DEMAND FUNCTIONS FOR UNITED STATES FOREST PRODUCT EXPORTS TO THE EUROPEAN ECONOMIC COMMUNITY[1]

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(Received September 1982)

ABSTRACT

The European Economic Community (EEC) is becoming an increasingly important market for United States forest products. Prediction of the future size of this market requires a quantitative assessment of the responsiveness of demand with respect to United States prices, the price of products from other countries, and major demand shifters within the EEC. To determine these elasticities, a theoretical dynamic demand model was developed. The model was estimated for each one of seven major groups of United States products sold in the EEC: softwood lumber (SITC 243.2), hardwood lumber (SITC 243.3), pulp and waste paper (SITC 251), veneer sheets (SITC 631.1), plywood (SITC 631.2), newsprint paper (SITC 641.1), and other paper and paperboard (SITC 641 excluding 641.1). Analysis of covariance was the estimation procedure used, based on pooled time series from eight EEC countries observed during the period 1961 to 1977. Elasticities appeared to be the same in all countries, except in the case of softwood lumber and newsprint. Demand was found to be elastic with respect to the American price, except for lumber. Own-price elasticities ranged between -0.21 (± 0.52) for softwood lumber and -4.72 (± 1.05) for newsprint paper. Cross elasticities of demand with respect to the price of products from other countries ranged from 0.21 (± 0.52) for softwood lumber to 8.36 (± 3.17) for hardwood lumber. Demand for hardwood lumber and pulp and waste paper was significantly and negatively affected by the general price level in the EEC. The level of economic activity in the EEC had a strong positive impact on demand for United States forest products.

Keywords: International trade, econometrics, elasticities, EEC, lumber, plywood, newsprint, paper, paperboard.

INTRODUCTION

United States exports of forest products have increased rapidly in recent years, rising from 5 million metric tons, valued at 0.5 billion dollars in 1961 to some 27 million tons valued at 7 billion dollars in 1980. This fast growth has been due to the development of new markets in the entire world, but especially in Japan and in the European Economic Community (EEC).[2] While exports to Japan have been largely in the form of primary materials—logs and chips—those to Western Europe have consisted mainly of intermediate products—softwood lumber, pulp and paper, and paperboard (Sedjo and Radcliffe 1981). According to a recent world outlook published by the Food and Agriculture Organization (FAO), sawn-

[1] The authors gratefully acknowledge the guidance and support of David Darr throughout this study. Financial support was provided by the USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, and by the School of Natural Resources, College of Agricultural and Life Sciences, University of Wisconsin, Madison.

[2] For the purpose of this study the EEC was defined as consisting of the following nine countries: The Netherlands, West Germany, Italy, France, Belgium, Luxemburg, Britain, Denmark, and Ireland. The three latter countries joined the EEC in 1973.

Wood and Fiber Science, 16(2), 1984, pp. 158–168

wood and panels consumption in Western Europe will continue to increase, though at a decreasing rate during the next twenty years. Pulp products are expected to maintain a vigorous growth (FAO 1982). Because of limited forest resources, an increasing share of the supplies will have to be imported. How well the United States fares among competing suppliers will depend on two factors: how United States prices compare with those of the rest of the world, and how sensitive the EEC demand is to changes in those prices. The latter problem must be solved prior to finding the solution of the global equilibrium implied in the former. With this in mind, the object of this paper is to establish empirical demand functions for United States forest products in the EEC and in the process to determine the elasticities of that demand with respect to the price of American products and to the price of products from other countries.

Recently, Stone (1979) investigated the EEC demand for imports in various Standard International Trade Classification (SITC) categories, including two forest product groups. His reported price elasticities of demand for cork and wood manufactures (SITC 631-633) and paper manufactures (SITC 641-642) were -1.57 and -0.80, respectively. Apart from covering very broad product groups, these elasticities refer to EEC imports from all countries. This study concentrates instead on the United States and deals with seven product groups at the three and four digit SITC level.

The paper first describes the theoretical model used in the analysis and then the data, which consist of pooled time series for eight EEC countries for the period 1961 to 1977. The empirical results are then presented showing that demand for all product groups except lumber is elastic with respect to their own price. Cross-price elasticities with products coming from other countries are equal to or higher than own-price elasticities. Demand for all products except lumber is elastic with respect to final output.

