Effects of Restrictions on Softwood Lumber and Plywood Trade in the Pacific Basin:

Application of the Spatial Temporal Forest Products (STFP) Model

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I. Introduction

Identification of patterns in availability and consumption of forest products throughout the world is necessary in order to make decisions regarding the management of timber supplies in various global regions. The major U.S. trading partners for forest products are Japan and Canada. Japan is the leading importer of U.S. forest products while Canada is the major exporter of these commodities to the United States.

Canada and the United States, from the standpoint of forest resources, could be considered as a single economic region, with only a political boundary and certain trade barriers separating them (Zivnuska). The United States is the only developed nation which has a surplus of growth over cut, yet still is a net importer of forest products. This is explained in part by the close relationship of the U.S. and the Canadian forest products industries for which the U.S. is the major market. In its wood trade balance

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with the rest of the world (excluding Canada), the U.S. is a net importer.

Outside of the import – export relationship with each other, both the U.S. and Canada are major exporters with other countries. In the Pacific Basin, Japan is the focal point for forest products trade with other countries. With rapid economic growth and a large population relative to land area, Japan's forest resources production falls short of domestic consumption, therefore, Japan has been a net importer of forest products.

The objectives of this study are three-fold. First, a spatial and temporal forest products model is developed incorporating the U.S., Canada, and Japan as major sectors. Second, the model's performance is evaluated outside the estimation period. Third, policy simulations (e.g., quota) are implemented and the model is evaluated as a policy tool in terms of its ability to correctly capture price and trade flow effects.

II. Production and Trade of Softwood Lumber and Plywood

The U.S. Position

The United States is the world's leading importer of forest products. It is also among the top exporters of forest products. Canada is the foremost supplier of imported forest products to the U.S., but according to Holland (*Report of the President's Advisory Panel on Timber and the Environment,* 1973), the future U.S. wood trade position is strongly linked to Japan with respect to both exports and imports of forest products. Therefore, it is necessary not only to examine domestic and Canadian demands, but also demand for forest products in Japan.

Imports of softwood lumber have more than tripled from 3.1 billion board feet in 1950. The most important source of these imports has been Canada, which provide nearly all (99% in 1971) of the softwood lumber imports. This large increase in imports from Canada has accompanied the expansion of British Columbia's sawmilling industry. One reason used to explain this increase in imports from British Columbia has to do with the Merchant Marine Act (Jones Act) which requires goods shipped between

U.S. ports to be shipped in vessels of U.S. registry. In the early 1970's, west coast mills were at a ten to fifteen dollar per thousand board feet (MBF) disadvantage relative to coastal British Columbia mills due to this act. However, imports have also increased in mid-western and eastern U.S. markets to which the lumber is shipped by rail. In the interior regions of Canada, provincial governments favor the subsidizing of forest industries in order to promote employment and economic activity.[1] One of the main impacts of the Jones Act, then, is the elimination of Alaskan lumber from markets in the 48 contiguous states. Most lumber produced in Alaska is destined for export to Japan.

The United States and Canada are the only important producers and consumers of softwood plywood in the world. Neither imports nor exports have been significant because of mutual tariff restrictions on softwood plywood. Woodbased panel markets exist in Japan, but at present, hardwood plywood made from Philippine mahogany (luan) are used, and softwood plywood is not likely to make much of an inroad there, due to the low price of the tropical hardwood, and to the tariff which Japan has on softwood plywood. However, Japan is the largest supplier of hardwood plywood imports for the United States, and future imports will continue to originate in Asia.

The Canadian Position

Canada is the world's most important exporter of forest products, both in value and volume. Even though domestic consumption of wood products is increasing, the majority of timber harvested goes into wood products for export trade. Although Canada exports forest products to more than fifty countries, the U.S. is the largest single market, taking approximately three-quarters of the value of Canada's forest products exports. Further development of Canadian forest potential will be heavily conditioned on expanding markets, especially export markets.[2] This has historically been the case for expanded sales of Canadian forest products, with the exception of plywood.

[1] See Holland, in *Report of the President's Advisory Panel on Timber and the Environment.* p. 301.

