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Timber demand/supply analysis of east Asian timber trade - trade among eight Japanese regions, China, Korea

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Abstract
Because of increasing supply of the imported wood at low price, the rate of wood self-sufficiency in Japan has dropped further below 20%. This resulted in abandoning the reforestation activities after harvesting, which could impinge on the sustainable forest management. In this study we first overview the current state of Japanese forestry with a focus on relationship between the timber market and the sustainable forest management. Secondly, we estimate price elasticity of lumber supply and demand for eight Japanese regions (Tohoku, Kanto, Hokuriku, Chubu, Kinki, Chugoku, Shikoku, and Kyushu), China and Korea. With the estimated price elasticities for these regions, we finally analyze the characteristics of the supply and demand structure through the spatial and inter-temporal partial equilibrium market model called JAFSEM (Japanese Forest Sector Model). Our results show the following; 1) at the present price level Japan would face to difficulty to continue the sustainable forest management, 2) Japanese regional lumber demand except Kyushu would increase, and 3) the additional demand for lumber would be met by Korea and China.

Key words: Timber trade, sustainable forest management, domestic harvest, price elasticity, JAFSEM

Introduction
Since the Kyoto Protocol was adopted as global warming preventive measures in 1992, it is admitted that forest contributed to atmospheric CO2 reduction by absorbing CO2 from the atmosphere and the storage function. Wood use such as biomass, forest product, wood housing and furniture is effective in preventing the increase of atmospheric CO2, in place of non-wood material and non-wood housing which mainly depend on fossil fuel and large energy consumption. Forest resource management and the wood use have been revaluated as an important substitution for preventing global warming. On the other hand, free trade could affect this situation adversely, impinging on the sustainable forest management. Japanese timber market has been dominated by the imported timber under the free trade since World War II with price decrease of the domestic timber, which discourage forest owners from reforesting after harvest.

Regarding the substitution between these foreign and domestic timber, Mori (1972) and Yukutake (1977) estimated the import price elasticity of North American timber from a supply and demand model based on quarter data from 1960 to 1971 and on annual data from 1960 to 1973, respectively. They found that the elasticity was more than unit, and that import of North American timber was remarkable to increase. Tachibana (1997) pointed out that the main product of the U.S. timber export shifted from logs to lumber by the model based on annual data from 1979 to 1994. Based on the simulation analysis on North American, Russian and New Zealand timbers with the annual data from 1970 to 2002, Yukutake et al.(2006) pointed out that changes of North American timber supply factors, e.g. the increase of the U.S. housing units, fossil fuel wholesale price and labor wages, would affect the Japanese timber market by increasing demand for New Zealand and Russian timber with less demands for domestic timber.

Other econometric supply and demand models on the timber trade have been developed by McKillop(1973), Gallagher(1980), Yukutake(1984), Mori(1991), Flora and Lane(1994), Nilsagard (1999) and so forth until now. However, all these models deal with national level aggregate data. First regional market model for Japanese forest sector model(JAFSEM) was developed by Yukutake & Yoshimoto(1996), which was a equilibrium model of Koopmans-Hitchcock type (Labys 1989). Then spatial regional model of the Samuelson type(Samuelson 1952) called JAFSEM (Japanese forest sector model) was developed by Yoshimoto et al.(1999) and Yoshimoto & Yukutake (2002).

In this study we first overview the current state of Japanese forestry with a focus on relationship between the timber market and the sustainable forest management. Secondly, we estimate price elasticity of lumber supply and demand for eight Japanese regions (Tohoku, Kanto, Hokuriku, Chubu, Kinki, Chugoku, Shikoku, and Kyushu), China and Korea. With the estimated price elasticity for these regions, we finally analyze the characteristics of the supply and demand structure through JAFSEM (Japanese Forest Sector Model) with some modification.

