SUBSTITUTION BETWEEN HARDWOOD PLYWOOD IMPORTS AND DOMESTIC PLYWOOD IN THE U.S. MARKET: A DEMAND ANALYSIS TEHNIQUE

(Substitusi Antara Kayu Lapis Kayu Daun Lebar Impor dan Kayu Lapis Domestik di Pasar Amerika Serikat: Suatu Teknik Analisis Permintaan)

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ABSTRACT

Fungsi permintaan impor kayu lapis daun lebar (dan tropik) di Amerika Serikat diturunkan dari minimasi biaya produksi dalam industri furniture and fixtures dengan kendala fungsi produksi Cobb-Douglas. Secara agregat, produksi furniture and fixtures diasumsikan dapat direpresentasikan oleh fungsi produksi Cobb-Douglas. Tiga model dinamis dari fungsi permintaan yang merefleksikan penyesuaian dari impor terhadap harga dan produksi furniture and fixtures diduga dari data impor bulanan untuk periode Januari, 1981 sampai Desember 1987 dengan menggunakan metode ordinary least squares. Hasil penelitian menunjukkan bahwa kayu lapis daun lebar impor bukan merupakan barang substitusi maupun komplementer bagi kayu lapis daun lebar domestik. Perubahan impor kayu lapis daun lebar (dan tropik) dapat dijelaskan oleh harga relatif kayu lapis daun lebar impor terhadap kayu lapis daun jarum domestik dan oleh produksi furniture and fixtures.

Kata kunci: Impor kayu lapis daun lebar dan tropik, Analisis fungsi permintaan, Ekonometrika

INTRODUCTION

In the United States, hardwood plywood is used in a wide range of applications, including residential and non-residential construction, repair and remodeling, manufactured housing, furniture, and cabinets and fixtures (U.S. Department of Commerce, 1994). A major portion of the United States consumption of hardwood plywood has been supplied by imports. Haynes (1990) stated that during the past decade, about 55 to 70 percent of hardwood plywood consumed in this country has been imported. This has been mainly due to the availability of large amount of imported tropical hardwood plywood from Asia at relatively low prices, suitable for use in construction and furniture industries (U.S. Department of Commerce, 1994). But, there has been a growing awareness that the sources of supply of tropical hardwoods are not limitless; on the contrary, they are shrinking and, for the most part, and are not being harvested and managed on a sustainable basis. This will cause world markets to experience increasing scarcity

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shrinking and, for the most part, and are not being harvested and managed on a sustainable basis. This will cause world markets to experience increasing scarcity of tropical forest products during the next decades (Ingram, 1993).

The objective of this study was to determine the price elasticity of substitution between imports of hardwood plywood (especially of tropical origin) and domestic species in the U.S. market. The understanding of this response is important to improve knowledge of markets for tropical forest products, and particularly their relationship with markets for timbers of temperate species.

PREVIOUS WORK

Two previous analyses of the United States import demand of hardwood plywood have been conducted by Chou and Buongiorno in 1982 and 1983. Chou and Buongiorno (1982) estimated that the long-term elasticity of hardwood plywood imports were -1.98 with respect to real import price and 1.10 with respect to housing starts in the United States. Further, Chou and Buongiorno (1983a) estimated that the long-term own-price elasticities for imports were, from Korea, -1.95, Taiwan, -1.85, Japan, -1.81, the Philippines, -1.77, and an aggregate *rest of the world*, -1.79. Both studies used monthly data from 1974 to 1979. Chou and Buongiorno (1983b) found that imports of hardwood plywood were more responsive to changes in import price and price of all commodities than to housing starts during the period January, 1974 to December, 1980.

Another study was conducted by Parthama and Vincent (1992) who found that the import price, the price of hardwood plywood from other countries, and housing starts were significant determinants of import quantity. A 1 % decrease in the Indonesian price raised U.S. import by nearly 3 %. This study analyzed the period July 1979 to December 1987.

THEORETICAL MODEL

Based on derived demand theory, demand for imported hardwood (or tropical) plywood are expressed as a function of (a) a measure of activity in the sector using hardwood plywood; (b) the import price of hardwood plywood; (c) the price of its most direct substitute in the form of domestically produced plywood; and (d) the price of all commodities.

