critical $\chi^2_{(5)}$ value of 15.09 at the 1% level, results in rejection of the homogeneity of intercept assumption. The F statistic using residual sum or square against a conditional hypothesis, homogeneous intercept given homogeneous slope, was also computed (Hsiao 1983, p.16). The computed F value of 3.98 also supports heterogeneous intercepts assuming homogeneous slopes. Some other statistics are calculated for a joint test for individual intercepts. The computed F statistic of 15.74 and Wald Chi-square statistic of 94.45 also supports heterogeneous intercepts with homogeneous slope.

Next, whether there is variation of intercepts over cross-sectional and time series units also is examined. The Lagrangian multiplier (LM) statistic developed by Breusch and Pagan (Judge et al. 1985, p.526, p.537; Kmenta 1986, p.629) are applied under the null hypothesis $\sigma^2_\mu = 0$ using restricted model residuals. The computed test value of 319.32 exceeds the critical $\chi^2_{(1)}$ value of 6.635 at the 1% level, supporting variation over individual countries. The LM value for the hypothesis $\sigma^2_\mu = \sigma^2_\lambda = 0$ is also calculated. The LM value of 2.39 is less than the critical value, suggesting that the intercept varies only over individual countries.

Whether effects are fixed or random must also be considered. Judge et at. (1985, p.527) suggested that, if the number of cross-sectional units is small, it is likely to be a fixed coefficients model since it is not reliable to estimate σ^2_μ when it is assumed that μ_i $\sim$ i.i.d.$(0,\sigma^2_\mu)$. Since the number of cross-sectional units is six, which is rather small, the fixed model was considered appropriate for this analysis.

Another consideration is existence of heteroskedasticity. The LM statistic for homoskedasticity defined by the Breusch-Pagan test (Judge et al. 1985, pp.446-447) is computed to be 35.95 exceeding the critical $\chi^2_{(16)}$ of 32.80 at 1% level. Also computed value of the so-called Glejser test of 86.75 exceeds the critical value. The results indicates heteroskedasticity within cross-sectional units. In addition, Kmenta suggested that, when the cross-sectional units are, for example, countries, the cross-sectional units are often mutually dependent (Kmenta 1986, p.623).

Since the empirical model used time series data and also includes a lagged dependent variable, it is doubtful whether autocorrelation exists. The tests are conducted for the model with correction for both heteroskedasticity and autocorrelation against the model no correction for them estimated using ordinary least squares. The likelihood ratio (LR) test gives a LR value of 84.19 which exceeds the critical $\chi^2_{(6)}$ value of 16.81 at 1% level and rejects misspecification. Also, the Hausman specification test statistic (Judge et al. 1985, p.617) is calculated to be -34080.48 which far exceeds the critical $\chi^2_{(16)}$ value of 32.00. The empirical model is specified as a cross-sectionally correlated and timewise autoregressive model with individual intercepts. Both tests suggest the empirical model is specified correctly.

6 Policy Analysis

The empirical gravity model was estimated using generalized least squares (GLS) specified as a cross-sectionally correlated within individual countries and timewise autoregressive model with individual intercepts as explained in Chapter 5.3. The results are obtained by generalized least squares procedure is described in Kmenta (1986, pp.622-625). The estimator for six cross-section units (countries) and thirteen time series can be written as follows:

$$\hat{\beta} = (X'\Omega^{-1}X)^{-1}X'\Omega^{-1}Y \tag{6.1}$$

The matrix Ω is specified as:

$$\underset{\substack{(6*13)\\ \mathrm{x}(6*13)}}{\Omega} = \begin{bmatrix} \sigma_{11}V_{11} & \sigma_{12}V_{12} & \cdots & \sigma_{16}V_{16} \\ \sigma_{21}V_{12} & \sigma_{22}V_{22} & \cdots & \sigma_{26}V_{26} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{61}V_{61} & \sigma_{62}V_{62} & \cdots & \sigma_{66}V_{66} \end{bmatrix}, \quad \text{where} \quad \underset{(13\text{x}13)}{V_{ij}} = \begin{bmatrix} 1 & \rho_j & \rho_j^2 & \cdots & \rho_j^{12} \\ \rho_i & 1 & \rho_w & \cdots & \rho_j^{11} \\ \rho_i^2 & \rho_i & 1 & \cdots & \rho_j^{10} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \rho_i^{12} & \rho_i^{11} & \rho_i^{10} & \cdots & 1 \end{bmatrix} \tag{6.2}$$

$$i, j = 1,2,\ldots 6$$

Since the model contains lagged dependent variable, ρ is estimated as follows to avoid a correlation between the lagged dependent variable and the disturbance. The estimated ρ is confined between +1 and -1.