Forest resources and harvesting

Sixty-seven percent of the land in Japan, 25.1 million ha estimated in 2002, is covered by forests. Artificial forest area is around 10.3 million ha. But the age distribution of plantation forest is not uniform. Most are from 30 to 50 years old which covers 67%. Forest stands older than 30 years are harvestable and the share of it is 97% in the total artificial forest stock of 2,330 million m3. Artificial forests mainly consist of sugi (Cryptomeria japonica) (57%; 1,336 million m3 on the stock level) and hinoki (Chamaecyparis obtusa) (21%; 492 million m3). They are the main species for softwood lumber in Japan. Annual increment of the total forest stock is around 800 thousand m3 (Rinyacho 2001). Sustainable forest management is basically possible if the amount of annual increment was harvested. It would be able to supply more than 50 million m3 at least, given that the recovery rate is 70% from forest stand to log. The peak of annual harvest was observed in 1960 with 75 million m3. Since then, annual harvest has been declining and it became 20 million m3 in 2002. Roughly speaking from the viewpoint of the forest stock level, we can supply approximately 3 times more than the current level.

Japanese timber markets

In 1964 the liberalization of timber import in Japan was almost completed. The foreign timber has occupied 51% of the total timber supply, 95.6 million m3, in 1969. Foreign timber increased remarkably afterwards, and the share of foreign timber in Japanese market rose to over 60% in 1973, and 70% in 1987. The share became 80% of the total wood supply, 112million m3 in 1996. The largest foreign timber suppliers are the U.S. and Canada, which produce hemlock (Tsuga heterophylla) and Douglus-fir (Pseudotsuga menziesii) for construction material along with sugi(Cryptomeria japonica), the major Japanese timer. More than 40% of the total timber supply until 1996 was from the U.S. and Canada. Due to the harvest regulation by the societal conservation movement for the spotted owl in the U.S., North American timber export had begun to decrease in 1989. The North American timber occupied only 21% of 87.2 million m3 total timber supply in 2003(Figure-1).

In place of North American timber, the domestic timber supply could increase. But the self-sufficient rate of the domestic timber decreased to 19%, and its amount became 16 million m3. Instead of North American timber, the increase of import from Russia and Europe timber, especially from Finland, Sweden and Austria, was remarkable(Yukutake & Yoshimoto 1999). Imported timber from Europe in ‘others’ category in Figure-1, was next to

Russian with 8% and occupied the same rate of 6% as the import from Indonesia and Malaysia in 1996.

In spite of increasing the available forest stock, the supply of domestic timber does not increase. Figure-2 shows log price tendency of sugi, hemlock and Douglus-fir. From Figure-2, we can see that the price of Miyazaki sugi and national average sugi became less than that of hemlock and Douglus-fir after 1989 when the spotted owl protection issue emerged.

The Japanese timber market was mainly dominated by foreign timber suppliers, because the domestic timber was insufficient in volume to satisfy demands in Japanese market and it was more expensive than the imported timber. However, even if the domestic lumber price dropped below prices for imported timber, its demands did not aim at the domestic timber. This implies that the price is not the

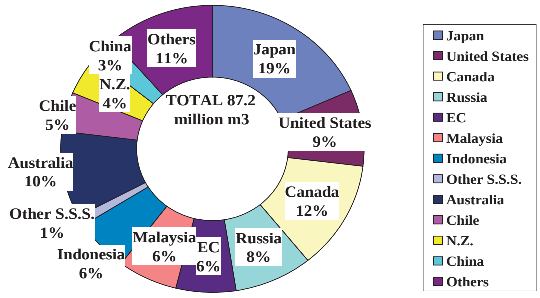

Figure.1 SOURCES OF WOOD SUPPLY (2003)
SOURCE:Foerstry Agency,"Table of Wood Demand and Supply"