[2] See Holland, p. 305.

British Columbia has been responsible for most of the expansion in the Canadian forest industries since the early 1950's. It is the province containing the largest area suitable for regular harvest of timber. This has come about largely as a result of government policy encouraging development of the provinces' forest resources. Economically accessible growing stock in Canada is able to sustain an annual allowable cut of approximately 8.5 billion cubic feet, which is about twice the volume of present cutting levels. Of this possible increase, one-third is located in British Columbia. This situation allows for large increases of forest products available for export, especially in the Pacific region.

The Japanese Position

Japan represents a potential market for expansion of U.S. and Canadian forest products exports, including exports of lumber. It is also an important source of imports of hardwood plywood. Although Japan is heavily forested, there are some major problems in supplying large quantities of forest products from her forest lands. First, most of the accessible timber was cut during World War II, and even with reforestation, many of these stands are not yet old enough to harvest. Second, softwoods are in greatest demand, but Japan's forests are only 37 percent coniferous. Finally, land ownership is not conducive to increasing output of the forests. Fifty-seven percent of Japan's forests are privately owned, much of this by small landowners, making it difficult to manage and harvest tracts of land of sufficient size of significantly increase forest products output.[3]

Even if output can be increased with the maturing of reforested areas and plantation, and conversion of old native coniferour stands, it is doubtful if increases in output can keep pace with expanding demand in Japan's expanding economy. With high numbers of housing units being constructed each year, lumber demand has been growing since the early 1950's, and lumber imports have rapidly increased, with Canada being the major supplier and the U.S. ranking second in exports of lumber

[3] As of the early 1970's, there were three million owners of private forest land in Japan. Ninety-four percent of these land owners were farmers. Only four percent of these land holdings exceed 25 acres in size, and there is very little consolidation of private forest land.

to Japan. During this same period, plywood production has increased nearly ten times, although exports of plywood are generally declining.

III. Previous Modeling Research

For the United States, an important portion of the lumber supply comes from imports, primarily from Canada. Imports of softwood lumber accounted for 28 percent of the total lumber consumed in 1978. Total imports increased 15 percent from the previous year. This shows that attention should be given to imports, not only from the view of the total share, but also from relative growth rates, and its effects on decision making regarding international trade as well as domestic forest products policies. Several studies have recognized the importance of the relationship between U.S. and Canada into their models (McKillop, 1967; Robinson, 1974; Adams, 1977). Buongiorno, *et al.* (1976) modeled monthly U.S. lumber imports. They stated that imports depend on importers' expectations of construction activity, domestic and foreign prices, and domestic prices of other goods.

In 1977, Haynes, Holley, and King developed the Equilibrium Timber Model (ETM). This model was a modification of the original Interregional Timber Model (ITM) (Holly, Haynes, and Kaiser, 1975). A linear programming formulation is used which allocates timber resources to products through the marketing system from various supply regions to demand regions.

The development of forest products research suggests that price and flows of these commodities are affected by the existence of excess demand in certain areas and excess supply in other areas, which represent consuming and producing areas, respectively. Forest products are transferred between these areas according to price differentials where trade barriers do not exist, and are transferred subject to trade barriers where they do exist. This leads to the inclusion of imports and exports when the models describe movements of forest products across borders. This research implies that a study which constructs a model meeting the objectives as described earlier could be of use in evaluating policy changes which affect the movements of forest products, or in forecasting future forest products needs in various regions of the world, given demand and supply relationships.

IV. The Spatial Temporal Forest Products (STFP) Model

The model developed here is a three country, two commodity model of softwood lumber and plywood trade between the U.S., Canada, and Japan. Whereas other forest product studies have used linear programming models, this research uses the linear complementary programming (LCP) technique. Like quadratic programming (Q^p), LCP is able to represent spatially distinct markets separated by transportation costs. The major deficiency of Q^p is that the Q matrix must by symmetric.[4] In LCP, the Q matrix can be asymmetric, thereby providing greater flexibility in representing commodity relationships. The general LCP problem can be stated as follows:

(1.1) Find x, p, w_1, and w_2 such that

$$\begin{bmatrix} w_1 \\ w_2 \end{bmatrix} = \begin{bmatrix} -b \\ c \end{bmatrix} + \begin{bmatrix} O & A \\ B & Q \end{bmatrix} \begin{bmatrix} p \\ x \end{bmatrix}$$

and $w_1 p = 0$ and $w_2 x = 0$ for x, p, w_1, and $w_2 \geqslant 0$, where x is a vector of consumption, supply, trade and storage quantities; p is a vector of prices; w_1 and w_2 are unknown slack vectors.

