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Impacts of the Environmental Conservation Movements in North America on the Japanese Softwood Timber Markets: an Econometric Analysis

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北米における環境保護運動が日本の針葉樹材貿易に与えた影響に関する実証的研究

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ABSTRACT: Foreign timber suppliers play a very important role in the Japanese timber market. They have been supplying more than 70% of Japanese timber demand since 1987. Because both suppliers and Japan are under pressure from worldwide environmental conservation movements, there are strong possibilities that the amount of log and lumber imports into the Japanese market may decline drastically. This paper attempts to examine the forest-related situation around the environmental conservation movements in North America from two different viewpoints. First, I would like to build a model to describe the softwood timber trade structure in Japan including imports from U.S. and Canada. Second, I would like to assess the impacts of the conservation policies on Japanese timber trade, such as the regulations on timber harvest in North America. In this study, I have developed a structural model for the first end, and a reduced form model for the second. According to the estimates, a 10% decrease of the timber harvest in Pacific Northwest may lead to 4.5% decrease of softwood log exports and 13% rise of its export price. In contrast, the same reduction may contribute to 13% diminution in U.S. lumber export and 14% increase in Canadian lumber export to Japan leaving the lumber prices unchanged. A reduction of 10% in the timber harvest in British Columbia may lead to 28% reduction of Canadian softwood lumber exports to Japan.

KEY WORDS: environmental conservation movements, Japanese softwood timber trade, reduced form model, structural model, timber harvest in North America

INTRODUCTION

Several econometric models have been developed to analyze Japanese timber markets. Those models have revealed many significant factors in Japanese timber markets. McKillop (1973) constructed an econometric model with three supply functions and three demand functions, using quarterly data from 1950 to 1970. He concluded that the Japanese demand for lumber from North America was totally inelastic. Gallagher (1980) built a softwood log trade model between U.S. and Japan with annual data during 1962-76, and found out two important facts. Firstly, Japan's import demand and U.S. exports supply were price sensitive in the log market. Secondly, the changes in the new housing construction starts and the domestic log production in Japan were critical in explaining levels of U.S. log exports to Japan. Yukutake (1985) developed a log and lumber trades model of Japan and connected his model to the Global Timber Model (GTM, Kallio et al. (1986)) of IIASA (International Institute for Applied Systems Analysis). He explained the structure of log and lumber markets in Japan with 41 equations with annual data during 1961-82. Mori (1991) developed a Japanese log trade model, dividing the log market into a domestic log market and an imported log market. His results indicate that both the demand and supply of domestic log, and the supply of imported log were inelastic with respect to their own prices from 1961 to 1986, while the demand for import log was elastic. Vincent et al. (1991) examined Japanese timber trade structure of sawlogs econometrically, utilizing annual data during 1970-87. They have concluded that the sawlogs from North America, the Soviet Union and the South Seas were substitutes for each other during 1970-87, and that imports from each region were affected by its relative net price of lumber (lumber price minus log input cost per unit of lumber). Furuido et al. (1991) modeled to explain an increase in the softwood lumber export from U.S. to Japan. They showed the importance of following three factors: the decline in the real lumber price in U.S. during 1965-84, the rise in export price to Japan and the diminishing new housing construction starts in U.S. during 1985-89. Nagata et al. (1992) attempted to model a coniferous wood trade between North America and Japan. They implied that the real prices of timber were important factors in U.S. timber market, while nominal prices played important roles in the Japanese market. Flora et al. (1994) modeled Japanese demands for the imported softwood log and lumber in the system of equilibrium models of Pacific Rim timber trade. And, Tachibana (1997) made a whole scale econometric model for Japanese softwood timber markets and revealed the full structures, utilizing the data between 1975-93.

Imported timber supply fulfilled 75% (83 million m^3 in a log equivalent term) of the total Japanese timber demand in 1993 and 78% (73million m^3) in 1998. Japan has gradually shifted the imports of softwood from logs to lumber. Japan imported 4.8 million m^3 in softwood lumber and 17.7 million m^3 in softwood logs in 1980, while 8.9 million m^3 and 14.7 million m^3 respectively in 1993. The most important softwood log supplier to Japan is U.S., and the principal lumber supplier is Canada who has shipped small quantities of logs to Japan. In contrast, imports from Russia were relatively small as the followings: 4.5 million m^3 in log and 0.3 million m^3 in lumber in 1993. In the case of trade between U.S. and Canada, U.S. exported 1.8 million m^3 logs and 0.74 million lumbers to Canada, whereas Canada exported 35.9 million m^3 lumber with negligible amount of logs in 1992. The magnitude of Canadian lumber export to U.S., that is 35.9 million m^3 in 1992, is quite noticeable.