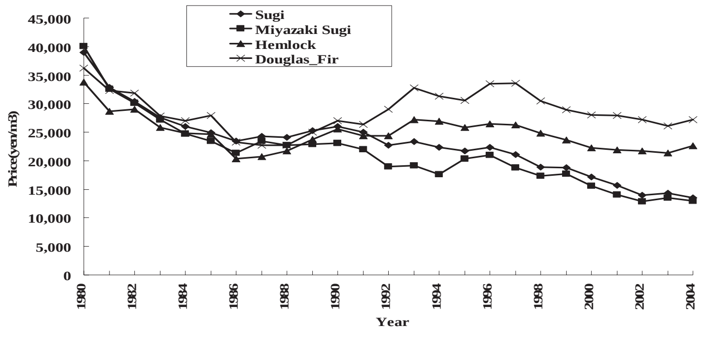

Figure 2 LOG price of sugi, hemlock and Douglus-fir
SOURCE:Ministry of Agriculture, Forestry and Fisheries, "Wood Price" and Miyazaki Prefecture,"Annual Report of Timber Statistics"

sole factor to determine timber supply. It's often pointed out that imported timber is preferred because 1) it's available just in time, 2) its supply is more stable, and 3) its wood quality is also more stable than domestic timber.

Sustainable forest management and production cost

The following is the comparison of the siliviculture costs between different countries(Yukutake & Yoshimoto 1999). Cost in Japan is represented by a major forestry prefecture, Miyazaki. The total siliviculture costs in Japan are approximately 1,500 thousand yen/ha, while those in Canada are 200 thousand yen/ha, in Sweden 300-400 thousand yen/ha, and those in New Zealand and China are both 100 thousand yen/ha. As can be seen, the silviculture costs in Japan are five to ten times higher than those in other countries except Korea, where silvicultural management costs are as high as 800 thousand yen/ha. One of the reasons for this difference is high weeding costs in Japan. Weeding costs are around 600-700 thousand yen/ha because of Asian monsoon climate zone with vigorous growth of understory vegetation. The weeding costs in Korea are 264 thousand yen/ha, and the costs are almost zero in other countries. Regarding the harvesting and logging costs, the Japanese forestry agency, Rinyacho estimates at 7,000 yen/m3 in Japan, 15,000 yen/m3 in Sweden, 14,000 yen/m3 in Finland and 31,000-36,000 yen/m3 in Austria (Rinyacho 2005).

Log purchase costs and lumber processing costs in sawmills of production scale of 10,000m3/year in 1995 were 16,000-20,000yen/m3 and 13,000-20,000yen/m3, respectively in Japan. Costs in Germany were 8,200yen/m3 for log purchase and 7,400yen/ m3 for processing in the case of the production scale of 6,000-20,000 m3/year. Costs were 6,000-7,000yen/m3 for log purchase and 3,500-4,900yen/m3 for processing in Austria, and 13,330yen/m3 and 5,860yen/m3 in Norway.

Transportation costs from the US, Canada, Chili and New Zealand to Japan by ship were 3,000-4,000 yen/m3 in 1995. These costs were almost half of the cost from Miyazaki to Tokyo, which was 7,000yen/ m3. In the beginning of 2000s, the costs fell to 5,000 yen/m3 with an improvement of transportation method from Miyazaki to Tokyo. However, transportation costs from foreign countries were also reduced, and from North America, it was 1,000 yen/m3, and was 3,000 yen/m3 even from North Europe. In the above case of German sawmill, the freight from Belgian port, Ante Rose, to Tokyo costed 5,900-7,080yen/m3. In the case in Austria, the cost to Tokyo was 5,000yen/m3 including the transportation cost, 1,760yen/m3, for 500km between Italy(Yukutake 2003).

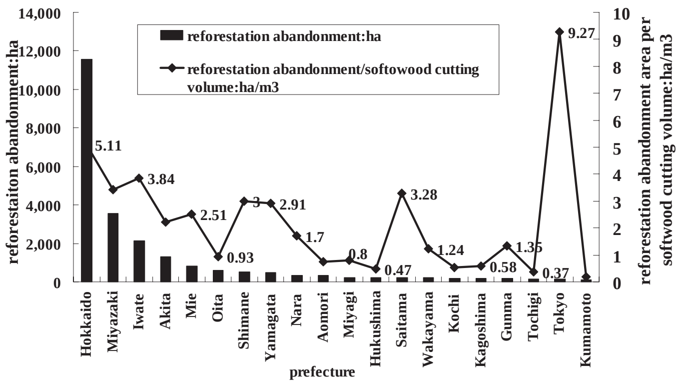

Figure.3 Top 20 prefectures of reforestation abandonment area more than 3years
SOURCE: Forest Agency

