



United States
Department of
Agriculture

Forest Service

Northeastern Forest
Experiment Station

Research
Paper NE-522

1983



A Revised Econometric Model of the Domestic Pallet Market

Albert T. Schuler
Walter B. Wallin



The Authors

Albert T. Schuler received his B.S. degree in forestry from Syracuse University and his Ph.D. degree in forest economics from Iowa State University. He began his career with the Forest Service in 1975 as a research economist with the Northeastern Forest Experiment Station. Dr. Schuler is now with the Forintek Canada Corporation Ottawa.

Walter B. Wallin received his B.S. and Ph.D. degrees from the University of Minnesota. His experience includes 8 years of teaching and research, 5 years in consulting, and 5 years as technical advisor to the Bangladesh Forest Research Institute at Chittagong, Bangladesh. He is currently a research forest products technologist at the Northeastern Forest Experiment Station's Forestry Sciences Laboratory in Princeton, West Virginia.

Manuscript received for
publication 30 October 1982

Abstract

The purpose of this revised model is to project estimates of consumption and price of wooden pallets in the short term. This model differs from previous ones developed by Schuler and Wallin (1979 and 1980) in the following respects: The structure of the supply side of the market is more realistically identified (from an economic theory point of view) by including lagged relationships; more recent data are incorporated into the data base; and the statistical correlation is improved.

The model is intended to provide reliable estimates of the quantity of pallets required and their real price over a relatively short term of 1 to 5 years. It is not intended to be used in determining policy concerning the growth or decline of palletization in materials handling.

The pallet industry consumes about 15 percent of the total U.S. lumber production and over 50 percent of the hardwood lumber production. Pallet demand has increased at an average annual rate of 8 percent since the mid-1950's. Because the pallet industry provides the largest volume market for hardwoods, it has an important effect on the utilization of the entire hardwood resource.

An econometric model is useful to both industry and government. This one can be used to provide quantitative information on the performance and structure of the pallet market; to identify the most important factors which are correlated with consumption and price of pallets; to make short-term projections of consumption and price needed to formulate plans for plant operations, sales, and raw material procurement; and to assess the demand on the forest resource.

This report describes an improved version of the model of the domestic pallet market which evolved from two earlier versions (Schuler and Wallin 1979; Schuler and Wallin 1980). It is the result of an ongoing effort to keep the model updated and to improve its effectiveness and reliability.

Model Development and Evaluation

Tables 1 and 2 list major factors assumed to affect pallet demand and supply, initial candidate variables selected to represent these factors, expected relationships between the variables and demand and supply (based on economic theory), and their units of measurement. The data base was annual observations of each variable over the sample period 1960 to 1980.

The data and sources used were as follows: for pallet price, pallet production, and wage rates in the pallet industry—annual reports of the National Wooden Pallet and Container Association, Washington, D.C.; for the industrial production index and wage rates of labor in materials handling—U.S. Bureau of the Census, 1960–1980; for price of red

oak lumber—Hardwood Market Report, weekly, 1960–1980; and for productivity in the pallet industry—U.S. Bureau of the Census, 1954–1977 and U.S. Bureau of the Census, 1970–1980.

The parameters for the demand and supply equations were estimated using the three-stage least squares procedure of Zellner and Theil (1962). It is an equilibrium-type model because we assume that demand = supply for the time period (1 year) used in our analysis. It is a simultaneous-equation model because we assume that demand, supply, and price of pallets are determined simultaneously (in our 1-year time period). Discussions with people knowledgeable of the structure of the pallet market and our observations confirm the assumptions of an equilibrium-type simultaneous-equation model.

The Model

Standard errors and associated t-statistics are given in Table 4.

$$\begin{aligned} \text{Pallet demand} &= 152,364 - 61,741 \text{ Pallet price} \\ \text{(1,000 units)} &+ 2,914 \text{ Industrial production index} \\ \text{DW} = 1.30 &- 97,131 \text{ Pallet substitute} \end{aligned} \quad (1)$$

$$\begin{aligned} \text{Pallet supply} &= -584,119 + 428,484 \text{ Pallet price} \\ \text{(1,000 units)} &- 3,055 \text{ Red oak lumber price} \\ \text{DW} = 1.72 &- 493,492 \text{ Pallet labor cost} \\ &+ 131,319 \text{ Productivity} \end{aligned} \quad (2)$$

The demand and supply equations were then solved simultaneously to yield reduced form equations suitable for projecting pallet consumption and price.

$$\begin{aligned} \text{Pallet consumption} &= 59,609 + 2,547 \text{ Industrial production index} \\ \text{(1,000 pallets)} &- 84,898 \text{ Pallet substitute} \\ &- 385 \text{ Red oak lumber price} \\ &- 621 \text{ Pallet labor cost} \\ &+ 16,539 \text{ Productivity} \end{aligned} \quad (3)$$

$$\begin{aligned} \text{Pallet price} &= 1.50 + 0.006 \text{ Industrial production index} \\ \text{(\$ 1967/unit)} &- 0.198 \text{ Pallet substitute} \\ &+ 0.0062 \text{ Red oak lumber price} \\ &+ 1.007 \text{ Pallet labor cost} \\ &- 0.268 \text{ Productivity} \end{aligned} \quad (4)$$

Discussion

The model, equations (1) and (2), is a good model from both economic and statistical perspectives. It is good from an economic viewpoint because each variable had the sign expected from economic theory of the firm. It is good from a statistical viewpoint because each variable was significant at the 0.07 percent level or better, the beta coefficients were at least twice as large as their standard errors, and no serial correlation was shown by the Durbin-Watson D-statistic. There was covariance across equations (1) and (2); therefore, the three-stage least squares estimating procedure provided parameter estimates with smaller standard errors than the two-stage least squares procedure.