$$\hat{\rho}_i = \frac{\Sigma e_{it} e_{i,t-1}}{\sqrt{\Sigma e_{it}^2}\sqrt{\Sigma e_{i,t-1}^2}} \qquad t = 2,3,\ldots,13 \tag{6.3}$$

and the variances and covariances can be estimated using the residuals from the ordinary least squares as:

$$\hat{\sigma}_{ij} = \frac{\hat{\phi}_{ij}}{1-\hat{\rho}_i\hat{\rho}_j} \qquad \text{where} \quad \hat{\phi}_{ij} = \frac{1}{T-K}\sum_{t=1}^{T}\hat{u}_{it}\hat{u}_{jt} \, . \tag{6.4}$$

Model I in Table 6.1 was the results estimated by generalized least squares with variation over the cross-section unit. Since the model includes lagged dependent variable, long-run effects for the Model I are also presented. For the purpose of comparison, a model with a correction for neither autocorrelation nor heteroskedasticity was used. The model was estimated by applying ordinary least squares. The results are shown as Model II in Table 6.1. As is hypothesized, model I shows better performance. Both Model I and II have reasonable R-squares. However, in both models some of the estimated parameters have unexpected signs.

6.1 Effects of Demographic Variables: Roundwood Production and Per Capita GDP

Roundwood production is included in the empirical gravity model as a measurement of domestic production capacity since lumber trade is closely related to the domestic supply capacity of its raw materials, roundwood, particularly exporting countries tend to export more value-added products, lumber. The coefficients are significant for both importer and exporter and estimated coefficient for the exporter has a negative sign and that for the importer has a positive sign. This implies that production power is interpreted as bargaining power. For an exporter, less production power indicates less bargaining power. This induces an importer to buy more lumber. For an importer, more bargaining power means they import more lumber. Also, the large coefficient on an importer's roundwood production suggests that the quantity of softwood lumber is quite sensitive to Japan's bargaining power.

The coefficients for per capita GDP are highly significant and have expected signs for both importer and exporter. Per capita GDP represents the absorption capacity of the domestic market. When the absorption power of an exporting country rises, less lumber is exported.

Table 6.1 Estimates of Softwood Lumber Trade Model Under Two Assumptions

dependent variable: quantity of softwood lumber imported

variable	**Model I : GLS**	[long-run effects]	**Model II : OLS**
roundwood production (i)	-1.14(-4.74)**	[-1.87]	-0.93(-1.32)
roundwood production (j)	6.81(4.02)**	[11.12]	9.22(2.04)*
per capita GDP (i)	-1.35(-4.83)**	[-2.20]	-1.01(-1.74)*
per capita GDP (j)	2.40(6.10)**	[3.92]	2.20(2.57)**
distance	0.29(0.75)	[0.47]	0.46(0.40)
tariff	-0.18(-2.77)**	[-0.29]	-0.20(-0.72)
export price	-0.81(-3.42)**	[-1.32]	-0.95(-1.11)
import price	0.31(1.31)	[0.51]	0.19(0.21)
exchange rate	0.22(0.75)	[0.36]	0.35(0.83)
raw material imports	0.27(1.50)	[0.44]	0.21(0.35)
lagged dependent variable	0.39(5.75)**	--	0.34(3.35)**
intercepts			
Canada	-27.89(-3.65)**	[-45.56]	-40.48(-1.93)*
US	-27.56(-3.61)**	[-45.00]	-40.21(-1.91)*
USSR	-28.34(-3.65)**	[-46.29]	-40.68(-1.91)*
New Zealand	-29.50(-3.84)**	[-48.18]	-41.93(-2.00)**
Korea	-33.04(-4.39)**	[-53.96]	-45.25(-2.12)**
Chile	-34.28(-4.63)**	[-55.98]	-47.06(-2.21)**
Buse $R^{2\,a}$ / R^2	0.9797		0.8588
DF	61		61
LLM	-161.5		-203.6

Note: - t-statistics in parentheses
- variables are in log form

* = Significant at 5%
** = Significant at 1%

[a] Buse R^2 is used for Model I

When it rises in an importing country such as Japan, more softwood lumber is imported.

6.2 Effects of Barrier to Trade: Distance and Tariff

Distance is commonly used for a gravity model analysis in place of transportation costs. Since transportation costs are a natural barrier to trade, the estimated parameter is expected to have a negative sign. However, the parameter is positive unexpectedly and insignificant although it has a negative sign as expected. This may occur because more than 80% of lumber is imported from Canada and the U.S. and the distance is relatively long. Also, it is reported that the transportation costs for North American lumber does not affect the competitiveness in Japanese market against those which are processed in Japan (Japanese Timber Union's Association 1990, p.32-33). Distance can be dropped from the model without affecting other variables.

Tariffs are another variable defined as a trade barrier in the traditional gravity model. The estimated parameter has the expected sign and is significant at the 0.5% level. However, the small value implies an insensitiveness of Japan's import tariffs to lumber imports.