The market price of Miyazaki sugi log in 2005 fell to 7,000-8,000 yen/m3. The price cannot cover the reforestation costs, which results in the recent abandonment of reforestation. The area where reforestation is not taken place more than three years after clear cut, was 22,000 ha in 1999 and 25,000 ha in 2003, according to the investigation by Forestry Agency. Figure-3 shows the worst twenty prefectures in 2003. Hokkaido which has the largest land area in the country was the top. The second place was Miyazaki, followed by Iwate, Akita, Mie and Oita. Note that in these prefectures from the second to sixth, forestry is actively operated. That is, such a prefecture with active forestry area tends to have larger reforestation abandonment.

Equation (1) shows the relationship of the clear cutting area with lags for five years(AMHA t to AMHAt-5) and reforestation(REFAt) area in Miyazaki(Nakada 2006).

□Model of time lag 5 years

$$REFA_t = \beta_0 \cdot AMHA_t + \beta_1 \cdot AMHA_{t-1} + \beta_2 \cdot AMHA_{t-2} + \beta_3 \cdot AMHA_{t-3} + \beta_4 \cdot AMHA_{t-4} + \beta_5 \cdot AMHA_{t-5} \quad (26)$$

□Almon lag model

$$REFA_t = \gamma_0 \cdot Z_t + \gamma_1 \cdot Z_{t-1} + \gamma_2 \cdot Z_{t-2} \quad (27)$$

$$Z_0 = AMHA_t + AMHA_{t-1} + AMHA_{t-2} + AMHA_{t-3} + AMHA_{t-4} + AMHA_{t-5} \quad (28)$$

$$Z_1 = AMHA_{t-1} + 2 \cdot AMHA_{t-2} + 3 \cdot AMHA_{t-3} + 4 \cdot AMHA_{t-4} + 5 \cdot AMHA_{t-5} \quad (29)$$

$$Z_2 = AMHA_{t-1} + 4 \cdot AMHA_{t-2} + 9 \cdot AMHA_{t-3} + 16 \cdot AMHA_{t-4} + 25 \cdot AMHA_{t-5} \quad (30)$$

Where,
parameterβi can be interpreted as the ratio of the area replanted i years after clear cutting to the total clear cut area. Equation (2)-(5) show a further specification of the model (1) using Almon lag, which we used to estimate β0□□□β5. Note that we don't use a constant term in this equation. We used the panel data of 1989 to 2003 for towns in Miyazaki prefecture. From the estimated values of Table-1, around 60% of harvested areas would be reforested by one year after, but the remaining 40% abandoned.

Table-1 Estimated parameters of reforestation ratio

current year of clear cutting area	β0	0.45
before 1 year of clear cutting area	β□	0.18
before 2 year of clear cutting area	β□	0.02
before 3 year of clear cutting area	β□	-0.05
before 4 year of clear cutting area	β□	-0.01
before 5 year of clear cutting area	β5	0.13

Comparing the trend of wage for harvesting and logging with that of the stumpage price (Rinyacho 2005), we were able to employ loggers for 11.8 person-day if we sold 1m3 at the stumpage in 1961. However, 1m3 at the current stumpage was equivalent to 3.7 person-day in 1975, to 1.8 person-day in 1985 and only to 0.4 person-day in 2003.