Chou and Buongiorno (1982) and Parthama and Vincent (1992) have derived demand for hardwood plywood imports from residential construction activity in the United States. But, in this study, for empirical reasons the U.S. demand for plywood imports is derived from furniture and fixtures production. It is assumed that production of furniture and fixtures can be represented at the aggregate level by a generalized Cobb-Douglas production function. The production function for furniture and fixtures is (Dixon *et al.*, 1980):

$$[1]\quad Y_t = a\ Q_t^{\alpha_1}\ DH_t^{\alpha_2}\ DS_t^{\alpha_3}\ DA_t^{\alpha_4}$$

Where Y_t is the volume of furniture and fixtures production; Q_t is the quantity of imported hardwood plywood (Q_H) or tropical plywood (Q_T); DH_t and DS_t are the quantities of domestically produced hardwood and softwood plywood consumed by the industry; DA_t is the quantity of all other inputs used in combination with DH_t, DS_t and Q_t to produce Y_t; and the α's are elasticities of furniture and fixtures production with respect to hardwood or tropical plywood input and other inputs. They all are positive constants.

The corresponding cost function has the form:

$$[2] \quad C_t = PMP_t\, Q_t + PDH_t\, DH_t + PDS_t\, DS_t + PDA_t\, DA_t$$

Where C_t is the cost of producing furniture and fixtures; and, PMP_t, PDH_t, PDS_t and PDA_t are, respectively, the import price of hardwood plywood (PMP_H) or tropical plywood (PMP_T), the domestic price of hardwood plywood, the domestic price of softwood plywood and the price of all other inputs.

If we assume that producers choose the input mix that minimizes cost, subject to the technology described by equation [1], the derived demand for total imported hardwood plywood is (Varian, 1984):

$$[3] \quad Q_t = b\ PMP_t^{\beta_1}\ PDH_t^{\beta_2}\ PDS_t^{\beta_3}\ PDA_t^{\beta_4}\ Y_t^{\beta_5}$$

Where β_1, β_2, β_3, β_4 and β_5, are long-term demand elasticities of hardwood (or tropical) plywood with respect to the import price of hardwood (or tropical) plywood, the domestic price of hardwood plywood, the domestic price of softwood plywood, the price of all other inputs and furniture and fixtures production, respectively.

Model [3] is a static equation. It measures long-term effect of changes in furniture and fixtures production and prices on imports. However, actual observations do not usually correspond to equilibriums. For example, during the time interval between two observations, *t-1* to *t*, the dependent variable adjusts only in part towards the equilibrium level corresponding to the new level of furniture and fixtures production and prices. The reason is that most of US hardwood plywood imports come from Southeast Asia, and therefore the lag between the decision to import and the time when the merchandise arrives at US ports may be of several weeks. The partial adjustment model is :

$$[4] \quad Q_t = b\ PMP_t^{\beta_1}\ PDH_t^{\beta_2}\ PDS_t^{\beta_3}\ PDA_t^{\beta_4}\ Y_t^{\beta_5}$$

in which the parameters with asterisks are short-term elasticities. Taking logarithms on both sides, the log-linear stochastic form of equation [4] is :

$$[5] \quad \ln Q_t = \lambda + \beta_1^* \ln PMP_t + \beta_2^* \ln PDH_t + \beta_3^* \ln PDS_t + \beta_4^* \ln PDA_t + \beta_5^* \ln Y_t + \psi \ln Q_{t-1} + \mu_t$$

Where μ_t is a random error.

The expected sign of β_1^* is negative and the remaining are all positive. The long-term estimates of the elasticities were then recovered as (Johnson *et al*, pp. 223-226):

$$[6] \quad \beta_1 = \frac{\beta_1^*}{(1-\psi)},\ \beta_2 = \frac{\beta_2^*}{(1-\psi)},\ \beta_3 = \frac{\beta_3^*}{(1-\psi)},\ \beta_4 = \frac{\beta_4^*}{(1-\psi)},\ \text{and}\ \beta_5 = \frac{\beta_5^*}{(1-\psi)}$$