Recalling that LCP differs from Q^p, the Q matrix is not assumed to be symmetric. The 0 is the zero or empty matrix and the A matrix is a matrix defining relationships between supply, demand, trade, and carry-over activities. The B matrix is the negative transpose of the A matrix, and defines the dual variables.

[4] Bartilson, Zepp, and Takayama (1978) state that the off-diagonal elements of the Q matrix represent the substitution and complementary relationships between different commodities. A symmetric Q matrix implies that the relationship be exactly equal between commodities. The chances of these symmetric matrices arising naturally from estimation of coefficients is very remote in practical econometric work, unless the symmetry condition is superimposed in the estimator.

The demand equations for softwood lumber and plywood are necessary in order to develop the relationships which govern trade between countries. First, the structural form of the equations are specified consistent with economic theory and lumber and plywood idustries in each country. Then, demand equations are estimated using ordinary least squares (OLS).

Softwood lumber is an input used in producing housing, furniture, and other wooden products, therefore, the demand for softwood lumber is derived from these final products. In each of the three trading countries, the primary use of lumber is in building construction, specifically, the construction of housing.

The three structural softwood lumber demand equations are:

(1.2) $Q_L^{US} = f(P_L^{US}, P_P^{US}, HS^{US}, D)$

(1.3) $Q_L^C = f(PRL, PPAD^C, VBP^C, CWI^C, D)$

(1.4) $Q_L^J = f(PLAD^J, PPAD^J, WC^J, D)$

where Q_L^i = per capita softwood lumber consumption in board feet (i = U.S., Canada, and Japan),

P_L^{US} = real producer price index of softwood lumber (1967 = 100),

P_P^{US} = real producer price index for plywood (1967 = 100),

HS^{US} = thousands of housing starts (annual), D = 0/1 dummy variable (1951-1972 = 0, 1973-1978 = 1) to represent the effects of the oil embargo,

PRL = real producer price index of softwood lumber in Canada divided by the real producer price index of softwood lumber in the U.S., (1967 = 100) adjusted by the U.S./ Canadian exchange rate,

$PPAD^C$ = real producer price index of plywood in Canada (1967 = 100) adjusted by the U.S./ Canadian exchange rate,

VBP^C = value of building permits in Canada in U.S. dollars,

CWI^C = index of general construction wage in U.S. dollars,

$PLAD^J$ = real producer price index of softwood lumber (1967 = 100) adjusted by the U.S./Japanese exchange rate,

$PPAD^J$ = real producer price index of plywood (1967 = 100) adjusted by the U.S./Japanese exchange rate, and

WC^J = millions of square meters of wood structure construction.

Like lumber, plywood is an input used primarily in construction, and demand is derived from the demand for final products. A major difference between lumber and plywood, however, is that plywood is traded on an extremely limited basis, and each country is its own primary market.

The structural plywood demand equations are:

(1.5) $Q_P^{US} = f(P_P^{US}, P_L^{US}, HS^{US}, NRC^{US})$

(1.6) $Q_p^C = f(PPAD^C, PLAD^C, VH^C, VBP^C)$

(1.7) $Q_p^J = f(PPAD^J, PLAD^J, NRC^J)$

where Q_p^i = per capita plywood consumption in square feet on a 3/8 inch basis (i = U.S., Canada, and Japan),

NRC^{US} = millions of square feet of non-residential construction in the U.S. (annual),

$PLAD^C$ = real producer price index for softwood lumber (1967 = 100) adjusted by the U.S./Canadian exchange rate,

VH^C = value of housing permits adjusted by the U.S./Canadian exchange rate,

VBP^C = value of non-residential building permits adjusted by the U.S./Canadian exchange rate, and

NRC^J = millions of square meters of non-residential construction.