Spatial and Temporal Market Equilibrium Modeling

We added China and Korea to 8 region (Tohoku, Kanto, Hokuriku, central part, Kinki, China, four countries, Kyushu) of a Japanese Lumber market of JAFSEM by Yoshimoto & Yukutake (2002). Figure-4 shows the network the trade. We used three difference types of lumber, i.e., domestic lumber processed from domestic forest resources, lumber processed in Japan from the US imported logs and imported lumber. Since Korea and China does not have enough available resources and data, we used the domestic lumber processed from imported logs and imported lumber as substitute. In order to construct JAFSEM, we need to estimate the price elasticity of the supply and demand for three type lumber in each region. The following supply/demand functions of logarithms are used to estimate the elasticity.

Equation (6) is a total lumber demand(QiD) function and is explained by lumber price(PiW) and wood construction start area(Hi) in 8 region in Japan. In the case of Korea we used GDP(KGN) instead of wood construction start area. In China it is explained by population(CN), because data of demand factor are not available. The coefficient, a2, is the price elasticity estimated of the total demand. Equation of (7) is an own country product lumber supply(QiDS) function. It is explained by an own country product lumber price(Pi□) and harvesting and logging wage(CiH) or manufacture wages(WiP). b2 is the own country product materials sawing product supply price elasticity value. Equation (8) is a supply function of lumber processed in Japan(QiUS) from the US imported logs. Korea and China are not included in this. c2 is the price elasticity of lumber processed in Japan from the US imported logs. We used equation (9) to estimate the price elasticity of import lumber supply function. Owing to a lack of price data in each Japanese 8 regions, for all of 8 regions, the same function was used. In addition, China uses a time trend(year) because there are not wage data.

□Total Lumber Demand Function

$$\log(Q_i^D) = a_1 + \underset{-}{a_2} \cdot \log(P_i^W) + \underset{+}{a_3} \cdot \log(H_i, KGDP, or\ CN) \quad (31)$$

□Domestic Lumber Supply Function

$$\log(Q_i^{DS}) = b_1 + \underset{+}{b_2} \cdot \log(P_i^D) + \underset{-}{b_3} \cdot \log(C_i^H\ or\ W_i^P)\ \ or\ Year \quad (32)$$

□US-JP Lumber Supply Function

$$\log(Q_i^{US}) = c_1 + \underset{+}{c_2} \cdot \log(P_i^U) + \underset{-}{c_3} \cdot \log(W_i^P) + \underset{-}{c_4} \cdot \log(Q_i^L) \quad (33)$$

□Supply Function of Imported Lumber

$$\log(Q_i^{MS}) = d_1 + \underset{+}{d_2} \cdot \log(PMS_i) + \underset{-}{d_3} \cdot \log(WA_i) + \underset{-}{d_4} \cdot \log(EXJA_i) \quad (34)$$

Variables are defined as follows.

QiD:Lumber Demand(103m3) of i region, PiW:Lumber Price(103yen) of i region, Hi:Wood Construction Area(103m2) of i region, KGDP:GDP(109won) of Korea, CN:Population (106people) of China, QiDS:Domestic Lumber Supply(103m3) of i region, PiD:Domestic lumber price(103yen) of i region, PiU:US-JPN lumber price(103yen) of i region, QiUS:US-JPN Lumber Supply(103m3) of i region, CiH:Harvesting wage(yen/m3) of i region, WiP:Manufacture Wage(103yen) of i region, QiL□US imported log supply(103m3) of i region, QiMS:Imported Lumber Supply of i region (103m3 of Japan and m3 of Korea & China), PMSi:Imported lumber price (103yen) of i region(Japan, Korea & China), Year:time trend, WA:Wage index of Exported countries(US, Canada, or New Zealand), EXJAi: Exchange Rate(yen/$)

(Data Source) The data of QiD, PiW, QiDS QiUS PiD and PiU are from "forest Product Demand & Supply" (Ministry of Agriculture, Forestry and Fisheries, 1975-2003), CiH and WiP from "Ministry of Health, Labour and Welfare"(1975-2003), Hi from "Annual Statistical Report of Construction"(Ministry of Construction, 1975-2003), QiL from Cooperation of Imported Timber in Japan, QiMS and PMSi from "FAOSTAT Database" provided by FAO on their Internet Homepage. The data of KGDP, CN, WA, and EXJA are from "International Financial Statistics Yearbook"(International Monetary Fund 2003). Annual data from 1974 to 2002 were used for estimating coefficients of equation (6), (7) and (8). As for the imported lumber, annual data from 1970 to 2002 were used.