DATA

This study used monthly data covering the period January 1981 to December 1987. Imports data on hardwood plywood (Q_H) were compiled from various issues of *U.S. General Imports: Schedule A Commodity* *by Country*: Table 2. Schedule A Commodity by Country of Origin, customs values, f.a.s., and c.i.f., published by the U.S. Bureau of the Census U.S. Department of Commerce. The Standard International Trade Classification (SITC) codes for the commodities of interest are: 6347040 for plywood with a face ply of Philippines mahogany, bagtikan, red lauan, white lauan etc., 6347050 for plywood with a face ply of mahogany, and 6347070 for plywood with a face ply of Spanish cedar and other. Imports data on tropical plywood (Q_T) were obtained by excluding imports of hardwood from Canada from total hardwood plywood imports. Unit value of imports, inclusive of cost, insurance and freight (c.i.f.) served as a measure of import price, PMP_t (PMP_H and PMP_T).

The United States prices of hardwood and softwood plywood, PDH_t and PDS_t, were measured by the producer price index for hardwood and softwood plywood, as published in various issues of *Producer Prices and Price Indexes*: Table 6. Producer Prices and Price Indexes for commodity groupings and individual items, published by the U.S. Bureau of Labor Statistics. This is also the source of the U.S. domestic producer price index for all commodities, PDA_t. Furniture and fixtures production, Y_t, in the U.S. was measured by the monthly index of furniture and fixtures industrial production, as published by U.S. Department of Commerce, Bureau of Economic Analysis, current business statistics (in CD ROM data bank, Item ID: EA BUSTAT S01085, February 18, 1995).

All data were expressed as indices, with the June 1982 serving as the basis. None was seasonally adjusted.

RESULTS

As shown in Figure 1 and Figure 2, the quantity curves of imported hardwood and tropical plywood (Q_H and Q_T) overlap. The price curves of imported hardwood and tropical plywood (PMP_H and PMP_T) overlap as well. Figure 1 also shows that quantity of hardwood and tropical plywood imports are subject to strong seasonal fluctuations. To solve this problem, unadjusted data plus dummy variables were used to account for monthly seasonal fluctuations not captured by the other explanatory variables in this study (see Lorell 1963).

Dynamic model

Model (5) was estimated by ordinary least squares. The results appear in Table 1. All coefficients have the expected signs, except for the negative coefficient of *PDA*, which would suggest some complementary between imported hardwood (or tropical) plywood and all commodities, but the standard error is too large to justifying any conclusion. The explanatory power of the model is low, with adjusted coefficient of determination R^2 of 0.50 for hardwood plywood and of 0.48 for tropical plywood. The Durbin's *h* statistic supports the null hypothesis of no serial correlation at 5% significance level. The *h* statistic is the computed *t*-statistic of lagged residuals with Durbin's method when some of the regressors are lagged dependent variables (Johnson *et al.*, 1987).

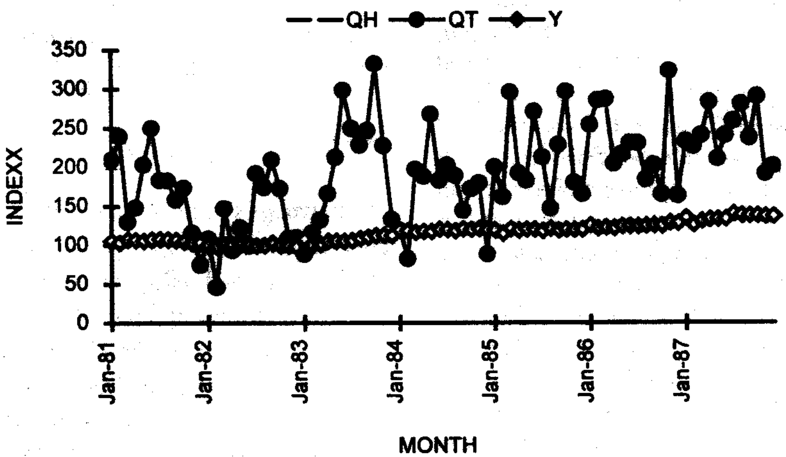

Figure 1. Changes in the period January 1981 to December 1987 in (i) the US imports of hardwood plywood (Q_H) and tropical plywood imports (Q_T), and (ii) furniture and fixtures production (Y). All data were expressed as indices, with the June 1982 serving as the basis.