6.3 Effects of Price Variables: Export/Import price and Exchange rate

The results show that export price significantly affect Japan's lumber trade; it is supported at the 0.1% level. Export price has a negative sign as is expected. The coefficient of export is less than unity in short-run implying Japan's lumber trade is insensitive to export price. However, in long-run, export price is getting more influential. Import price has a positive coefficient and is statistically significant only at 10% level. The positive sign implies that the elasticity of substitution among importable goods exceeds unity since the price and the quantity demand is positively related in the Marshallian demand equation when the elasticity exceeds unity. The coefficient of import is as less than unity even though in long-run. Import price does not have a strong influence in Japan's softwood lumber imports.

The coefficient for exchange rate has an expected positive sign; an appreciation of Japanese yen induces the imports of more lumber. However the estimator is statistically insignificant. Like most of the other price related variables, small value of exchange rate's coefficient implies it does not affect Japan's lumber imports.

In summary, prices do not have a significant role in Japan's softwood lumber trade. Distance, which pulls the prices up, and exchange rate, which makes Japanese yen relatively strong, have no relation to the quantities of lumber exported to Japan. Tariffs show strong ties to lumber trade, but has only a small influence. One of the reasons for this is that imported lumber is differentiated by the origin for a particular utilization, but, compared to Japanese lumber, is diversified and can meet various purposes since lumber processed in Japan generally has a specific utilization. Another reason for this is that, since rebuilt and reform of houses , and new construction by house owners are quite often in Japan, durability of lumber may not obvious and the change in prices may not capture it.

6.4 Effects of Variables indicating Historical Trade Habits: Value of raw material trade, Lagged dependent variable and Individual intercepts

Overall these variables performed well in this analysis. The value of raw material trade shows a positive relation to the quantity of softwood lumber traded to Japan. This suggests that

Japan tends to import lumber from the countries where Japan also imports other raw materials. If a country is new to Japan as a raw material exporter, it might be difficult to enter the Japanese softwood lumber market. In contrast, if a country already exports other raw materials to Japan, but so far exported no lumber, the country could be a potential lumber exporter. The coefficient is statistically significant at 10% level.

The model contains a lagged dependent variable which is often known as the partial adjustment or stock adjustment model. The idea for the model is that, consumers do not change their consumption behaviour due to inertia. Deaton and Muellbauer (1983) discussed the model as one of the two most commonly used models for analyzing the demand for durable goods.[6] The coefficient for the lagged dependent variable is expected to be positive and between zero and one. The estimator is satisfactory and highly significant at 0.1% level. This implies the variable captured the property of the partial adjustment model.

Unity minus the estimator for the lagged independent variable is known as the coefficient of adjustment. In this analysis, it is calculated as 0.6123 and this is highly significant. This means 61% of the difference between the desired (long-run) and actual (short-run) quantity imported is eliminated in a given year. Long-run results are calculated by dividing all coefficients by the coefficient of adjustment. The results are also presented in Table 6.1 in brackets.

Individual intercepts are statistically significant at 0.1% for all exporting countries. Also

---

[6]Deaton and Muellbauer provide a good discussion about the demand for durable goods. To distinguish purchases of durable goods form consumption of nondurable food, volatility of purchase and discrete decision making processes are the major properties of consumer's behaviour towards durable goods that need to be considered. (Deaton and Muellbauer 1983, chapter 13)

they capture the characteristics of each countries. Canada, the US and USSR are major exporters in the world wood market. Their coefficients are relatively close. Particularly, those of Canada and the US are quite alike. This is because both countries export similar species of softwood lumber such douglas fir and hemlock while USSR export larch and white fir. Although New Zealand produce relatively small amount of wood products, the value is quite close to the former three countries. In contrast, the estimated intercepts for Korea and Chile, developing countries, are distinctively different from the other four developed countries. This is true despite the fact that Korea, Canada and the US export lumber from similar species to Japan, while Chile and New Zealand export lumber from the same species. One of the reasons for this is that both lumber and sawlogs are first class commodity in the world market; 80% of them are produced in developed countries and are traded among developed countries. Another is that the quality of lumber from the developing countries was inferior for the period under consideration because of inadequate silviculture. The estimated individual intercepts can be said that they capture the characteristics of lumber trade.

6.5 Variables dropped from analysis

Some variables which might link Japan's lumber imports and log imports are dropped from this analysis. The total value of logs exported to Japan from each country, its quantity, and log export policies in each exporting country are the dropped variables. They are statistically insignificant and have small values.

Variables for the deficit to surplus ratio against trade to Japan and the importance of Japan as a trader are also dropped. They are meant to reveal Japan's trade habits. Some variables that reflect a country's economic condition, such as perestroika in the USSR, are also dropped. They are all statistically insignificant.