Estimated value of equation (6), (7) and (8) by three stage least-squared method (3SLS) shows and a result of equation (9) is expressed in Table-2. It can be pointed out, especially, that the price elasticity of the total lumber demand in Japanese region is very elastic except Kyushu, which is the most important production region of the domestic timber, China and Korea. Tohoku and Kanto were comparatively elastic about the price elasticity of lumber processed in Japan from the US imported logs, and Kyushu was less than others elastic. China was supposed to have 1, because a desirable estimated value was not provided. Tohoku is comparatively high about the supply price elasticity of own country produced lumber, but Kyushu is low. Korea was supposed to have 1, again because a desirable elasticity was not estimated.

Table-2 Estimated value of demand/supply function

	3sls	Tohoku	Kanto	Hokuriku	Chubu	Kinki	Chugoku	Shikoku	Kyushu	Korea	China
		Region									
Total Lumber Demand	a_1	-4.1686	-5.3059	-5.7917	-9.7870	2.6704	-1.18924	-2.834	-2.235	7.0452	-
		(-.236)	(-.099)	(-2.488)	(-.203)	(0.915)	(-0.998)	(-1.251)	(-2.828)	(6.381)	-
	a_2	-2.6122	-2.1466	-2.6222	-1.8148	-1.7038	-1.28764	-3.286	-0.73836	-.4804	-
		(-5.786)	(-.838)	(-4.405)	(-.755)	(-3.498)	(-5.067)	(-2.891)	(-3.946)	(-.932)	-
	a_3	2.4403	3.2455	2.6889	2.7812	1.3473	1.6651	2.9858	1.4702	0.2087	-
		(8.916)	(4.544)	(7.641)	(6.346)	(3.857)	(12.318)	(4.328)	(10.234)	(3.019)	-
	R^2	0.5678	0.3890	0.5991	0.5261	0.3333	0.807696	0.3901	0.8094	0.9014	-
	DW	1.0884	1.0538	1.2905	1.2835	0.3382	1.5906	1.6283	1.5726	1.9801	-
	SE	0.2319	0.2442	0.2134	0.2084	0.249503	0.1249	0.2354	0.0858	0.2026	-
Domestic Lumber Supply	b_1	9.7597	7.4930	6.0026	6.5550	7.1187	8.1107	5.6590	6.6676	-	30.2410
		(14.284)	(14.987)	(6.348)	(7.965)	(10.204)	(11.16)	(9.364)	(16.633)	-	(-4.324)
	b_2	0.6307	0.4090	0.6736	0.6416	0.5432	0.0823	0.408804	0.2763	-	0.5192
		(3.582)	(3.649)	(3.041)	(3.379)	(3.276)	(0.500)	(3.304)	(3.300)	-	(3.423)
	b_3		-0.9515		-.80557	-1.06791	-0.75908	-0.23941	0.0007	-	-0.0078
			(-8.606)		(-0.122)	(-15.375)	(-1.4405)	(-3.770)	-0.0136	-	(-2.206)
	b_3	-0.8526		-1.0252						-	
	(W_i^P)	-14.742		(-14.454)						-	
										-	
	R^2	0.8224	0.9316	0.8685	0.8078	0.8960	0.8215	0.6602	0.3099	-	0.2350
	DW	0.3639	0.6843	0.6081	0.2332	0.4689	0.3048	0.4093	0.4465	-	0.4832
	SE	0.1133	0.0778	0.1111	0.1168	0.0955	0.0962	0.0751	0.071804	-	0.3209
US-JP Lumber Supply	c_1	-1.6335	-0.0670	2.2300	1.2323	-0.69072	2.4501	-0.23111	1.0371	-	-
		(-0.996)	(-.055)	(3.750)	(1.799)	(-1.007)	(4.650)	(-0.242)	(1.792)	-	-
	c_2	0.9335	0.7669	0.1351	0.4960	0.6164	0.1348	0.9295	0.1844	-	-
		(2.626)	(3.370)	(0.808)	(4.048)	(4.626)	(1.009)	(4.295)	(1.498)	-	-
	c_3	0.7491	0.6806	0.6248	0.7091	0.7785	0.763301	0.6926	0.7446	-	-
		(9.588)	(12.985)	(9.808)	(18.590)	(27.644)	(11.825)	(9.596)	(31.120)	-	-
	c_4		-0.0991		-0.1704		-0.2136	-0.24976		-	-
			(-.959)		(-.395)		(-3.113)	(-2.984)		-	-
	c_5			-0.226918						-	-
	DM2			(-2.445)						-	-
	R^2	0.7657	0.9306	0.9126	0.9721	0.9776	0.7590	0.8179	0.9781	-	-
	DW	0.5215	0.7049	1.1449	1.4007	1.7487	0.6212	1.4040	1.3157	-	-
	SE	0.1726	0.1258	0.0826	0.0746	0.0663	0.9618	0.0945	0.0653	-	-