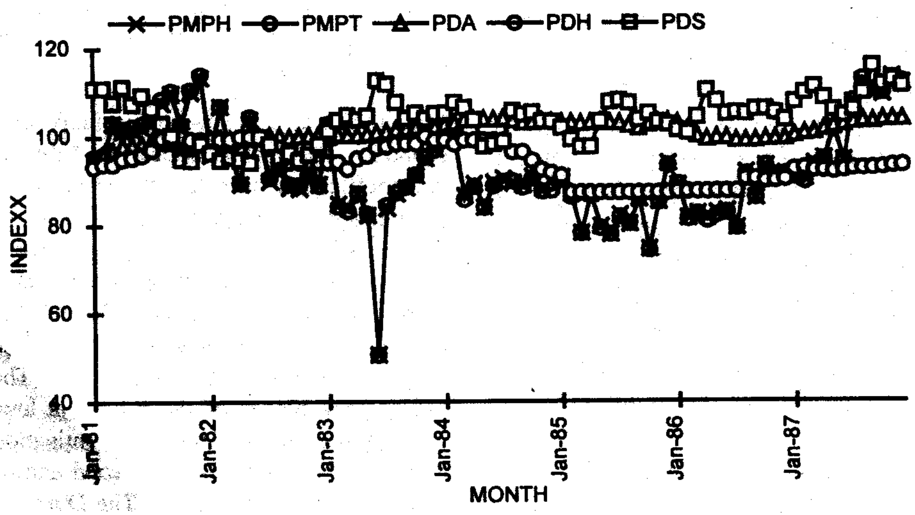

Figure 2. Changes in the period January 1981 to December 1987 in (i) price of imported hardwood plywood (PMP_H) and tropical plywood (PMP_T), (ii) producer price of all commodities (PDA), (iii) the domestic price of hardwood plywood (PDH), and (iv) the domestic price of softwood plywood (PDS). All data were expressed as indices, with the June 1982 serving as the basis.

The coefficients of *PDH*, *PDS* and *PDA* are statistically insignificant in the equation. This is consistent with the study results of Chou and Buongiorno (1982) and Parthama and Vincent (1992). The lack of significance of the coefficients of *PDH* and *PDS* is consistent with the fact that domestically produced hardwood plywood represent a small part of total consumption (Haynes 1990) and that, in the United States market, softwood plywood is used in applications generally different from those of hardwood plywood, i.e., mostly for housing construction (U.S. Department of Commerce, 1994). Superficially, it suggests that there is no substitution or complementary between hardwood or tropical plywood imports and domestic hardwood (or softwood) plywood.

Table 1. Estimated equations of U.S. demand for hardwood and tropical plywood import with Model 5

MODEL	PRODUCTS	*Coefficient of independent variables*						ESS *DF*	R2	*h*
		PMP	PDH	PDS	PDA	Y	Q_{t-1}			
5	Harwood	-0.93* (0.33)	0.26 (0.89)	0.92 (0.77)	-1.26 (2.05)	1.43* (0.60)	0.23* (0.11)	4.53 *65*	0.50	-0.42
	Tropical	-0.86* (0.33)	0.15 (0.91)	0.94 (0.78)	-1.19 (2.09)	1.36* (0.60)	0.24* (0.11)	4.67 *65*	0.48	-0.59

Notes : All variables are natural logarithms of indices (June, 1982 = 100) of imports, *Q*, import price, *PMP*, domestic price hardwood plywood, *PDH*, domestic price of softwood plywood, *PDS*, producer price index of all commodities, *PDA*, furniture and fixtures production, *Y*, respectively. Numbers in parentheses are standard errors of corresponding coefficients. * Indicate coefficients significantly different from zero at the 5% significance level. *ESS* and *DF* are, respectively, the sum of squares of residuals and the number of degrees of freedom. R^2 and *h* are the coefficient of determination corrected for degree of freedom and the Durbin's statistic, respectively.

However in Table 1, PMP_t and PDS_t have coefficients of same magnitude and opposite signs, so it is plausible to assume that the demand for imports is homogeneous of degree zero in prices. This leads to a more parsimonious model :

$$[7]\quad \ln Q_t = \eta_0 + \xi^* \ln \frac{PMP_t}{PDS_t} + \delta^* \ln Y_t + \sigma \ln Q_{t-1} + \mu_t$$

Model (7) is special case of model (5) in which : $\beta_1^* = -\beta_3^*$ and $\beta_2^* = \beta_4^* = 0$, a hypothesis that was tested.