THEORETICAL MODEL

Let U_{ijt} be an index of the amount of American product j used by country i in the EEC during period t; W_{ijt} be an index of the quantity of that product used in that country during the same period originating from the rest of the world; Q_{ijt} be an index of the amount of all other commodities used in combination with product j to produce a particular output designated by the variable Y_{ijt}.

In the remainder of the discussion, the subscripts i, j, t are omitted to simplify notations. It should be kept in mind, however, that each variable refers to a particular commodity group, a specific country, and a given year.

It is assumed that the relationship between output Y and inputs, U, W and Q can be described by a generalized Cobb-Douglas production function (Dixon et al. 1980):

$$Y = aU^{\alpha_1}W^{\alpha_2}Q^{\alpha_3}u. \tag{1}$$

The associated cost function is:

$$C = PU \cdot U + PW \cdot W + PQ \cdot Q \tag{2}$$

where C is an index of the cost of producing Y while PU, PW and PQ are, respectively, indices of the price of the American forest product of interest in a specific country of the EEC in a given year, the price of the same product originating from other countries, and the price of all other inputs used in producing Y.

TABLE 1. *Demand for United States forest products in the EEC according to model (6), 1961–1977.*[a]

Product group (SITC, revised)	Coefficients of independent variables					R^2	r (h)	n
	PU	PW	PQ	Y	U_{-1}			
Softwood lumber	−0.32	0.04	0.19	0.01	0.34	0.86	−0.14	54
(243.2)	(0.47)	(0.44)	(0.53)	(0.54)	(0.11)		(−2.62)	
					***		**	
Hardwood lumber	−0.16	2.38	−2.63	2.37	0.74	0.84	−0.18	54
(243.3)	(0.28)	(0.69)	(1.13)	(1.05)	(0.10)		(−2.65)	
		***	**	**	***		**	
Pulp and waste paper	−0.82	1.34	−0.56	1.01	0.10	0.83	−0.14	54
(251)	(0.27)	(0.28)	(0.25)	(0.16)	(0.10)		(−1.73)	
	***	***	**	***				
Veneer sheets	−0.94	0.54	0.84	4.48	0.28	0.87	0.04	51
(631.1)	(0.29)	(0.44)	(0.74)	(1.37)	(0.10)		(0.50)	
	***			***	***			
Plywood	−1.67	1.00	1.06	3.50	0.19	0.93	0.11	50
(631.2)	(0.32)	(0.74)	(0.92)	(1.36)	(0.11)		(1.67)	
	***			***	**			
Newsprint paper	−3.43	4.90	0.07	2.68	0.18	0.64	−0.16	41
(641.1)	(0.63)	(2.11)	(3.91)	(3.28)	(0.13)		(−2.74)	
	***	***					***	
Other paper and paperboard	−1.51	1.17	−0.43	0.87	0.40	0.90	−0.14	54
(641–641.1)	(0.38)	(0.49)	(0.44)	(0.62)	(0.08)		(−1.46)	
	***	***			***			

[a] PU, PW and PQ are natural logarithms of, respectively, the price of the United States product, the price of the same product from the rest of the world, and the price of all inputs used with that product. Y is real domestic product, except in the case of pulp and waste paper, where it is paper and paperboard production. Numbers in parentheses under coefficients are standard errors. ** and *** indicate coefficients significantly different from zero at the 0.95 and 0.99 confidence level, respectively. R^2 is the coefficient of determination, corrected for degrees of freedom, n. r is the coefficient of serial correlation and h is Durbin's (1970) statistic.

It is assumed that decision makers choose the input mix which minimizes cost, subject to the technology described by (1). This leads to a conditional factor demand for American forest products of the form (Varian 1978):

$$U = a_0 PU^{a_1} PW^{a_2} PQ^{a_3} Y^{a_4} \epsilon \tag{3}$$

where

$$a_0 = (a\alpha_1^{-\alpha_2-\alpha_3}\alpha_2^{\alpha_2}\alpha_3^{\alpha_3})^{-1/(\alpha_1+\alpha_2+\alpha_3)}$$
$$a_1 = -(\alpha_2 + \alpha_3)/(\alpha_1 + \alpha_2 + \alpha_3)$$
$$a_2 = \alpha_2/(\alpha_1 + \alpha_2 + \alpha_3)$$
$$a_3 = \alpha_3/(\alpha_1 + \alpha_2 + \alpha_3)$$
$$a_4 = 1/(\alpha_1 + \alpha_2 + \alpha_3)$$
$$-1/(\alpha_1 + \alpha_2 + \alpha_3)$$
$$\epsilon = u.$$