The lending rates of Banks are considered to have some influence on the demand for lumber. However, that for both importer and exporter are dropped since they are not only insignificant but also affect the other variables, particularly the signs. Also, both estimators have opposite signs as to what is expected. One of the reasons for this is exchange rates of two countries capture differences in macroeconomic effects so that inclusion of inflation rates and landing rates create correlations among those variables

7 Summary and Conclusions

The purpose of this study is to evaluate factors affecting Japan's softwood lumber trade flows. A commodity specific gravity model was applied to analyze the Japanese softwood lumber market. In a gravity model, commodity is considered to be differentiated by its origin, the exporting countries. Factors affecting the export supply systems are integrated into a single gravity equation as well as factors affecting the import demand system, and those factors are analyzed simultaneously. The traditional gravity model employed only cross-section units;in order to assess chronological influence, separate estimations were conducted for each year. However, the gravity model employed in this analysis combines both time series and cross-sectional data. It enabled the investigation of the dynamics of the trade system which is more realistic than using only time series data or cross-sectional data.

The evaluation of non-price factors such as policies and historical relationships is one of the major objectives of this analysis. For this purpose, the empirical gravity model presented a satisfactory result. The conventional trade relations bared a significant role in trade to Japan. For countries which lack the historical trade relations to Japan, this can be considered as a sort of barrier to entry. In other words, the results characterized the Japanese market as a monopsonistic and also monopolistic market and supported a general opinion concerning the Japanese market that is the Japanese market is not a open market.

The result also concludes that log trade has only a small influence on lumber trade, or may not have any influence. This indicates that Japan's decision making processes of importing logs and lumber are independent. In general, it is considered that Japan has a strong preference to logs over lumber. However, the results of this analysis cannot identify the causal relationship between lumber trade and log trade. One of the reasons for that is the decline in the domestic lumber industry in Japan for the last decade. Another is that since the world resource market is moving in the direction of sustainable development and resource exporting countries are regulating their resource export, Japan is now adjusting her trade practise toward this direction.

While non-price factors performed satisfactorily in this analysis, the classical aspects of the traditional gravity model are eliminated. Price variables including tariffs, a proxy for transportation costs and exchange rate shows a less influence on the Japan's softwood lumber imports particularly in short-run. Some are even not statistically significant. Since Japan's needs to lumber are so diversified, consumers in Japan may choose lumber by their own purpose; prices might be the secondary factor. To produce lumber which meet Japan's consumers needs may increase lumber exports to Japan.

Another consideration for this analysis is the specification of trade flows. The specification of a single importing country, Japan, and other exporting countries restricts the availability of estimating procedures. A single importer implies that, for some variables, the data are the same for all cross-sectional units. For example, income or population data for importer are repeatedly used no matter what the exporting country is. This means, for those variables, there is no change in behaviour over cross-sectional units since for each year the data are fixed. This is the reason why the intercept varies only over individual cross-sectional units. Also, this may prevent some relevant variables from being added to the model. For example, adding dummy variables for a particular country for the purpose of indicating the preference to the country, or technology will create constant values for the cross-sectional units. This prevents the use of the random effect model or the error components model since constant values for a cross section unit do not give a so-called within estimator. Originally, the gravity model was developed for an analysis of bilateral trade flows in the world market. This analysis showed the limitation of applying the gravity model to one direction multi flows trade analysis. However, the specification of trade flow was also due to a limitation of data availability particularly in USSR.

Suggestion for Further Study

On one hand, a gravity model allows the inclusion of various factors in a model and can analyze dynamic effects on the world trade using both time series data and cross-sectional data. On the other hand, a large amount of information for both importing countries and exporting countries is required. The availability of the data constrain performance of the gravity model. However, the model is still one of the more powerful tools to analyze international trade.

For the analysis of the lumber trade, it is necessary to develop more variables which reveal the characteristics of durable goods rather than conventional variables. Also additional trade flows would improve the analysis enabling access to more effective and adequate estimation procedure.

BIBLIOGRAPHY

Alston, Julian M., C.A. Carter, R. Green, and D. Pick (May 1990) "Whether Armington Trade Models?" *American Journal of Agriculture Economics* 72:455-467

Anderson, James, (March 1979), "A Theoretical Foundation of the Gravity Equation." The *American Economic Review*, 69:106-116.

Bergstrand, Jeffrey, (1989) "The Generalized Gravity Equation, Monopolistic Competition, and the Factor-proportions Theory in International Trade." *The Review of Economics and Statistics*, 71:143-153.

Bergstrand, Jeffrey. (August 1985), "The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence." *The Review of Economics and Statistics*, 67:474-481.

Birchenhall, C, and P. Grout, (1984), *Mathematics for Modern Economics*, Maryland: Barnes & Noble Books.