The issues of worldwide environmental conservation have cast considerable influences on the Japanese timber markets. For instance, the exhaustion of tropical forest has led to a decline in the tropical log imports in quantity. The wild life protection movements in North America have put more restrictions on harvesting activities that also contribute higher log prices. Johnson et al.(1995) found that a partial ban on Washington log exports, in effect in 1991 and 1992, had not reduced Washington's timber revenue.

This paper develops a structural model and a reduced form model for Japanese softwood timber markets and assesses the impacts of the environmental conservation movements, especially the restrictions to timber harvest and log export in North America on the timber markets.

THEORETICAL MODEL

Figure 1 is a simplified flow diagram of Japanese softwood timber markets. Two major suppliers to the log market are domestic forest owners and U.S. The domestic log supply and logs imports from U.S. are modeled explicitly. The important lumber suppliers are domestic sawmills, Canada and U.S. The domestically processed lumber and imported lumbers from Canada and U.S. are modeled. Log supplies from

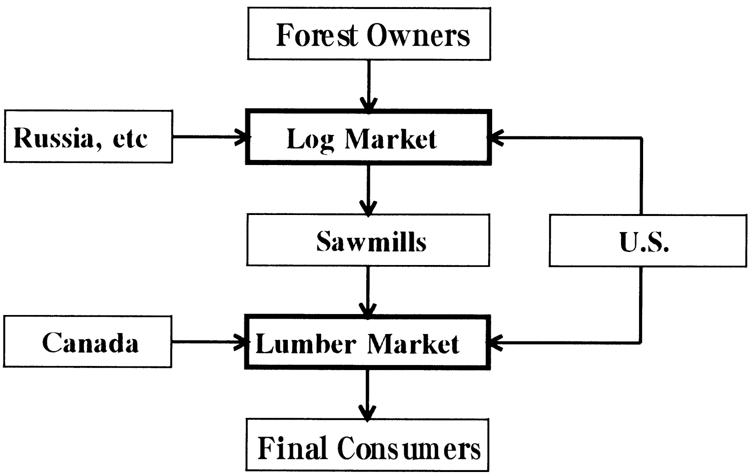

Fig. 1 The Structure of Japanese Softwood Timber Markets

Russia and other regions are treated as exogenous variables in the model, because the imports of these regions are volatile.

1. Softwood round log markets in Japan

(1) Domestic log

Domestic forest owners determine their log supply (SR_J), based upon their own forest stand volume (V_J with the expected sign " + "), the logging cost (C_J, -) and domestic log price (PRJ, +).

$$SR_J = f\,(PR_J, V_J, C_J)$$

Domestic sawmills decide domestic log demand (DR_J) considering the domestic log price (PR_J, -) and domestically processed lumber supply with a time lag (SL_J (-1), +). The capacity of sawmills (CP_J, +) plays as a scale factor in the demand.

$$DR_J = f\,(PR_J, CP_J, SL_J\,(-1))$$

The amount of domestic log demand is equal to that of domestic log supply in equilibrium.

$$DR_J \equiv SR_J$$

(2) U.S. log

The amount of log supply (SR_A) from U.S. to Japan is determined with its own price (PR_A, +), the timber harvest volume (TH_A, +) and the new housing starts (HS_A, -) in U.S.

$$SR_A = f\,(PR_A, TH_A, HS_A)$$

The amount of U.S. log demand (DR_A) in Japan is decided with its own price (PR_{AJ}, -), and the lagged domestically processed lumber supply (SL_J (-1)). The log price is converted from U.S. dollar basis to Japanese yen basis. The sawmill capacity (CP_J, +) plays as a scale factor in the demand.

$$DR_A = f\,(PR_{AJ}, CP_J, SL_J\,(-1))$$

The demand for imported logs from U.S. in Japan is equated with the supply of logs from U.S. to Japan in equilibrium.