The coefficients a_1, a_2, and a_3 are the elasticities of demand of the American product of interest in a specific EEC country with respect to its price, the price of the same product from other countries, and the price of other inputs. Since all α's are positive, the own-price elasticity a_1 is negative while the two cross-price elasticities a_2 and a_3 are positive. In addition, it is readily seen that $a_1 + a_2 + a_3 =$

TABLE 2. *Demand for United States forest products in the EEC after imposition of homogeneity in prices (model (7)), 1961–1977.*[a]

Product group (SITC)	Coefficient of independent variables				R^2	r (h)	n
	PU/PQ	PW/PQ	Y	U_{-1}			
Softwood lumber	−0.27	0.02	−0.12	0.35	0.86	−0.15	55
(243.2)	(0.42)	(0.38)	(0.23)	(0.11)		(−2.56)	
				***		**	
Hardwood lumber	−0.18	2.34	1.90	0.72	0.84	−0.17	55
(243.3)	(0.28)	(0.69)	(0.43)	(0.09)		(−1.95)	
		***	***	***			
Pulp and waste paper	−0.80	1.30	0.98	0.09	0.83	−0.12	55
(251)	(0.26)	(0.24)	(0.12)	(0.09)		(−1.37)	
	***	***	***				
Veneer sheets	−0.90	0.47	5.09	0.28	0.87	0.06	52
(631.1)	(0.28)	(0.43)	(1.03)	(0.10)		(0.77)	
	***		***	***			
Plywood	−1.67	0.90	3.95	0.20	0.93	0.11	51
(631.2)	(0.32)	(0.70)	(1.13)	(0.11)		(1.41)	
	***		***	**			
Newsprint paper	−3.54	5.74	4.60	0.19	0.65	−0.15	42
(641.1)	(0.60)	(1.63)	(1.23)	(0.13)		(−2.64)	
	***	***	***			**	
Other paper and paperboard	−1.80	1.25	−0.62	0.53	0.89	−0.22	55
(641–641.1)	(0.38)	(0.52)	(0.31)	(0.07)		(−2.14)	
	***	***	**	***		**	

[a] Variables and symbols are defined in Table 1.

0, i.e., the conditional demand is homogeneous of degree zero in prices so that given a certain level of output Y, the demand for the American product does not change if all prices change by the same proportion (Varian 1978). The elasticity a_4 is positive and measures the shifts in demand arising from changes in output Y.

Equation (3) is static so that the elasticities are best interpreted as measuring long-term effects of changes in output and prices on demand. It is generally recognized, however, that demand does not adjust instantaneously to its long-run equilibrium level following a change in any of its determinants (Turnovsky 1968; Khan 1974; Yadav 1975; Goldstein and Khan 1976; Wilson and Takacs 1978). Many reasons have been advanced to explain the adjustment lag; for example, Malinvaud (1970) suggested that imports are linked to contracts between distant countries that cannot respond promptly to changes in demand, while Griliches (1967) developed a detailed theory of the cost of adjusting demand. We use here one of the simplest mechanisms describing the dynamics of demand, along the lines of the partial adjustment model suggested first by Nerlove (1956, 1958). To do this Eq. (3) is rewritten as:

$$U^* = a_0 PU^{a_1} PW^{a_2} PQ^{a_3} Y^{a_4} \epsilon \tag{4}$$

where U^* is the desired quantity of the American product of interest given the prices PU, PW, and PQ and the level of output Y. It is then assumed that only

TABLE 3. *Demand for United States forest products in the EEC after imposition of homogeneity in prices and zero elasticity with respect to other inputs (model (8)), 1961–1977.*[a]