Chen, Nen-Jing, G.C.W. Ames and A.L. Hammett, (1988) "Implications of a Tariff on Imported Canadian Softwood Lumber", *Canadian Journal of Agricultural Economics* 36:69-81

Chou, Jien-Jen, and J. Buongiorno (1983) "United State Demand for Hardwood Plywood Imports by Country of Origin", *Forest Science* 29:225-237

Cohen, David H. (October 1990) *A Brief History of The Marketing of B.C. Softwood Lumber*, Forest Economics and Policy Analysis Research Unit, Working Paper 152, Vancouver Canada

Deaton, Angus, and J. Muellbauer (June 1980) "An Almost Ideal Demand System", *The American Economic Review* 70:312-326

Deaton, Angus and J. Muellbauer, (1983), *Economics and Consumer Behaviour*, New York: Cambridge University Press.

Food and Agricultural Organization, (1990) *Yearbook of Forest Products 1989*, Rome.

Forestry Agency, ed. (Oct. 1990) "National Forest Management Accounts, 1989", *Rinya Jiho*, Rinya Kousaikai, Tokyo

____, (Sep. 1990) "Investigation of the Timber Stands Market", *Rinya Jiho*, Rinya Kousaikai, Tokyo

___, (July 1988) "Activities of Forestry Cooperatives", *Rinya Jiho*, Rinya Kousaikai, Tokyo

___, (July 1988) "Private Companies' Forest Management", *Rinya Jiho*, Rinya Kousaikai, Tokyo

___, (Oct. 1988) "Private Woodlot Owners' Forest Management", *Rinya Jiho*, Rinya Kousaikai, Tokyo

___, (July 1990) "Activities of Forestry Development Corporations", *Rinya Jiho*, Rinya Kousaikai, Tokyo

Franceson, A., G. Kornak, A. Nagy, (August 1983) *An Historical Analysis of International Trade in Forest Products*, International Institute for Applies Systems Analysis WP-83-80, Austria

Hsiao, Cheng, (March 1975), "Some Estimation Methods for A Random Coefficient Model", *Econometrica*, 43:305-325.

Hsiao, Cheng, (1986), *Analysis of Panel Data*, New York: Cambridge University Press.

Institute of Shipping Economics and Logistics, *Shipping Statistics*, various issues,

International Monetary Fund, (1991) *A Study of the Soviet Economy*, Washington, D.C.

___, *Direction of Trade*, various issues, Washington, D.C.

___, *International Financial Statistics*, various issues, Washington, D.C.

Japan, Forestry Agency, (1990a). *Ringyo Hakusho 1989* (Forestry White Paper 1989), Tokyo.

___, Forestry Agency, ed. (August 1990b). *Mokuzai Jukyu to Mokuzai Kougyo no Genkyo* (Demand and Supply of Wood Products and the Current Condition of the Forestry Industry 1990), Tokyo.

___, Ministry of Agriculture, Forestry and Fisheries, Economic Affairs Bureau, Statistics and Information Department, ed. *Nourinsuisan Toukei Geppo* (Monthly Statistics of Agriculture, Forestry and Fisheries), various issues, Tokyo

___, Ministry of Agriculture, Forestry and Fisheries, Economic Affairs Bureau, Statistics and Information Department, *Nourinsuisan-sho Toukeihyo* (statistical Yearbook of MAFF), various issues, Tokyo

____, Ministry of Agriculture, Forestry and Fisheries, Economic Affairs Bureau, Statistics and Information Department, (October 1990) *Mokuzai Jukyu Hokokusho 1989* (Reports on Demand and Supply of Timber 1989), Tokyo

____, Ministry of Construction, Economic Affairs Bureau, Research and Information Department, ed. *Kensetsu Tokei Geppo* (Monthly of Construction Statistics) various issues, Tokyo,

____, Ministry of Finance, ed. *Nihon Boueki Geppo* (Japan Export and Import), various issues, Japan Tariff Association, Tokyo

____, Ministry of Finance, Nihon (Japan Monthly Summary of Trade), various issues, Tokyo

____, Ministry of International Trade and Industry, (June 1990) *Kogyo Tokei 1988* (Census of Manufactures 1988), Minister's Secretariat, Research and Statistics Department, Tokyo

Japan Tariff Association, *Gaikoku Boueki Gaikyo* (The Summary Report Trade of Japan), various issue, Tokyo

Japanese Timber Union's Association, (March 1990) *Seizai Koujo no Genkyo to Bunseki* (Current Condition and An Analysis of Sawmills) Fourteenth Edition, Tokyo.

Judge, G.G., W.E. Griffiths, R.C. Hill, H. Lutkepohl, and T. Lee, (1985), *The Theory and Practice of Econometrics*, Second Edition, New York: Wiley.

Kallio, M., D.P. Dykstra, and C.S. Binkley, eds. (1986) *The Global Forest Sector; An Analytical Perspective*, New York: John Wiley & Sons

Kmenta, J, (1986), *Elements of Econometrics*, Second Edition, New York: MacMillan Publishing Company.