$$DR_A \equiv SR_A$$

2. Softwood lumber markets in Japan

(1) Domestically processed lumber

Domestic sawmills determine their lumber supply (SL_J) taking the domestically processed lumber price (PL_J, +), log price (PR_J, -) and the log supply from Russia and the other countries (OTR) as given. The capacity (CP_J, +) indicates their productivity.

$$SL_J = f\,(PL_J, PR_J, CP_J, OTR)$$

The demand for domestically processed lumber (DL_J) is a function of its own price (PL_J, -), the price of imported lumber (PL_S, +), which is to be a substitute, and the new housing construction starts with a lag (HS_J (-1), +) or lagged Gross Domestic Products (GDP_J (-1), +) in Japan. The housing starts or the GDP plays as a scale factor in the demand.

$$DL_J = f\ (PL_J,\ PL_S,\ HS_J\ (-1) \text{ or } GDP_J\ (-1))$$

The domestically processed lumber demand is equated to its supply in equilibrium.

$$DL_J \equiv SL_J$$

(2) U.S. Lumber

The lumber supply (SL_A) from U.S. to Japan is determined taking its own price (PL_A, +), the stumpage price for saw timber (STP_A, -), the timber harvest volume (TH_A, +) and the new housing starts in U.S. (HS_A, -) as given.

$$SL_A = f\ (PL_A,\ STP_A,\ TH_A,\ HS_A)$$

The demand (DL_A) for U.S. lumber in Japan is a function of its own price based on Japanese yen (PL_{AJ}, -), the price of substitutable lumber (PL_S, +) and Japanese housing starts with a delay of time (HS_J (-1), +) or Japanese GDP with a lag (GDP_J (-1), +).

$$DL_A = f\ (PL_{AJ},\ PL_S,\ HS_J\ (-1) \text{ or } GDP_J\ (-1))$$

The demand for the imported lumber from U.S. in Japan is equal to the supply of lumber from U.S. to Japan in equilibrium.

$$DL_A \equiv SL_A$$

c) Canadian lumber

Canadian lumber supply (SL_C) to Japan is determined with its own price (PL_C, +) and the timber harvest volume (TH_C, +) in Canada. In this model the new housing starts of U.S. (HS_A, -) is used as an explanatory variable, because Canada exports a lot of lumber to U.S. at the same time and the new housing starts in Canada is much smaller than U.S. So the situation of U.S. housing market has influenced strongly upon Canadian lumber supply.

$$SL_C = f\ (PL_C,\ TH_C,\ HS_A)$$

The lumber demand (DL_C) in Japan is determined, taking its own price based on Japanese yen (PL_{CJ}, -), the price of substitutable lumber (PL_S, +) and Japanese new housing starts with a delay (HS_J (-1), +) or Japanese GDP with a lag (GDP_J (-1), +) as given.

$$DL_C = f\ (PL_{CJ},\ PL_S,\ HS_J\ (-1) \text{ or } GDP_J\ (-1))$$

The demand for the imported lumber from Canadian in Japan is equated to the lumber supply from Canada to Japan in equilibrium.

$$DL_C \equiv SL_C$$

ESTIMATION RESULTS OF THE STRUCTURAL MODEL

The theoretical model described so far constructs a system of simultaneous equations. These equations are specified in the logarithmic linear in both sides. To estimate the coefficients of these equations, the two-stage least-squares (2SLS) is used to mitigate the simultaneous equation bias (Johnston, 1991) with annual data during 1973-93. The environmental conservation movements for the northern spotted owl in North America, especially in U.S. had been brisk up dramatically between the end of 1980's and the beginning of the 1990's. So this study targets the period in which U.S. enacted Forest Resource Conservation and Shortage Relief Act(1990), and tightened the restrictions to timber harvest and log export.

Most of U.S. data are for Pacific Northwest: Oregon, Washington and Alaska, while Canadian data are mainly for British Columbia. Domestic prices, import prices and the logging wage rate in Japan are deflated using Japanese wholesale price index. Export prices are deflated by the producers' price index in the corresponding country. The estimation results are showed in Figure 2.