Product group (SITC)	Coefficients of independent variables			R^2	r (h)	n
	PU/PW	Y	U_{-1}			
Softwood lumber (a)	−0.10	−0.19	0.35	0.87	−0.14	56
(243.2)	(0.35)	(0.20)	(0.11)		(−1.84)	
			***			
(b)	−0.14		0.34	0.87	−0.10	57
	(0.34)		(0.11)		(−1.33)	
			***			
Hardwood lumber	−0.23	1.83	0.79	0.81	−0.10	56
(243.3)	(0.30)	(0.47)	(0.10)		(−1.31)	
		***	***			
Pulp and waste paper	−1.15	0.85	0.16	0.79	−0.16	56
(251)	(0.26)	(0.13)	(0.10)		(−1.92)	
	***	***				
Veneer sheets	−0.81	5.48	0.31	0.86	0.04	53
(631.1)	(0.27)	(0.13)	(0.10)		(0.54)	
	***	***	***			
Plywood	−1.59	4.39	0.21	0.93	0.10	52
(631.2)	(0.31)	(1.06)	(0.10)		(1.21)	
	***	***	**			
Newsprint paper	−3.59	4.57	0.24	0.63	−0.25	43
(641.1)	(0.61)	(1.25)	(0.12)		(−3.84)	
	***	***	**		***	

[a] Variables and symbols are defined in Table 1. Other paper and paperboard demand not estimated because homogeneity in prices was rejected (see Table 4).

some fraction of any desired adjustment is accomplished during one time period, so that the actual relative change in demand between periods $t - 1$ and t is part of the relative difference between the desired demand in period t and the actual demand in period $t - 1$, specifically:

$$U/U_{-1} = (U^*/U_{-1})^{\gamma} \tag{5}$$

where γ is a coefficient with a value between 0 and 1 measuring the speed of adjustment. $\gamma = 1$ corresponds to an instantaneous adjustment, in which case Eqs. (4) and (3) are identical. It has been noted elsewhere that this partial adjustment formulation is equivalent to a distributed-lag structure with geometrically decreasing weights (Koyck 1954; Johnston 1972). Substituting (4) in (5), solving for observed demand, and taking logarithms leads to:

$$\begin{aligned} \ln U = {} & \gamma a_0 + \gamma a_1 \ln(PU) + \gamma a_2 \ln(PW) + \gamma a_3 \ln(PQ) \\ & + \gamma a_4 \ln(Y) + (1 - \gamma)\ln(U_{-1}) + \gamma\epsilon \end{aligned} \tag{6}$$

in which the coefficients of the logarithm of each variable in the equation are now the short-term elasticities of demand. It is apparent that the corresponding long-term elasticities can readily be obtained from these coefficients and from the coefficient of lagged demand.

Model (6) is the basic model used in this study. As such it assumes that the law governing demand for United States products is the same in all EEC countries apart from random variations measured by $\gamma\epsilon$. In addition, as indicated earlier the theoretical basis for the model implies homogeneity of degree zero in prices ($a_1 + a_2 + a_3 = 0$). This constraint imposed on (6) leads to:

$$\ln U = \gamma a_0 + \gamma a_1 \ln(PU/PQ) + \gamma a_2 \ln(PW/PQ) + \gamma a_4 \ln(Y) + (1 - \gamma)\ln(U_{-1}) + \gamma\epsilon. \quad (7)$$

Finally, if there is only substitution between the American product and the same product originating from other countries, but not with other goods used to produce Y, so that $a_3 = 0$, then the homogeneity condition becomes $a_1 + a_2 = 0$ and the demand equation reduces to:

$$\ln U = \gamma a_0 + \gamma a_1 \ln(PU/PW) + \gamma a_4 \ln(Y) + (1 - \gamma)\ln(U_{-1}) + \gamma\epsilon. \quad (8)$$

Whether each assumption is acceptable in the present situation will be tested using the following data.