Koo, Won W., D. Karemera, and R. Taylor, (1990), *A Gravity Model Analysis of Meat Trade Policies*.

Larue, Bruno, and J. Mutunga, (July 1991), "The Gravity Equation, Black Market Exchange Rates, Market Size, and Linder's Hypothesis", *Working Papers Series*, University of Guelph, Department of Agricultural Economics.

Layard, P.R.G., and A.A. Walters, (1978), *Microeconomic Theory*, New York: MacGraw-Hill Book Company.

Lindsey, Patricia J. and Q. Paris, (March 1988), "Modelling of International Markets for Differentiated Products: A New Approach", *The Second International Conference on Economic Modelling*, London.

McKillop, William, (1973) "Structural Analysis of Japanese-North American Trade in Forest Products", *Forest Science* 19:63-74

Mori, Yoshiaki, (June 1981) "An Econometric Model of the Japanese Timber Market", *The Current State of Japanese Forestry, Contribution to the XVII IUFRO World Forestry Cogress*, Kyoto: Japanese Forest Economic Society.

Okumura, Masahiro, and K. Suzumura, (1984), *Microeconomics I*, Tokyo: Iwanami Shoten.

Parks, Richard W., (1967), "Efficient Estimation of A System of Regression Equations When Disturbances are Both Correlated", *Journal of the American Statistical Association*, 62:500-509

Random Lengths, (August 24, 1989) "Japanese Certify COFI, APA", Exports. Oregon

____, (March 1, 1990) "Houses Cost More in Japan", Export, Oregon.

____, (June 8, 1989) "U.S. Targets Japanese Trade Practices", *Export*, Random Lengths Publications, Inc. Oregon.

____, (May 10, 1990) "Japanese Imports of Softwood Logs and Lumber Rise", Export, Oregon.

____, (September 20, 1990) "Packaged Home Gaining Popularity in Japan", Export, Oregon.

____, (September 6, 1990) "New Zealand Begins Selling Timber Plantation", Export, Oregon.

____, (June 7, 1990) "British Columbia Faces Critical Timber Decisions", Export, Oregon.

Random Lengths, "Chile chili Exports More Wood Products", Export, Oregon.

Small and Medium Enterprise Agency, (1990) *Dainanakai Kogyo Jittaikihonchosa Hokokusho* (The 7th. Investigation of Small and Medium Size Enterprise, December 1987), Tokyo.

Summary, Rebecca M., (1989), "A Political-Economic Model of U.S. Bilateral Trade", *The Review of Economics and Statistics*, 71:179-182

Thursby, Jerry, and Marie C. Thursby, (1987), "Bilateral Trade Flows, The Linder Hypothesis, and Exchange Risk", *The Review of Economics and Statistics*, 69:488-495.

United Nations, *International Trade Statistics Yearbook*, various issues. New York.

USSR, The State Committee of the USSR on Statistics, The information and Publication's Centre, *The USSR in Figures*, Finansy i Statistika Publishers, Moscow

Varian, Hal R., (1984), *Microeconomic Analysis*, Second Edition, New York: Norton & Company.

Wiseman, A.C. and R.A.Sedjo, (August 1981) "Effects of an Export Embargo on Related Good: Logs and Lumber", *American Journal of Agricultural Economics* 63:423-429

Wood Products Stockpile Corp., (March 1988) *Mokuzai Juyoudoko Sogo Chousa* (Total Investment of Trend of Demand for Timber), Tokyo

Wood Products Stockpile Corp., (Nov. 1990) "Increasing Restrictions on American Log Exports", *Wide*, Tokyo

APPENDIX: Data used in the Emperical Model

1. Roundwood Production (1000 m^3)

Year	Canada	USA	former USSR	New Zealand	Korea	Chile	Japan
1976	129,496	254,597	321,700	9,032	5,923	5,568	35,760
1977	135,454	259,553	315,100	8,923	5,870	6,381	34,231
1978	145,974	280,651	302,300	8,243	5,849	6,832	32,558
1979	148,942	290,987	295,700	8,143	5,771	8,108	33,784
1980	158,842	418,453	356,600	9,995	8,760	13,828	34,557
1981	144,572	419,016	358,200	10,315	8,579	13,869	31,632
1982	129,673	396,896	355,900	10,015	8,439	12,764	32,154
1983	156,965	437,762	355,700	9,691	8,404	13,859	32,316
1984	167,482	474,562	367,900	8,934	7,747	14,997	32,874
1985	168,654	476,120	368,000	9,341	6,739	15,710	33,074
1986	177,097	511,489	382,800	9,341	6,730	16,448	31,613
1987	177,097	530,103	389,800	9,434	6,939	16,556	30,984
1988	179,957	529,795	393,700	10,153	6,803	16,761	30,998
1989	176,976	533,168	382,100	10,557	6,803	16,864	30,601