1. Softwood round log markets in Japan

(1) Domestic log

[a] Supply equation

The coefficient of the domestic log price is positively significant, implying that a rise in the price leads to an increase in the domestic log supply. The softwood standing volume contributes positively to the log supply. On the other hand, the logging wage rate is negatively related to the supply as expected. The estimated value shows that an increase of 10% in the wage rate leads to 6.4% decrease in supply. The time trend was adopted in order to explain a continuous change in the supply structure. The estimated coefficient turns out to be negatively significant at the 1% level, indicating that the supply has been shifting downwards, probably reflecting the factors such as the depopulation of mountainous villages and the advancing age structure of logging laborers.

[b] Demand equation

The coefficient of the domestic log price is negatively significant as expected. The coefficient of the sawmill capacity is 3.820 and positively significant at the 1% level, while that with a lag is -3.449 and negatively significant. These estimated values jointly indicate that an increase of 10% in the capacity may eventually lead almost 3.7% increase in the domestic log demand. The coefficient of the domestic processed lumber supply with a lag is positive, implying that an increase in the lumber supply leads to an increase in the demand in the following year.

Fig. 2 Estimation Results of The Structural Model

Softwood Round Log Markets in Japan

(1) Domestic log

[a] $SR_J = 0.026 + 0.455PR_J + 1.711V_J - 0.643C_J - 0.072TT1$

(-0.005) (5.455***) (3.941***) (-4.678***) (-3.910***)

R^2=0.953, DW=1.805

[b] $DR_J = 8.893 - 0.546PR_J + 3.820CP_J - 3.449CP_J(-1) + 0.487SL_J(-1)$

(4.976***) (-3.254***) (4.063***) (-4.415***) (3.110***)

R^2=0.906, DW=1.495

(2) U.S. log

[c] $SR_A = -5.603 + 0.536PR_A + 1.222TH_A - 0.222HS_A - 0.291DM$

(-1.660*) (4.507***) (4.923***) (-1.429*) (-3.125***)

R^2=0.699, DW=1.531

[d] $DR_A = -29.976 - 0.316PR_{AJ} + 12.483CP_J - 9.337CP_J(-1) + 0.044TT2$

(-5.687***) (-3.359***) (11.848***) (-11.693***) (8.453***)

R^2=0.900, DW=2.022

Softwood Lumber Markets in Japan

(1) Domestically processed lumber

[e] $SL_J = 6.998 + 0.633PL_J - 0.210PR_{AJ} + 0.637CP_J + 0.163OTR - 0.022TT2$

(2.781***) (6.430***) (-3.782***) (4.386***) (1.993**) (-6.954***)

R^2=0.977, DW=1.525

[f] $DL_J = 8.443 - 0.218PL_J + 0.730HS_J(-1)$

(10.586***) (-1.991**) (13.063***)

R^2=0.905, DW=2.143

(2) U.S. Lumber

[g] $SL_A = -9.951 + 1.017PL_A - 0.256STP_A + 1.516TH_A - 1.209HS_A + 0.128TT1 - 0.229TT3$

(-2.243**) (2.745***) (-2.249**) (4.248***) (-5.319***) (17.277***) (-3.801***)

R^2=0.974, DW=1.977

[h] $DL_A = -8.119 - 0.882PL_{AJ} + 2.076GDP_J(-1)$

(-1.031) (-2.287**) (7.134***)

R^2=0.885, DW=1.436

(3) Canadian Lumber

[i] $SL_C = -1.120 + 0.273PL_C + 0.845TH_C - 0.431HS_A + 0.049TT1$

(-0.214) (1.919**) (1.793**) (-1.811**) (5.015***)

R^2=0.934, DW=1.360

[j] $DLC = 5.189 - 0.693PL_{CJ} + 3.473PL_J - 0.924DM$

(1.025) (-1.378*) (4.753***) (-3.822***)

R^2=0.659, DW=1.609

Notes:
(1) The numbers in the parenthesis under the estimated coefficient indicate t-statistics of the coefficient. Superscripts“ *** ” indicates significance at 1% level, “ ** ” at 5% level and “ * ” at 10% level.
(2) R^2: R-square of the estimated equation
(3) DW: Durbin-Watson statistics of the estimated equation
(4) Variable with (-1): the variable with a time lag

(2) U.S. log

[c] Supply equation

The estimated coefficient for the own price, or the own price elasticity of U.S. log supply to Japan, is positive and larger than that of domestic log supply. The timber harvest in U.S. has a positive effect on the log supply to Japan. The fact that estimated value exceeds unity reveals that an increase or decrease in the timber harvest leads to a further increase or decrease in U.S. log supply. The coefficient of the new housing starts in U.S. is negatively related to the supply, but the t-value is relatively low. The coefficient value indicates that the new housing starts have a small negative influence on the supply to Japan. This probably reflects the fact that the logs supplied to Japan and consumed in U.S. are in different quality and constitute different markets. The coefficient of dummy variable, which is designed to describe structural changes after the first oil crisis, is negatively significant. It shows that U.S. log supply to Japan increased after the oil crisis probably reflecting the changes in the exchange rate, freight and other market factors.