All other variables were defined previously.

The above specification for softwood lumber and plywood demand fit the Marshallian form, where quantity is a function of own price, income and other appropriate shifters. Although income is not entered directly into the equation, it is included implicitly in housing starts which are a function of disposable income.

The other necessary components of the STFP model are supply, transportation costs, and storage costs. Since forest products are derived from a perennial, it is assumed that each country's supply of softwood lumber and plywood is fixed in the short run.

The transportation costs for softwood lumber and plywood are shown in Table 1.1. These costs reflect the quoted rates for the various years, and may be substantially above the actual rates paid by exporting firms. The ocean transportation costs for lumber are open competitive rates as quoted by shipping lines. The ocean transportation costs for plywood are the agreed upon rates for all carriers as provided by the Pacific Westbound Con-

Table 1.1

TRANSPORTATION COSTS

From	U.S.		Canada		Japan	
To	Lumber[a]					
	1980	1981	1980	1981	1980	1981
U.S.	0	0	10	10	89	78
Canada	62	73	0	0	94	82
Japan	89	78	94	82	0	0
To	Plywood[b]					
	1980	1981	1980	1981	1980	1981
U.S.	0	0	33	38	79	87
Canada	33	38	0	0	79	87
Japan	79	87	79	87	0	0

[a] In \$U.S. per million board feet (MBF).
[b] In \$U.S. per thousand square feet 3/8 inch basis.

ference in San Francisco. Trade from Canada to the U.S. is assumed to be by rail from the interior of British Columbia to the mid-western United States, a distance of approximately 1800 miles. Trade from the U.S. to Canada is assumed to be by truck from mills near the border to nearby markets on the other side of the border.

The storage or carry-over costs are not available in published form. Therefore, costs had to be estimated based on the costs for storage of other agricultural commodities which are commonly held in storage from year to year. Corn on the Kansas City market in 1979 had a storage costs of approximately 9.2 percent of market price. Using this percentage as a base, a figure of ten percent of the price of lumber and plywood was used, based on the known prices in 1980. It should be noted, however, that this method is inaccurate, as no allowance is made for the expectations of the suppliers of forest products on the next year's prices. The storage costs used are illustrated in Table 1.2.

Table 1.2

CARRY-OVER COSTS

	Lumber[a]	Plywood[b]
U.S.	26.4	18.7
Canada	18.5	18.4
Japan	49.3	25.8

[a] In $U.S. per MBF.
[b] In $U.S. per thousand square feet 3/8 inch basis.

V. Empirical Results

The OLS demand equations were estimated over the period 1951-1978 and the results are shown in Tables 1.3 and 1.4. The signs of the coefficients for all explanatory variables are consistent with *a priori* expectations.

Table 1.3

SOFTWOOD LUMBER DEMAND EQUATIONS

Independet[a)] Variables	Intercept	Independent Variables	F[b)]	$\bar{R}^2$[c)]	D.W.[d)]
Q_L^{US}	82.266	$-.319 \cdot P_L^{US}$ + .658) $\cdot P_P^{US}$ + .0289 $\cdot HS^{US}$ −5.283 $\cdot$ D (−1.80)[e)] (10.46) (3.69) (−0.87) (−0.21)[f)]	41.46	0.86	1.66
Q_L^C	165.391	−113.097 $\cdot$ PRL + 1.447 $\cdot PPAD^D$ + 31,140 $\cdot VBP^C$ (−1.51) (3.71) (1.03) (−0.41) −.523 $\cdot CWI^C$ + 43.765 + D (−2.06) (3.08)	11.80	0.71	1.73
Q_L^J	81.971	−70.756 $\cdot PLAD^J$ + 109.065 $\cdot PPAD^J$ + .613 $\cdot$ WC (−1.20) (2.26) (2.93) (−0.21) −21.374 $\cdot$ D (−4.39)	6.90	0.63	1.55

a Units of measurement are board feet per person.
b The highest critical F-value at the 90% level of significance is 3.83.
c Coefficient of determination adjusted for degrees of freedom.
d Durbin-Watson statistic.
e Figures in parentheses are t-statistics.
f Figures in parentheses are price elasticities.