Source: *FAO Yearbook, Forest Products*, FAO

2. Per Capita Gross Domestic Products (US$)

Year	Canada	USA	former USSR	New Zealand	Korea	Chile	Japan
1976	8,710.1	7,889.8	2,013.6	4,479.6	769.6	950.6	3,479.2
1977	8,617.7	8,735.2	2,157.3	5,040.1	970.9	1268.0	6,065.7
1978	8,788.2	9,742.9	2,340.7	5,423.3	1,285.3	1424.7	8,448.6
1979	9,394.4	10,768.3	2,469.3	6,593.5	1,613.2	1887.7	8,710.0
1980	10,911.3	11,787.1	2,637.3	8,042.7	1,633.8	2475.0	9,070.5
1981	12,044.4	13,043.4	2,524.9	10,665.8	1,774.7	2891.4	9,919.0
1982	12,217.5	13,406.1	2,657.6	13,382.6	1,839.0	2118.3	9,138.9
1983	13,108.3	14,287.1	2,613.1	16,038.5	1,923.2	1685.8	9,894.2
1984	13,747.1	15,760.3	2,440.0	20,854.1	2,230.4	1610.0	11,582.5
1985	13,912.9	16,665.4	2,707.0	27,546.0	2,111.7	1319.8	11,107.3
1986	14,355.9	17,474.4	3,065.5	31,643.1	2,573.9	1363.9	16,340.2
1987	16,229.2	18,520.7	3,518.2	30,775.1	3,170.9	1511.0	19,711.4
1988	18,921.6	19,751.9	3,633.4	30,005.5	4,168.2	1731.9	23,628.4
1989	20,989.9	20,874.1	3,724.7	35,226.5	5,025.3	1807.0	23,276.1
1990	21,965.6	21,696.2	3,719.5	36,461.4	5,603.5	2131.4	23,773.0

Source: *International Financial Statistics*, IMF

3. Distance from Major Ports to Japan (km)

Canada	7457.0
USA	8741.0
former USSR	1077.0
New Zealand	9280.0
Korea	1160.0
Chile	17234.0

Source: *World Atlas*, Time Publication Ltd.

4. Lloyd's Ship Manager Freight Indices

Year	Indices
1976	80.4
1977	79.6
1978	83.8
1979	107.4
1980	127.7
1981	117.1
1982	95.1
1983	102.0
1984	103.4
1985	100.0
1986	94.4
1987	104.4
1988	116.7
1989	121.9
1990	118.4

Source: *Shipping Statistics*, the Institute of Shipping Economics and Logistics

5. Weighted Average of Tariff on Lumber Imported by Japan (%)

Year	Canada	USA	former USSR	New Zealand	Korea	Chile
1976	0.09	0.03	0.27	0.36	0	0
1977	0.11	0.04	0.67	0.23	0	0
1978	0.17	0.04	1.96	0.31	0	0
1979	0.16	0.05	2.57	0.47	0	0
1980	0.22	0.05	3.30	0.81	0	0
1981	0.26	0.07	3.44	0.39	0	0
1982	0.26	0.06	2.92	0.13	0	0
1983	0.60	0.15	2.60	0.35	0	0
1984	0.64	0.07	2.78	0.29	0	0
1985	0.73	0.06	3.25	0.20	0	0
1986	0.70	0.04	3.48	0.28	0	0
1987	0.84	0.12	3.23	0.22	0	0
1988	0.92	0.21	4.08	0.34	0	0
1989	1.06	0.23	4.82	0.36	0	0
1990	1.30	0.27	4.77	1.03	0	0

Source: *Japan Export and Import: Imports of Commodity by Country*, the Japan Tariff Association

6. Export price of Softwood Lumber (US$/m^3)

Year	Canada	USA	former USSR	New Zealand	Korea	Chile
1976	78	126	95	68	110	56
1977	82	127	111	66	152	60
1978	89	127	115	78	143	62
1979	104	190	128	103	205	80
1980	96	167	135	127	210	110
1981	91	146	142	124	196	106
1982	84	151	126	107	190	98
1983	93	138	126	112	151	84
1984	87	141	126	161	151	79
1985	86	139	126	125	126	74
1986	93	145	126	144	164	76
1987	105	147	126	155	173	88
1988	107	145	157	155	214	115
1989	116	176	167	211	214	118