Since all variables in the model (7) are expressed in logarithms, the coefficient ξ^* can be interpreted as short-term elasticity of hardwood (or tropical) plywood imports with respect to relative prices ($\frac{PMP_t}{PDS_t}$, the ratio of the import price of hardwood plywood to domestic price of softwood plywood), whereas δ^* can be interpreted as the short-term elasticity of hardwood (or tropical) plywood imports with respect to level of production in furniture and fixtures industry (Y_i). The long-term estimate of the elasticity (ξ and δ) were then recovered as :

$$[8]\quad \xi = \frac{\xi^*}{(1-\sigma)},$$

$$\delta = \frac{\delta^*}{(1-\sigma)},$$

The results of estimation of model (7) by ordinary least squares appear in Table 2. All coefficients have the expected signs, and all of them are significantly different from zero at least at 5% significance level. The explanatory power of the model is slightly increased, with adjusted coefficient of determination R^2 of 0.51 for hardwood plywood and of 0.50 for tropical plywood. The Durbin's *h* statistic supports the null hypothesis of no serial correlation at 5% significance level.

Table 2. Estimated equations of U.S. demand for hardwood and tropical plywood import with Model 7

MODEL	PRODUCTS	Coefficients of independent variables			ESS *DF*	R^2	*h*
		Y	Q_{t-1}	PMP/PDS			
7	Harwood	1.22* (0.35)	0.25* (0.11)	-0.86* (0.24)	4.56 *68*	0.51	-0.40
	Tropical	1.20* (0.35)	0.25* (0.11)	-0.81* (0.24)	4.71 *68*	0.50	-0.55

Notes : Variables, R^2, *DF*, *ESS*, and *h* are defined as in Table 1. *PMP/PDS* is import price relative to the domestic price of softwood plywood.

An F-test based on the sum of squares of residuals for model (5) and model (7) showed that the restriction imposed by model (7) could not be rejected, since calculated F-value (0.14 for hardwood plywood and 0.19 for tropical plywood) is lower than the tabulated F-value with 3 and 65 degrees of freedom ($F_{0.95} \approx 2.76$). This means that the quantity of imported hardwood plywood was affected mostly by the relative price of hardwood to softwood plywood and furniture and fixtures production.

In model (7), the short-term elasticity of hardwood plywood import with respect to relative price and the number of furniture and fixtures production are -0.86 (± 0.24) and 1.22 (± 0.35), respectively. The corresponding long-term elasticity obtained from that model is -1.14 (± 0.32) and 1.62 (± 0.39), respectively. Similarly, the short-term elasticity of tropical plywood import with respect to relative import price and the furniture and fixtures production are, respectively, -0.81 (± 0.24) and 1.20 (± 0.35). The corresponding long-term elasticity obtained from that model are -1.08 (± 0.32) and 1.61 (± 0.40), respectively.

The coefficient of lagged imports in model (7) is significant and less than one as expected (π = 0.25 for both hardwood and tropical plywood). The smaller the coefficient of the lagged dependent variable, the faster the adjustment of imports to the new number of furniture and fixtures production and the relative price. 99% of the adjustment of imports to Y_t and $\frac{PMP_t}{PDS_t}$ would occur within 3.3 months (99% of the adjustment is completed in a time interval, θ, such that $\pi^\theta = 0.01$ where $\pi = 0.25$. This leads to $\theta \approx 3.3$ months).

The statistical results obtained from model (7) are very satisfactory, except for the low value of the coefficient of determination, indicating that this simple model can explain about half of the variance in monthly imports.

Distributed-lag model

A distributed-lag model was investigated as an alternative to the dynamic model (7). The alternative model is :

$$[9] \quad \ln Q_t = \eta_0 + \sum_{i=0}^{m} \xi_i \ln\left(\frac{PMP_t}{PDS_t}\right)_{t-1} + \sum_{i=0}^{m} \delta_i \ln Y_{t-i} + \mu_t$$

where m indicates the length of the lag. Each ξ_i, and δ_i measures the relative change in imports in month, t, arising from the relative change in the relative price and the number of furniture and fixtures production in month t-i. $\sum_{i=0}^{m} \xi_i$ and $\sum_{i=0}^{m} \delta_i$ therefore measure the total or long-term elasticities of imports with respect to the relative price and the number of furniture and fixtures production.