THE DATA

As mentioned earlier, seven groups of forest products were considered in this study: softwood lumber (SITC 243.2), hardwood lumber (SITC 243.3), pulp and waste paper (SITC 251), veneer sheets (SITC 631.1), plywood (SITC 631.2), newsprint paper (SITC 641.1), and other paper and paperboard (SITC 641 excluding SITC 641.1). The consumption of a particular American product in a given EEC country during a specific year was taken to be equal to imports by that country from the United States during that period, as published by the Organization for Economic Cooperation and Development (OECD).[3] Annual data were collected for the period 1961 to 1977 for the four major EEC importers of a particular product group.[4] The countries were selected from the following set: The Netherlands, West Germany, Italy, France, Belgium-Luxemburg, Britain, Denmark, and Ireland. The three latter countries joined the Community in 1973; dummy variables were used to allow for possible shifts of the demand functions of these countries after their entry in the EEC. The selected countries imported more than 80 percent of all EEC imports from the United States during the period of observation. This led to 68 observations for each commodity group, except for veneer sheets, plywood, and newsprint which had only 67, 65, and 57 observations respectively, because of missing data. Unit values of imports were used to measure PU, the price of American products and PW, the price of products from the rest of the world. Quantity and value of imports from the rest of the world were computed by subtracting imports from the United States from total imports. The CIF import values reported by the OECD are recorded in U.S. dollars so that

[3] OECD, Statistics of Foreign Trade, Series C: Trade by commodities-Market summaries, OECD, Paris (various issues). All quantities are recorded in metric tons, except British imports of veneer sheets and plywood, which had to be converted from square meters to metric tons for many years. In that case FAO's conversion factors were used (FAO 1979).

[4] For newsprint paper five major importers had to be used to obtain a sample sufficiently large, because of non-trade in some years.

TABLE 4. *Test statistics for three alternative models of United States forest products demand in the EEC, 1961–1977.*[a]

Product group (SITC)	Unrestricted model (6)		Restricted model (7)			Restricted model (8)		
	SSR_6	n_6	SSR_7	n_7	F_7	SSR_8	n_8	F_8
Softwood lumber (243.2)	4.98	54	4.99	55	0.11	5.12	56	0.76
Hardwood lumber (243.3)	14.77	54	14.84	55	0.26	17.89	56	5.70 ***
Pulp and waste paper (251)	0.88	54	0.88	55	0.12	1.09	56	6.44 ***
Veneer sheets (631.1)	18.19	51	18.35	52	0.45	18.71	53	0.73
Plywood (631.2)	13.76	50	13.83	51	0.25	14.16	52	0.73
Newsprint paper (641.1)	80.65	41	81.44	42	0.40	85.35	43	1.19
Other paper and paperboard (641–641.1)	1.72	54	1.96	55	7.53 ***			

[a] SSR_i = sum of squares of residuals for model i, n_i = number of degrees of freedom, $F_7 = (SSR_7 - SSR_6)/(SSR_6/n_6)$, $F_8 = [(SSR_8 - SSR_6)/2]/(SSR_6/n_6)$. *** indicates that the model is rejected at the 0.99 confidence level.

unit values reflect price in the foreign countries, transport and related costs and exchange rates. These unit values were expressed in the importer's currency using exchange rates published by the International Monetary Fund.[5]

Three demand shifters (Y) were used in the analysis: housing starts, real gross domestic product (GDP) and paper and paperboard production. It was initially felt that housing starts would be a better measure of demand shifts than GDP for mechanical wood products. This did not turn out to be the case. Therefore, the following results use GDP for all products, except for pulp and waste paper demand, which uses paper and paperboard production as a shifter since this is clearly the final output in which imported pulp is used. GDP statistics were obtained from the United Nations' Yearbook of National Accounts.[6] These statistics are reported in national currency units at nominal prices. The implicit price deflator of each country, obtained from the same United Nations Yearbook was used to calculate real GDP. The implicit price deflator also served as an indicator of the price of all other inputs (PQ). Paper and paperboard production statistics were taken from FAO's Yearbook of Forest Products.[7] All time-series used in the empirical estimations were expressed as indices with 1975 as base year except for newsprint imports and unit values where 1968 was the base because it was the only year in which all the selected countries imported newsprint from the United States.

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[5] International Monetary Fund, International Financial Statistics, The Bureau of Statistics, IMF, Washington, D.C. (various issues).

[6] United Nations, Yearbook of National Accounts Statistics. United Nations, New York (various issues).

[7] FAO, Yearbook of Forest Products, FAO, Rome (various issues).