(Note) c_5 of Hokuriku is dummy variable of 2002=1

Table-3 estimated vale of price elasticity for imported lumber

	d_1	d_2	d_3	d_4	d_5	R^2	DW	SE
Japan								
	9.6949	0.4739	-0.0380	-1.1544		0.9300	1.7674	0.1327
	(2.605)	(1.570)	(-0.142)	(-16.404)				
Korea								
	-09.4420	3.4344	66.5285	-4.7010	5.5245	0.9018	1.7829	0.5617
	(-2.840)	(2.288)	(2.717)	(-2.363)	(3.277)			
China								
	-35.9597	0.5696	9.4229	1.8360		0.9055	1.5395	0.5027
	(-2.030)	(2.251)	(2.465)	(10.006)				

(Note) d_5 of Koea is GDP of Exported Country

From Table-3, the supply price elasticity of the imported lumber in Korea is the most elastic with 3.45. That of China was 0.57 and in Japan was 0.47. Owing to a lack of price data in each Japanese 8 regions, all of 8 regions were set to have the same elasticity of imported lumber. Thus, the imported lumber supply function for each region was determined with the assumption that each supply function is a portion of the derived imported lumber supply function for the nation. Accordingly, the imported lumber supply(QiMS) of each region was set from the proportion of imported lumber in each region of total imported lumber（Yoshimoto & Yukutake 2002）.

$$\begin{aligned}
\underset{[\{d_i\},\{s_j\},\{q_{i,j}\}]}{\text{maximize}}\ NSP &= (Consumer\ Surplus) + (Producer\ Surplus) \\
&\quad - (Transportaiton\ Costs) \\
&= \sum_{i=1}^{m}\{\int_0^{d_i} PD_i(x)dx - PD_i(d_i)\cdot d_i\} \\
&\quad + \sum_{j=1}^{n}\{PS_j(s_j)\cdot s_j - \int_{S_0^j}^{s_j} PS_j(x)dx\} - \sum_{i=1}^{m}\sum_{j=1}^{n} T_{i,j}\cdot q_{i,j}
\end{aligned}$$

$s.t.$

$$\begin{aligned}
d_i &= \sum_{j=1}^{n} q_{i,j} \qquad \forall i \\
s_j &= \sum_{i=1}^{m} q_{i,j} \qquad \forall j \\
&\{d_i\},\{s_j\},\{q_{i,j}\} \geq 0
\end{aligned} \qquad (10)$$

where PDi( ) and PSi( ) are the demand and supply function of the i-th region, Ti,j is the transportation costs from the i-th to j-th region, sj is the supply quantity at the j-th region, di is the demand quantity at the i-th region, and $q_{i,j}$ is the quantity delivered from the i-th region to j-th region.