There is no theoretical reason for using a polynomial of a particular degree or a particular length of lag, m. A second-degree polynomial was used in this study. The value of m was set at 6 months because it maximized R^2 for that polynomial. Instead, model (7) is in fact equivalent to a distributed-lag model of infinite length, with parameters ξ_i and δ_i that decline exponentially as i increase.

Table 3. A distributed-lag demand model of hardwood plywood imports

Lag number I (months)	Coefficient of independent variables			
	$(PMP/PDS)_{t-1}$	SE	Y_{t-1}	SE
0	-0.125	0.025	0.120	0.027
1	-0.214	0.043	0.205	0.047
2	-0.267	0.054	0.256	0.058
3	-0.285	0.057	0.273	0.062
4	-0.267	0.054	0.256	0.058
5	-0.214	0.043	0.205	0.047
6	-0.125	0.025	0.120	0.027
Sum	-0.497	0.301	1.435	0.326
Mean lag	3 months		3 months	
R^2	0.55			
ESS (DF)	4.12 (64)			
DW	1.61			

Notes : Variables, R^2, *DF* and *ESS* are defined as in Table 1. *SE* and *DW* are standard errors and the Durbin-Watson statistic, respectively.

Table 4. A distributed-lag demand model of tropical plywood imports

Lag number I (months)	Coefficient of independent variables			
	$(PMP/PDS)_{t-I}$	SE	Y_{t-I}	SE
0	-0.122	0.025	0.118	0.028
1	-0.208	0.043	0.201	0.047
2	-0.260	0.054	0.252	0.059
3	-0.278	0.057	0.269	0.063
4	-0.260	0.054	0.252	0.059
5	-0.208	0.043	0.201	0.047
6	-0.122	0.025	0.118	0.028
Sum	-0.458	0.301	1.411	0.331
Mean lag	3 months		3 months	
R^2	0.55			
ESS (DF)	4.20 (64)			
DW	1.61			

Notes : Variables, R^2, *ESS*, *DF*, *SE* and *DW* are defined as in Table 1 and Table 2.

The results of estimation of model (9) by ordinary least squares appear in Table 3 and in Table 4. In overall fit, model (9) is better than model (7), the adjusted coefficient of determination was 8% higher and the sum squares of residuals was 10% lower. Also, coefficients have the expected signs and are significantly different from zero at least at 5% significance level or hardwood plywood and by 11% for tropical plywood. The Durbin-Watson statistics support the null hypothesis of no serial correlation at 5% significance level. However, the adjusted coefficient of determination was still low: 55% of the variance in monthly hardwood plywood imports can be explained by the import price relative to that of softwood plywood, and by production of furniture and fixtures.

The long-term elasticities of hardwood plywood obtained from model (9) are -1.50 (± 0.30) with respect to relative price and 1.44 (± 0.33) with respect to the number of furniture and fixtures production. Meanwhile, the long-term elasticities of tropical plywood obtained from that model are -1.46 (± 0.30) with respect to relative price and 1.41 (± 0.33) with respect to the number of furniture and fixtures production. The mean lag is of 3 months for both hardwood and tropical plywood imports.

CONCLUSIONS

The results suggest that there is no substitution or complementary between imported and domestic hardwood.

In the United States, hardwood and tropical plywood have many substitutes. Cheaper reconstituted panel products such as particleboard, fiberboard, and oriented-strand board are increasingly replacing plywood in a variety of end uses in the US (Parthama and Vincent, 1992).

The U.S. demand for hardwood and tropical plywood imports appeared to be explained mostly by the price of imports relative to that of domestic softwood plywood and the total production of the furniture and fixtures industry.

Model (9) is the best model in terms of goodness of fit and parameter significance. However, the value of the coefficient of determination indicates that only 55% of the variance in monthly hardwood (or tropical) plywood imports can be explained by the models.

In summary, production of furniture and fixtures and ratio of import price to domestic price of softwood plywood have nearly the same effect on hardwood plywood imports, as measured by their respective elasticities.

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