TABLE 5. *Long-term elasticities of demand for United States forest products in the EEC, 1961–1977.*[a]

Product group (SITC)	Long-term elasticities with respect to:				Adjustment speed (yr)
	PU	PW	PQ	Y	
Softwood lumber	−0.21	0.21			2.1
(243.2)	(0.52)	(0.52)			
Hardwood lumber	−0.64	8.36	−7.72	6.79	7.0
(243.3)	(1.01)	(3.17)	(3.71)	(2.00)	
		***	**	***	
Pulp and waste paper	−0.88	1.43	−0.55	1.08	1.0
(251)	(0.27)	(0.24)	(0.18)	(0.09)	
	***	***	***	***	
Veneer sheets	−1.17	1.17		7.94	2.0
(631.1)	(0.46)	(0.46)		(0.79)	
	***	***		***	
Plywood	−2.01	2.01		5.56	1.5
(631.2)	(0.42)	(0.42)		(0.84)	
	***	***		***	
Newsprint paper	−4.72	4.72		6.01	1.6
(641.1)	(1.05)	(1.05)		(0.73)	
	***	***		***	
Other paper and paperboard	−2.52	1.95	−0.72	1.45	2.5
(641–641.1)	(0.66)	(0.81)	(0.71)	(0.84)	
	***	***		**	

[a] Variables and symbols are defined in Table 1.

MODEL ESTIMATION

The demand models (6), (7) and (8) were estimated for each product group by pooling time series from all countries in the sample. This methodology was used because the objective of the study was to determine the average elasticities of demand for United States forest products in the entire EEC and not for each individual country. Compared with the alternative procedure, which consists of using one single time-series relating to all of the EEC, pooling has the advantage of increasing considerably the number as well as the variability of the observations. However, pooling may lead to biased estimates of elasticities if there are important differences between countries unaccounted for by variables in the model. Several techniques have been proposed to reduce this bias. One of the simplest, analysis of covariance, was used here; it has been shown to have robust statistical properties and it has been adopted widely to estimate static or dynamic models from pooled cross section and time-series data (Mundlak 1961; Hoch 1962; Johnson and Lyon 1973; Houthakker et al. 1974). Applied to our situation, the technique consists in replacing the constant $\gamma\ a_0$ in each model by dummy variables, one for each country in the sample. The slope coefficients remain constant and measure the average elasticity across country—whether the elasticities differ significantly from country to country will be tested presently.

Apart from the covariance adjustment, the models were estimated by ordinary least squares. This assumes among other things that the independent variables are exogenous and thus uncorrelated with the disturbance term. In our case it implies that the price of imports from the United States (PU) is exogenous to the importing country. Given the partial adjustment theory used in the model, it

TABLE 6. *Test of equality of demand elasticities for United States forest products across EEC countries.*[a]

Product group	Model	Unpooled data URSSR	n	Pooled data RSSR	m	Computed F	Critical F_{99}
Softwood lumber	(8)	3.50	51	5.12	6	3.93	3.2 ***
Hardwood lumber	(7)	9.72	43	14.84	12	1.89	2.6
Pulp and waste paper	(7)	0.66	43	0.88	12	1.19	2.6
Veneer sheets	(8)	13.28	44	18.71	9	2.00	2.8
Plywood	(8)	9.75	43	14.16	9	2.16	2.8
Newsprint	(8)	33.43	31	85.35	12	4.01	2.8 ***
Other paper and paperboard	(6)	0.94	39	1.72	15	2.16	2.5

[a] URSSR and RSSR = unrestricted and restricted sum of squares of residuals, m = number of degrees of freedom, F = [(RSSR − URSSR)/m]/URSSR/n has an F distribution with degrees of freedom m and n. *** indicates a significant difference of elasticities between countries at the 0.99 confidence level.

seems plausible to hold that prices are determined in the United States and that imports are adjusted by the importing EEC countries. The same is true for the price from the rest of the world (PW).

The results of estimation of models (6), (7) and (8) by analysis of covariance are reported in Tables 1, 2 and 3. The tests of the restrictions implied by models (7) and (8) relative to model (6) are reported in Table 4. The values of F_7 in Table 4 show that the assumption of homogeneity of degree zero of the demand function with respect to prices imposed by model (7) is valid, except for other paper and paperboard, for which it is rejected. For the remaining products, the additional assumption implied by model (8) that the price of other inputs (PQ) does not play a role in the determination of demand is acceptable, except for hardwood lumber and pulp and waste paper as indicated by the high value of F_8 for those groups of products in Table 4. The models that are most satisfactory up to this point are then: model (6) for other paper and paperboard (Table 1); model (7) for hardwood lumber and pulp and waste paper (Table 2); and model (8) for the other four product groups (Table 3).