Demand and supply functions are derived with one set of price and quantity by using price elasticity. The price and quantity was from the data in 2002. Table-4 shows the transportation costs necessary to solve the proposed problem, based on our hearing survey in Japan, China and Korea. Figure–4 shows the equilibrium solution in comparison to the current demand/supply quantities in 2002. The total amount of the domestic lumber demand was estimated at 33.7million m^3 and increased to 3million m^3 more than the actual amount in 2002. China and Korea decreased by 2~3million m^3 than the actual amount. All region of Japan area

Table-4 Transportaion costs among region(Yen/m3)

Region	Tohoku	Kanto	Hokuriku	Chubu	Kinki	Chugoku	Shikoku	Kyushu	Korea	China
Tohoku	2000	3500	4000	4500	6000	7000	7000	7000	12000	13000
Kanto	-	2000	3500	3000	3500	3500	4000	5000	10000	11000
Hokuriku	-	-	2000	3000	2800	4000	4000	7000	10000	11000
Chubu	-	-	-	2000	3000	4000	4000	5000	10000	12000
Kinki	-	-	-	-	2000	3000	3000	4000	9000	12000
Chugoku	-	-	-	-	-	2000	2500	4000	9000	12000
Shikoku	-	-	-	-	-	-	2000	4000	9000	12000
Kyushu	-	-	-	-	-	-	-	2000	7000	10000
Korea	-	-	-	-	-	-	-	-	2000	5000
China	-	-	-	-	-	-	-	-	-	2000

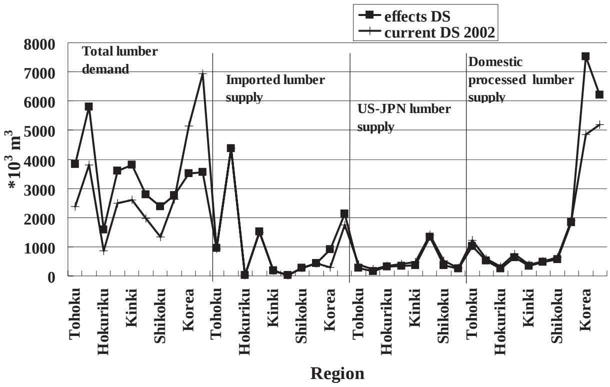

Figure.5 Simulation effects of lumber demand/supply

except Kyushu showed increase by 1□2million m^3. The total amount of imported lumber supply estimated at 10.8million m^3, and increased by 1million m^3 more than the actual amount in 2002. Increase in Japanese 8 region was observed from the actual amount, as well as in Korea and China. The total amount of lumber processed in Japan from the US imported logs was estimated at 3.4million m^3. The total amount of domestic processed lumber supply was 19.4million m^3 and increased by 2.1million m^3. In particular, Korea and China increased by 1□2million m^3, while all regions in Japanese showed decrease.

Discussion and Conclusion

Our findings are as follows.

(1) In a view point of only forest stock level, it would be possible for Japan to increase the self-sufficient rate. However, it might not be possible for Japan to be self-sufficient to supply timber due to high production costs, i.e., costs of silviculture, harvesting and logging, lumber processed, distributing and so forth, which are too expensive compared to imported foreign countries.

(2) One of the major environmental problems regarding forest management has been that artificial forests have been left unmanaged, resulting in unhealthy forests and reforestation abandonment possibly leading to such natural disasters as soil erosion.

(3) From a simulation result by JAFSEM, it would be difficult for Japan to continue the current lumber supply at the present price level, and Japanese regional lumber demand except Kyushu would increases. Additional demand increase might be met by the supplies from Korea and China.

Free trade could affect adversely the sustainable forest management. It could make the maintenance of healthy forest resources difficult. Production cost differences, e.g., the differences of silvicuture costs, which are inherit to natural and geographical characteristics, should be reconsidered in the trade agreements. Some of the costs cannot be avoided. In such a case, the commonly applied financial measures, e.g. subsidy, have to be introduced to stimulate competition and sustainability of the forest management through the fair competitive markets.

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