Table 1.4

PLYWOOD DEMAND EQUATIONS

Dependent[a)] Variable	Intercept	Independent Variables	F[b)]	$\bar{R}^2$[c)]	D.W.[d)]
Q_P^{US}	81.971	$-.852 \cdot P_P^{US}$ + .299 $\cdot P_L^{US}$ + .0249 $\cdot HS^{US}$ + .0336 $\cdot NRC^{US}$ (−6.92)[e] (4.08) (5.22) (4.92) (−1.40)[f]	166.96	0.96	2.10
Q_P^C	2.497	−.531 $\cdot PPAD^C$ + .419 $\cdot PLAD^C$ + 54.288 $\cdot VH^C$ + 45.667 $\cdot VBP^C$ (−2.27) (7.34) (3.24) (−0.28)	53.62	0.90	1.62
Q_P^J	−10.640	−119.161 $\cdot PPAD^J$ + 146.119 $\cdot PLAD^J$ + .683 $\cdot NRC^J$ (−3.20) (5.01) (7.70) (−0.28)	64.37	0.93	2.24

a Units of measurement are in square feet of 3/8 inch basis plywood per person.
b The highest critical F-value at the 90% levels of significance is 3.83.
c Coefficient of determination adjusted for degrees of freedom.
d Durbin-Watson statistic.
e Figures in parentheses are t-statistics.
f Figures in parentheses are price elasticities.

The price elasticity of demand for softwood lumber are -0.21, -0.41 and -0.21 for the U.S., Canada and Japan respectively. The estimated price elasticity of demand for U.S. softwood lumber is comparable with other studies (Robinson; Adams and Haynes, 1981). Elasticities for Canada and Japan from previous research were not found, however, given the similarities between markets in the three countries, it is likely that the price responsiveness in Canada and Japan is inelastic and of similar magnitude to that in the U.S.

The price elasticity of demand for plywood were calculated to be -1.40, -0.28 and -0.28 for the U.S., Canada and Japan respectively. Although the U.S. price elasticity is of far greater

Table 1.5

BASE SCENARIO RESULTS

		U.S.		Canada		Japan	
		1980	1981	1980	1981	1980	1981
Price of Lumber:	estimated	236	257	174	184	424	422
($U.S./MBF)	actual	264	263	184	183	493	432
	% error	-10.6	-2.3	-5.4	0.5	-14.0	-2.3
Quantity: demanded:	estimated	31.9	29.6	5.5	5.2	14.7	14.7
(Million MBF)	Actual	32.5	29.9	5.1	5.0	14.4	14.1
	% error	-1.8	-1.0	7.3	3.8	2.1	4.3
Net trade:[a]	estimated	8.6	7.8	9.8	9.2	1.3	1.5
(Million MBF)	actual	8.4	8.0	10.1	9.4	1.7	1.4
	% error	2.4	-2.5	-3.0	-2.1	-23.5	7.1
Price of plywood:	estimated	192	191	188	191	261	269
($U.S./1000 ft.^{2})	actual	187	186	186	185	258	278
	% error	2.7	5.7	1.1	3.2	1.2	-3.2
Quantity: demanded:	estimated	21.0	21.9	2.1	2.4	14.5	12.5
(Million ft.^{2})	actual	18.6	18.5	2.1	2.1	14.5	12.5
	% error	12.9	18.5	0.0	14.3	0.0	0.0
Net trade:[b]	estimated	0.0	0.0	0.0	0.0	0.0	0.0
(Million ft.^{2})	actual	.10	.10	.05	.03	.05	.07

[a] Net trade in lumber consists of imports for the U.S. and Japan, and exports for Canada.
[b] Net trade in plywood consists of imports for the U.S., and exports for Canada and Japan.

magnitude than the others, and is larger than what is expected for plywood, McKillop, *et al.* (1980) conducted a study which found regional price elasticities for plywood in the U.S. to be between -0.23 and -1.69. All three price elasticities derived in this study are within this range.