[d] Demand equation

The coefficient of the price is negatively significant, but showing the price elasticity is much smaller than that of the domestic log demand (equation [b]). The coefficient for the domestic sawmills capacity is 12.483 and positively, while that with a lag is -9.337 and negatively significant. These estimated coefficients jointly show that a continuous increase of 10% in the capacity can eventually lead to 30% rise in the demand. This percentage is almost eight times larger than that of the counter part for the domestic log demand. The coefficient for time trend from 1973 up to 89 is positively significant, implying that the demand for U.S. logs have continuously shifted upwards probably reflecting a preference change of Japanese consumption, especially of the housing issues.

2. Softwood lumber markets in Japan

(1) Domestically processed lumber

[e] Supply equation

The price coefficient is positively significant. The figure indicates that a rise of 10% in the price leads to 6.3% increase in the supply. As to input log prices, the coefficient of U.S. log price is negatively significant, while the other log prices turn out insignificant. The coefficient of the sawmill capacity is positively significant and has almost the same magnitude as that of the price. The coefficient for the log supply of Russia and other regions is positively significant as expected. The coefficient of the time trend for 1973-89 is negatively significant. Taking equations for the log demand [b] and [d] together into consideration, the estimation may be concluded that the log demand had drifted away from domestic to U.S. logs during the period.

[f] Demand equation

In the regression trials, the coefficients of the prices of substitutable lumbers, such as the price of imported lumber from Canada, are insignificant and thus they are omitted from the report. The coefficient of the domestically processed lumber price is -0.218 and negatively significant. The estimated value in the absolute term is small, reflecting the price-irresponsive nature of the domestically processed lumber. The domestic new housing starts with a lag is positively related to the demand. The estimate indicates those simultaneous and proportional increases in the lumber price and the new housing starts would lead to an increase in the demand for the lumber.

(2) U.S. Lumber

[g] Supply equation

The price coefficient is positively significant and nearly equal to 1, showing that U.S. lumber export to Japan may increase at the same rate as the price rise. The stumpage price has a negative relation to the supply as expected, but the absolute value of the coefficient is small, that is to say 0.25. The coefficient for U.S. new housing starts is 1.209 and negatively significant, while that for the timber harvest is 1.516 and positively significant. These estimates in the absolute term are larger than 1. The results may show that a relatively small portion of the timber harvest has been exported to Japan, and hence it is strongly influenced by the timber harvest level and the domestic demand in U.S. since the export is residual in nature in U.S. lumber market. Comparing these two estimated values, the timber harvest in U.S. has a strong impact on U.S. lumber supply to Japan. Taking account of equation [c] together, the timber harvest level in U.S., especially in Pacific Northwest, is very important for the Japanese timber markets. The coefficients for time trend in 1973-93 and in 1990-93 are both significant; the former is positive, while the latter is negative, indicating that the export supply to Japan has decelerated at the begging of the 1990's.

[h] Demand equation

Because of insignificant t-values, the substitutable lumber prices are rejected. The own price coefficient is -0.882 and negatively significant, the value itself is indicating higher price responsiveness. Japanese GDP with a time lag is positively related to the demand. The estimate shows that a rise of 10% in the GDP would result in 20% increase in the demand. It indicates that the lumber demand in Japan has been shifted strongly to U.S. lumber followed by the GDP increase.

(3) Canadian Lumber

[i] Supply equation

Because of the lack of data, I have to estimate the export prices from 1973 to 84. The export price data after 1985 up to 1993 are available. These data are extrapolated to the missing dates based upon the export prices of “western hemlock” lumber from U.S. to Japan, because Canadian lumber exports to Japan are mainly hemlock.