Source: *FAO Yearbook, Forest Products*, FAO

7. Import Price of Softwood Lumber (Yen/m^3)

Year	Canada	USA	former USSR	New Zealand	Korea	Chile
1976	35906.9	36693.6	22312.5	19422.0	33173.7	53142.9
1977	35664.3	33461.7	24172.4	19881.1	34045.2	23485.1
1978	28803.7	29809.1	16976.2	17067.6	28068.5	17314.3
1979	42910.2	44134.7	28225.6	23238.9	41248.8	18109.8
1980	47995.7	45829.6	36443.2	32892.5	44852.1	37029.9
1981	39903.6	41408.5	19213.0	27390.8	37460.5	32877.6
1982	40761.0	42198.1	18805.2	28616.8	40841.9	25662.0
1983	39716.2	38105.8	19326.1	26383.4	36072.8	24353.3
1984	37784.7	36552.8	18765.7	25287.1	32877.8	24694.3
1985	37532.4	35815.9	19639.5	25497.0	33215.9	24753.9
1986	32028.2	28940.0	14207.5	18602.6	25594.2	19841.2
1987	34854.7	31168.3	13581.1	16370.8	25882.7	17930.1
1988	33807.8	31045.4	17177.6	19035.5	29332.7	21955.0
1989	37812.5	38492.3	22560.4	18892.6	34099.4	23528.9
1990	39070.8	40085.5	23883.6	23394.9	38344.6	26958.5

Source: *Japan Export and Import: Imports of Commodity by Country*, the Japan Tariff Association

8. Exchange Rate (respective currency (US$ etc.)/ Yen)

Year	Canada	USA	former USSR	New Zealand	Korea	Chile
1976	3.32	3.37	2.53	3.36	1.63	5.23
1977	3.96	3.72	2.72	3.62	1.80	5.69
1978	5.42	4.75	3.33	4.93	2.30	5.71
1979	5.35	4.56	3.10	4.67	2.21	4.87
1980	5.16	4.41	2.91	4.30	2.68	4.89
1981	5.44	4.53	3.26	3.94	3.09	33.01
1982	4.95	4.01	2.93	3.02	2.94	58.53
1983	5.19	4.21	3.24	2.82	3.27	105.30
1984	5.45	4.21	3.58	2.44	3.39	115.58
1985	5.72	4.19	3.23	2.09	3.65	172.00
1986	8.25	5.93	4.06	3.11	5.23	176.84
1987	9.17	6.91	4.16	4.09	5.69	204.39
1988	9.60	7.80	4.78	5.12	5.71	331.94
1989	8.58	7.25	4.59	4.34	4.87	415.38
1990	8.06	6.91	4.35	4.12	4.89	675.27

Source: *International Financial Statistics*, IMF

9. Japan's Raw Material Imports (Million Yen)

Year	Canada	USA	former USSR	New Zealand	Korea	Chile
1976	341,734	934,256	186,744	52,391	40,857	64,505
1977	335,782	939,678	222,113	52,311	49,070	57,407
1978	274,325	880,634	159,207	51,162	46,876	52,564
1979	437,469	1,309,674	212,073	75,554	56,427	79,347
1980	539,945	1,441,871	212,900	83,409	42,121	109,257
1981	429,142	1,126,143	153,738	68,311	24,598	82,845
1982	444,487	1,154,677	154,977	75,018	28,373	98,730
1983	408,674	1,111,612	135,452	67,244	32,785	88,460
1984	453,516	1,192,645	119,667	66,019	30,478	97,591
1985	448,278	1,086,759	111,019	60,427	34,378	92,225
1986	321,258	761,792	104,973	41,614	28,070	63,694
1987	385,158	821,174	78,853	44,237	30,874	55,966
1988	430,717	934,825	93,792	47,080	32,159	66,496
1989	518,008	1,118,600	107,579	50,775	43,459	70,360
1990	504,907	1,119,972	95,491	67,033	46,361	85,817

Source: *Japan Export and Import: Imports of Commodity by Country*, The Japan Tariff Association

10. Consumer Price Index

Year	Canada	USA	former USSR	New Zealand	Korea	Chile	Japan
1976	49.4	52.9	93.0	33.3	36.9	8.0	69.0
1977	53.4	56.4	93.3	38.1	40.7	15.0	75.0
1978	58.2	60.6	94.0	42.6	46.6	21.0	78.0
1979	63.5	67.5	94.9	48.4	55.1	28.0	91.0
1980	70.0	76.6	96.0	56.7	70.9	38.1	87.4
1981	78.6	84.6	96.8	65.4	86.0	45.6	91.7
1982	87.2	89.7	100.0	76.0	92.3	50.2	94.2
1983	92.2	92.6	100.6	81.6	95.4	63.8	95.8
1984	96.2	96.6	99.6	86.6	97.6	76.5	98.0
1985	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1986	104.2	101.9	101.8	113.2	103.0	119.5	101.0
1987	108.7	105.7	103.3	131.0	106.0	143.3	101.0
1988	113.1	109.9	103.9	139.4	114.0	164.3	101.0
1989	118.7	115.2	106.0	147.3	120.0	192.2	104.0
1990	124.4	121.4	109.9	156.3	130.0	242.3	107.0

Source: *International Financial Statistics*, IMF