The STFP model results for 1980 and 1981 are shown in Table 1.5. The model seems to perform fairly accurately. The lumber and plywood prices generated are within 14% and 6% of their respective actual prices. Demand quantities for lumber are within 8% but for plywood, estimated errors are as much as 19%. A reason for these large errors is the low plywood consumption levels during the early 1980's.

Table 1.6

7.5 BILLION BOARD FEET QUOTA RESULTS

		U.S.		Canada[a]		Japan	
		1980	1981	1980	1981	1980	1981
Price of lumber:	quota	336	283	155	174	405	412
($U.S./MBF)	base	236	257	174	184	424	422
	% change	42.4	10.1	-10.9	-5.4	-4.5	-2.4
Quantity demanded:	quota	30.9	29.3	5.8	5.2	15.4	15.1
(Million MBF)	base	31.9	29.6	5.5	5.2	14.7	14.7
	% change	-3.1	-1.0	5.5	0.0	4.8	2.7
Net trade:	quota	7.5	7.5	9.4	9.3	1.9	1.8
(Million MBF)	base	8.6	7.8	9.8	9.2	1.3	1.5
	% change	-12.8	-3.8	-4.1	1.1	46.2	20.0
Price of plywood:	quota	226	200	192	181	261	268
($U.S./1000 ft.^{2})	base	192	191	188	191	261	269
	% change	17.7	4.7	2.1	-5.2	0.0	-0.4
Quantity demanded:	quota	21.2	21.9	2.0	2.4	14.5	12.5
(Million ft.^{2})	base	21.0	21.9	2.1	2.4	14.5	12.5
	% change	1.0	0.0	-4.8	0.0	0.0	0.0
Net trade:	quota	0.1	0.0	0.0	0.0	0.0	0.0
(Million ft.^{2})	base	0.0	0.0	0.0	0.0	0.0	0.0

[a] Under this scenario, Canada adds approximately 100 million BF of lumber to its inventory from 1980 to 1981.

Net trade for lumber was within 8% for all countries with the exception of Japan in 1980. Lumber trade to Japan is not large, therefore, even a small absolute error translates into a large percentage error. Also, the lumber price for Japan in 1980 was low by 14%, and this would explain the larger estimated quantities demanded for lumber.

Net trade of plywood is not presented with percent errors, as all errors are 100%, due to the model estimating no plywood trade. However, trade of plywood was so small, that estimates of no trade are not far off in absolute terms.

VI. Policy Application

A hypothetical quota on lumber imports into the U.S. is used as an example illustrating barriers to trade. The effective quota is set at 7.5 billion board feet per year. The quota is introduced into the model by removing the restriction limiting the price differential between importing and exporting countries to be equal to the transportation cost in the A matrix. If a quota is effective, the price differential should widen, and the transportation cost is no longer the link between prices. The right hand side (RHS) value for supply in the importing country is increased by the quota amount, and in the exporting country, it is decreased by the quota amount. This procedure basically provides for no trade between the countries, except that which has already been included in the supply RHS adjustments.

Comparison of the quota to the base scenario indicates that the results are consistent with *a priori* expectations (Table 1.6). The price of lumber increased in the U.S. and decreased in Canada. Also, quantity demanded declined in the U.S. and increased in Canada. The magnitude of the changes suggests that the model properly reflected the difference in the amount of restriction between 1980 and 1981. In other words, the change was greater in 1980 than in 1981, due to the smaller difference between the quota level and actual imports. Canadian exports decreased in the first year, but increased in the second, as a result of the price in Japan being lowered far enough to induce an increase in quantity demanded.