The coefficient for the export price is 0.273 and positively significant. The price elasticity of the Canadian lumber supply to Japan is small, probably reflecting the Canadian policy of promoting lumber export, which is not necessarily priced responsive. The timber harvest in Canada has a positive effect on the supply, while the new housing starts in U.S. have a negative impact. These two estimated values, which are 0.845 and -0.431 respectively, indicate that the timber harvest in Canada, especially in British Columbia, has proportionally more influence upon the Canadian lumber supply to Japan than the new housing starts in U.S. The coefficient of time trend from 1973 to 93 is positively significant, probably based upon the above policy.

[j] Demand equation

The price coefficient is negative, but the t-value is relatively small. The domestically processed lumber price in Japan is positively related to the demand. Its estimated value or the price elasticity of the demand is very large, implying that the demand for Canadian lumber is very sensitive to change in the price of the domestically processed lumber. Several variables were put for the scale factors in the equation, but none were accepted even with the 10% significant test.

ESTIMATION RESULTS OF THE REDUCED FORM MODEL

The model can be regarded as a block-wise recursive system. Hence majority of the endogenous variables has relatively minor simultaneity; e.g., the first two equations have only two endogenous variables, i.e., SR_J, DR_J and PR_J. Therefore, the corresponding reduced form equations have one of these two endogenous variables as left-hand side and only those exogenous variables appearing in the first two structural equations as right-hand side. The next stage sets up the reduced form equation system taking this block-wise recursive structure into consideration. The equations are specified in the logarithmic linear in both sides and estimated with the ordinary least squares (OLS). The coefficients on the reduced form equations should explain both of “ direct ” and “ indirect ” contributions, that is to say the total contributions of the exogenous variables on the endogenous variables. The estimation results of the reduced form model are shown in Table 1.

1. Equilibrium quantity of the domestic log

The coefficient of the softwood standing volume is positively significant and about 1. It implies that the standing volume may proportionally contribute to the equilibrium quantity of domestic logs. In other words, the domestic log will be able to increase in quantity at the same rate as the softwood standing volume increase. The coefficient for the logging wage rate is negatively significant, showing that a rise of 10% in the

Table 1 Estimation Results of the reduced form model

	C	V_J	C_J	CP_J	CP_J(-1)	GDP_J(-1)	HS_J(-1)	SL_J(-1)	HS_A	STP_A	TH_A	TH_C	R/PPI*	TT1	TT2	TT3	R^2 DW
SR_J&DR_J	6.725	0.987	-0.482	2.405	-2.111									-0.042			0.927
	(2.169)	(3.838)	(-3.961)	(6.308)	(-7.275)									(-3.446)			1.702
PR_J	19.96	-2.707	0.436					0.830						0.121			0.916
	(2.039)	(-3.867)	(1.520)					(3.612)						(4.094)			1.446
SR_A&DR_A	-35.08			10.15	-7.135						0.446				-0.046		0.916
	(-6.993)			(11.02)	(-9.998)						(4.629)				(-9.897)		2.194
PR_{AJ}	13.84			7.834	-6.767				0.261		-1.294						0.928
	(4.176)			(13.80)	(-12.21)				(3.033)		(-9.203)						1.825
DL_J&SL_J	4.918			3.271	-2.538		0.146								0.007		0.987
	(2.893)			(6.091)	(-6.050)		(2.420)								(3.929)		1.990
PL_J	6.398				-0.628		0.536								-0.017		0.701
	(1.576)				(-2.619)		(4.586)								(-3.759)		1.804
DL_A&SL_A	-43.02					3.098			-0.777		1.279					-0.140	0.949
	(-7.309)					(16.75)			(-3.408)		(3.211)					(-2.880)	1.605
PL_{AJ}	-0.133								0.281	0.276			0.281			0.088	0.779
	(-0.066)								(2.564)	(5.256)			(6.640)			(3.330)	1.765
DL_C&SL_C	-4.940								-0.637		-1.405	2.812					0.939
	(-1.149)								(-3.342)		(-5.537)	(13.68)					2.130
PL_{CJ}	-2.042						0.871								0.016		0.548
	(-0.599)						(4.145)								(2.113)		2.230

Notes: The numbers in the parenthesis under the estimated coefficient indicate t-statistic of the coefficient.
* indicates R: the exchange rate (\/US$) and PPI: the producers' price index of the U.S.
R^2, DW and (-1): the same as figure 2.

wage rate leads to 4.8% decreases in the equilibrium quantity. The estimated coefficients for the capacity of sawmills without and with a lag, 2.4 and -2.1, reveal that 10% increase in the capacity may contribute to the equilibrium quantity increase of 3%. The coefficient of TT1 that is negative indicates that the equilibrium quantity has been continuously shifted downwards during 1973-93.