For newsprint Durbin's h statistic seems to indicate significant negative serial correlation of the residuals. However, the nature of serial correlation is ambiguous in this analysis, which combines time-series with cross-sectional data. Some of the computed differences in residuals relate to different countries so that the value of r and h changes depending on the order in which countries are entered. In addition, the serial correlation coefficient r is always small ($r < -0.25$) and therefore no attempt was made to correct it, especially after considering the dubious value of the standard correction procedures (Maddala 1977).

The variables in all models have the expected sign, except for Y whose coefficient is negative in the demand equation for softwood lumber (model (a) in Table 3) and PQ which has a negative sign in the equation for paper and paperboard (Table 1), hardwood lumber and pulp and waste paper (Table 2). Since the standard error of the coefficient of Y was large, the equation for softwood lumber was reestimated after eliminating that variable, leading to model (b) in Table 3. On the other hand, the coefficients of PQ in the hardwood lumber and pulp and waste paper equations are significant at the 95% confidence level, which may indicate complementarity

between imports from the United States and other inputs used in the EEC in combination with these products.

The long-term demand elasticities implied by the final models are reported in Table 5, together with their standard errors. Demand for United States softwood lumber is very inelastic with respect to both the price of the American product and the price of the same product from other countries. In fact the price effects are statistically insignificant. Hardwood lumber imports are also irresponsive with respect to the American price, but very elastic with respect to the price of competitors and to the general level of prices within the EEC. Demand for all other products is elastic with respect to the American price and to the other countries' price, the price elasticities for newsprint paper are especially high. Demand for all products, except softwood lumber, is elastic with respect to the demand shifter Y. In the case of softwood lumber, the level of economic activity as represented by real GDP did not appear to have any effect on American imports. Table 5 also reports the adjustment speed θ for each commodity group.[8] This is the time, in years, it takes demand to adjust for 90% of its full response to a change in prices or economic activity. Adjustment speeds vary from 1 year for pulp and waste paper to 7 years for hardwood lumber.

A final test was done to determine if the final elasticities reported in Table 5 are the same in all countries. The procedure consisted of comparing the total sum of squares of residuals obtained when the final model for a commodity was applied to each country individually with that obtained when the same model was applied to all countries pooled according to the analysis of covariance method. The results appear in Table 6. The hypothesis is accepted for five commodity groups. But the elasticities for softwood lumber and newsprint demand appear to differ significantly from country to country so that for those commodities, the elasticities in Table 5 must be viewed as averages for the entire EEC. It was not possible to estimate the elasticities for each individual country because of the short time-series used.

SUMMARY AND CONCLUSIONS

The purpose of this study was to estimate the demand for United States forest products used in the EEC. A theoretical model was suggested, based on the derived demand concept in which United States forest products compete (or are used in combination) with the same products coming from other countries and with other inputs in manufacturing a particular output. A dynamic form of the model was adopted to reflect the slow adjustment of demand to changes in the economic environment. The model was estimated for seven commodity groups based on observations from major importing countries in the EEC during the period 1961–1977. Analysis of covariance was used in the estimation, leading to one equation for each commodity group. Demand for United States forest products in the EEC was found to be elastic with respect to its own price, except for lumber. Elasticities ranged from -0.21 (± 0.52) for softwood lumber to -4.72 (± 1.05) for newsprint paper. Cross-price elasticities with products originating from other countries were

[8] The adjustment speed satisfies the relation: $(1 - \gamma)^{\theta} = 0.10$ where γ is defined as in Eqs. (6), (7) and (8) (Yadav 1975).

usually equal to or higher than own-price elasticities, ranging from 0.21 (±0.52) for softwood lumber to 8.36 (±3.17) for hardwood lumber. Demand for hardwood lumber and pulp and waste paper appeared to decline significantly as the general price level in the EEC increased. The level of economic activity in the EEC, as measured by real GDP or the level of paper and paperboard output in the case of pulp had a strong effect on demand for all United States products, except for softwood lumber. The demand elasticities reported here must be viewed as averages for the entire EEC, although it was found that only for softwood lumber and newsprint did the elasticities differ significantly from country to country. For these two product groups, measurement of the demand relationship for each individual country would require much longer time-series than those used in this study.

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