The effects on plywood were not as strong as those on lumber. In the U.S., the price increased, through the substitution effect for lumber. Increased lumber price is an incentive for the construction industry to substitute more plywood for lumber, thus driving the plywood price upwards. In Canada, where the reverse is expected because of a decrease in the lumber price, an interesting phenomenon took place. In the first year, plywood prices actually increased, instead of decreasing. The reason for this is that the increased use of plywood in the U.S. drove prices high enough for the U.S. to begin importing plywood from Canada. This reduced the Canadian plywood supply, and the Canadian price increased. In the second period, however, the increase in plywood price in the U.S. was not large enough to make imports economically feasible. Therefore, the lower lumber price in Canada induced increased lumber consumption, which, in turn, decreased plywood consumption. Consequently, the plywood price fell in Canada in the second period.

The effects in Japan, the third trading partner, are almost entirely felt on lumber. There are relatively no effects on plywood in Japan. The magnitude of the price and quantity changes in Japan are dependent on the response of Canadian consumption to price changes. In this case, the price decrease is not enough to induce complete consumption of the excess supply, and it is made available to Japan at a lower price. It should also be noted that the quota affected the price differential between time periods. Depending on how restrictive the quota is in one year relative to the next, prices can fluctuate widely. This occurred in the U.S. and Canada. The point is that the 1980 price of lumber in Canada is 19 dollars less than in 1981. The maximum carry-over cost is $18.50. Under the quota scenario, Canada carried over, or increased its stocks of lumber by approximately 100 million board feet.

VII. Summary

The STFP model has shown to be an effective policy evaluation tool. The model performed well in describing the softwood lumber and plywood markets in the U.S., Canada, and Japan. When it was adjusted to include barriers to trade, the results were consistent with economic theory.

Although the quota scenario showed market adjustments in the proper direction, i.e., increase or decrease, one should use caution in interpreting the magnitudes of these changes (recalling that there is some error between the base scenario and the actual market). However, of importance is the percentage changes in price and quantity brought about by the specific trade policy. This information will enable policy makers to have estimates of policy impacts.

Areas for further research and application of the STFP model include: (i) model simulations for alternative policy scenarios such as tariffs, (ii) expanding the number of forest products to include pulp and paper, and (iii) dividing the U.S. and Canada into major supply areas and estimating regional effects.

References

Adams, Darius M., "Effects of National Forest Timber Harvest on Softwood Stumpage, Lumber, and Plywood Markets," Res. Bull. 15. Forest Research Lab., University of Oregon, Corvallis, 1977.

——— and R. Haynes, "U.S.-Canadian Lumber Trade: The Effects of Restrictions," *Issues in U.S. International Forest Products Trade,* Baltimore: The Johns Hopkins University Press, 1981.

Haynes, R. W., D. Lester Holley, Jr. and Richard A.King, *A Recursive Spatial Equilibrium Model of the Softwood Timber Sector.* Technical Report 57, School of Forest Resources, North Carolina State University, Raleigh, 1978.

Holley, D. Lester, Jr., Richard W. Haynes and H. Fred Kaiser, Jr., *An Interregional Timber Model for Simulating Change in the softwood Forest Economy.* Technical Report 54, School of Forest Resources, North Carolina State University, Raleigh, 1975.

Bartilson, Stan, G. A. Zepp, and T. Takayma, *A User's Manual for the ICRAND Mathematical Programming System.* Economics Report 19, University of Florida, Gainesville, 1978.

Buongiorno, Joseph, Jieh-Jen Chou and Robert N. Stone. "A Monthly Model of the United States Demand for Softwood Lumber Imports," *Forest Science,* 25(4), 1979, 641-655.

McKillop, W. L. M., "Supply and Demand for Forest Products. An Econometric Study," *Hilgardia*, 38, 1967, 1-132.

———, Thomas W. Stuart and Peter J. Geissler, "Competition Between Wood Products and Substitute Structural Products: An Econometric Analysis," *Forest Science*, 26, 1980, 134-148.

President's Advisory Panel on Timber and the Environment, *Report of the President's Advisory Panel on Timber and the Environment.* Washington, D.C., U.S. Government Printing Office, 1973.

Robinson, V. L., "An Econometric Model of Softwood Lumber and Stumpage Markets, 1947-1967," *Forest Science*, 20(2), 1974, 171-179.

Zivnuska, J. A., *U.S. Timber Resources in a World Economy.* Baltimore: The Johns Hopkins Press, 1967.