2. Price of the domestic log

The coefficient for the softwood standing volume is negatively significant, indicating that the price has declined in 2.7 times more rapidly than the standing volume increased. The estimated coefficient of the logging wage rate, 0.44, indicates that 10% rise in the wage rate may contribute to 4.4% increase of the log price. If the wage rate increases continuously, the difference between the log price and the wage rate as a cost factor in the term of cubic meter must be small gradually. The domestically processed lumber supply with a lag has a positive impact on the price. The coefficient shows that 10% increase in the supply may lead to 8.3% rise of the log price. The coefficient of TT1 is positive.

3. Equilibrium imports of U.S. log into Japan

The estimated coefficients of the domestic sawmill capacity, both current and lagged, jointly show that 10% growth of the capacity can eventually contribute to 30% increase of U.S. log imports in Japan. This contribution is ten times larger than that for the domestic log. This rate is almost the same as the above structural model. Governmental subsidy to make large-scale sawmills must lead to the demand for U.S. logs significantly. The coefficient for the timber harvest in U.S. reveals that the log export to Japan may reduce only in 45% of the harvest reduction rate. The time trend coefficient for 1973-89 is negative.

4. Import price of U.S. log in Japan

The estimated coefficients for the sawmill capacity, that is 7.8 and -6.8, current and lagged respectively show that the growth of sawmill capacity in the long run may lead to rise in the price almost proportionally. The coefficient of U.S. housing starts is positive that is 0.26, which has a small impact on the price. The estimated value for timber harvest in U.S., that is -1.29, implies that the timber harvest may influence the price reversibly but strongly.

5. Equilibrium quantity of the domestically processed lumber

The coefficient for the sawmill capacity indicates that a continuous 10% increase in the sawmill capacity may contribute to 7.3% increases in the domestically processed lumber supply. The estimated value of the Japanese housing construction starts with a delay is positive but small contribution. The time trend coefficient during 1973-89 is positively significant.

6. Price of the domestically processed lumber

The sawmill capacity with a lag has a negative effect on the price. The coefficient indicates that an increase of 10% in the capacity may lead to 6.3% diminution of the price. The situation of Japanese lumber industry must be in the increasing returns. The coefficient of the domestic new housing starts reveals that 10% increase in the housing starts may contribute to the price rise of 5.4%. The coefficient of time trend during 1973-89 is negative but very small.

7. Equilibrium imports of U.S. lumber into Japan

The coefficient of GDP_J with a lag is very large; Japanese GDP growth may lead lumber imports growth at the three times faster rate. The coefficient of the new housing construction starts with a lag reveals that 10% increase in U.S. housing starts leads to 7.8% decrease in the lumber export. A decrease of 10% in the timber harvest in U.S. may induce 12.8% decrease in U.S. lumber exports to Japan. The time trend coefficient during 1990-93 shows that the lumber imports has shifted downwards since 1990.

8. Import price of U.S. lumber in Japan

The domestic factors of U.S. (housing starts, stumpage price and exchange rate) influence the import price significantly. Those three coefficients happen to have almost identical values of about 28%. The coefficient of TT3 is positive.

9. Equilibrium imports of Canadian lumber into Japan

The coefficient of the timber harvest in Canada, that is 2.8, shows that the timber harvest in Canada may have 2.8 times larger contribution to the lumber export to Japan. If the timber harvest in Canada decreases due to the environmental consideration, Canadian lumber export to Japan will be diminished drastically. U.S. timber harvest may have negatively influenced on the lumber export from Canada to Japan through the timber trade between U.S. and Canada. An increase of 10% in U.S. timber harvest leads to 14% diminution of the lumber export. The estimated coefficient of U.S. housing starts reveals that 10% increase in U.S. housing starts leads to 6.4% decrease in the lumber export from Canada to Japan.

10. Import price of Canadian lumber in Japan

The Japanese new housing starts with a lag have a positive correlation to the price. The coefficient indicates that an increase of 10% in the housing starts leads to 8.7% rise in the price. The coefficient of TT2 is positive.

CONCLUSION

This study has successfully modeled the structure of Japanese softwood timber market including imports from U.S. and Canada. The estimations enable us to quantify the impacts of exogenous changes on Japanese timber market, such as more stringent harvesting regulation for the environmental protection.

There are two main important findings noticeable on the supply sides in the model. Firstly, the most important factor in determining the domestic softwood log supply is identified as the forest standing volume. Hence, the domestic log supply is expected to increase significantly in a near future, since huge but young Japanese man-made forests are increasing rapidly in standing volume and soon to reach the harvesting ages. Secondly, the own price elasticity of export supply, both for log and lumber, from U.S. are higher than those of the domestic supply in Japan. U.S. timber supply has been more price-driven than that of Japanese forest-related industry. On the demand sides, the sawmill capacity plays a very important role in log demand, especially for the logs imported from U.S.

If U.S. curtail timber harvest in Pacific Northwest by 10%, softwood log exports to Japan would decrease by 4.5% with price increase of 13%, thus without losing revenue but with increasing revenue on the contrary. The same harvest curtail at the same time leads the lumber export decrease of 13%. This has no effects on the price, so U.S. would lose revenue due to the curtail in the lumber market. Canada, however, benefits from U.S. timber harvest curtail, since the 10% curtail would induce 14% increase in the export without price changes. If Canada curtails timber harvest in British Columbia by 10%, their softwood lumber exports to Japan would decrease by 28% without price change, and thus export value would decrease. The environmental conservation movements including wild life protection movements have become very popular in U.S. and Canada. Hence the regulation on timber harvesting may result in more than 10% harvesting reduction. The environment-oriented policy, thus, would affect the Japanese timber market very seriously.

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APPENDIX: The list of the variables

<Endogenous variables with units: Data source (b) and (e)>

DL_i: demand for softwood lumber (i = A: 1000 b.f., C: 1000 b.f., J: m^3)
DR_i: demand for softwood round log (i = A: 1000 b.f. scribner scale, J: m^3)
PL_i: real price of softwood lumber (i = A: US $ / 1000 b.f., C: Canadian $ / 1000 b.f., J: Japanese yen / m^3)
PR_i: real price of softwood round log (i = A: US $ / 1000 b.f. scribner scale, J: Japanese yen / m^3)
SL_i: supply of softwood lumber (i = A: 1000 b.f., C: 1000 b.f., J: m^3)
SR_i: supply of softwood round log (i = A: 1000 b.f. scribner scale, J: m^3)

<Exogenous variables with units>

C_J: real logging wage rate in Japan (yen/day): Data Source (c)
CP_J: capacity of sawmills in Japan (kw): (b)
DM: 1 in 1973 and '74, and 0 otherwise
GDP_J: real Gross Domestic Product in Japan (billion yen): (a)
HS_A: new housing starts in U.S. (1000 units): (d)
HS_J: new housing construction starts in Japan (units): (b)
OTR: imported logs from Russia and other regions (m^3)]: (b)
R: the exchange rate of U.S. dollar to Japanese yen (yen / US$): (d)
STP_A: stumpage price of Douglas-fir on National Forest in Pacific Northwest (US$ / 1000 b.f.): (f)

TT1: time trend during 1973〜1993; such as 73, 74, ... 92, 93
TT2: time trend from 1973 up to 89; such as 73, 74... 88, 89, 89, 89, 89, 89
TT3: time trend during 1990〜1993; such as 0, 0, ... 0, 1, 2, 3, 4
TH_A: timber harvest in Pacific Northwest (million b.f. scribner scale): (f)
TH_C: timber harvest in British Columbia ($1000m^3$): (f)
V_J: softwood stand volume in Japan ($1000m^3$): (c)

Note: Subscript " i " indicates that A: Pacific Northwest, C: British Columbia, J: Japan. PR_{AJ} is the real price of imported softwood log and PL_{AJ} is the imported softwood lumber from U.S. in Japan. PL_{CJ} is the real price of imported softwood lumber from Canada in Japan. The deflators are the wholesale price index or producers' price index of the corresponding country. The annual softwood standing volumes in Japan are calculated in the base of the surveys conducted in about 5 year intervals.

Data Sources

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