All price variables in the model were converted to 1967 dollars (deflated by the Producer Price Index for all commodities) because models estimated with nominal price data produced variables with incorrect signs (according to the economic theory of the firm) and weaker statistical correlations than the deflated price variables.

The consumption and price projection equations, (3) and (4), were evaluated to determine how closely they fitted the sample data (Table 3). If the equations fit the sample data closely, then they should provide a good means for projecting pallet consumption and price beyond the data base, at least for a few years. However, our projection equations are reduced-form equations and not regression equations. Therefore, we cannot evaluate their consistency over time or their predictive power by standard statistical methods. Some commonly used measures of "goodness of fit" for reduced-form equations are Theil's U-coefficient and mean absolute percentage error.

Table 1.—Major demand factors, variables, expected relationships between variables and demand, and units for the pallet model. The names in parentheses in the variable column are those used in equations 1 through 4

Factor	Variable	Expected relationship	Unit
Pallet demand	Pallet consumption	—	1000 pallets
Pallet price	Mill realization/price which equals total dollar volume of sales ÷ total units produced. Sales are in 1967 dollars (Pallet price)	Positive	\$ 1967/pallet
U.S. industrial and food production activity—a proxy for price of output of the demanding industry	An index of the weighted average production of durable (25%) and non-durable manufactured goods (Industrial production index)	Positive	Index (1967 = 100)
Price of substitute for pallets	A 3-year moving average of the ratio of pallet price to manual labor wage rate (Pallet substitute)	Negative ^a	Ratio

^a Ordinarily one would expect the relationship to be positive for a true substitute good, however, because of the construction of the variable, we would expect the relationship to be negative.

Table 2.—Major supply factors, variables, expected relationships, and units for the pallet model. The names in parentheses in the variable column are those used in equations 1 through 4

Factor	Variable	Expected relationship	Unit
Pallet supply	Pallet consumption	—	1000 pallets
Pallet price	Mill realization price which equals total dollar volume of sales ÷ total units produced. (Sales are in 1967 dollars) (Pallet price)	Positive	\$ 1967/pallets
Production costs	A 2-year moving average, lagged 1 year, of grade 3A red oak lumber (Red oak lumber price)	Negative	\$ 1967/Mbf
	A 2-year moving average, lagged 1 year, of hourly wage rates of pallet production workers (Pallet labor cost)	Negative	\$ 1967/hour
	Productivity in the pallet industry (Productivity)	Positive	Pallets/man-hour

Table 3.—U-coefficient, mean absolute percentage error (MAPE), and mean percentage error (MPE) for the revised model and the previous model

Model	U-coefficient ^a	MAPE ^b	MPE ^c
----- Percent -----			
1. Revised model			
Consumption (1000 pallets)	0.41	5.4	<1
Price (\$ 1967/pallet)	0.69	4.5	<1
2. Previous model (Schuler & Wallin 1980)			
Consumption (1000 pallets)	0.52	7.4	4.0
Price (\$ 1967/pallet)	0.64	4.5	<1

$P_t = P_t - A_{t-1}$

$A_t = A_t - A_{t-1}$

P_t = Predicted value in year t.

A_t = Actual value in year t.

N = 21 for revised model and 18 for previous model.

$$^aU = \left[\frac{N}{\sum_{i=2}^N (P_i - A_i)^2} \right]^{1/2} \left[\frac{N}{\sum_{i=2}^N A_i^2} \right]^{1/2}$$

$$^bMAPE = \frac{1}{N} \left[\sum_{t=1}^N \left| \frac{P_t - A_t}{A_t} \right| \right] \times 100$$

$$^cMPE = \frac{1}{N} \left[\sum_{t=1}^N \frac{P_t - A_t}{A_t} \right] \times 100$$

The results listed in Table 3 indicate that our revised model fits the sample data well. Values near zero for each of the "goodness of fit" measures indicate a good fit to the data; and good fit over the sample period suggests that the consumption and price equations can project future levels for those variables. How well they actually perform will depend on how well we can project the independent variables and whether structural changes occur in the pallet market.

Comparison with Previous Model

In this improved version of the model, a pallet industry productivity variable is included in the supply equation, and it is assumed that the supply responses to production

cost changes are lagged. We felt that the instantaneous response of pallet supply to changes in production costs assumed in the previous model was not realistic because of built-in rigidities such as labor contracts and lumber supply arrangements. After testing several lags for pallet labor and lumber costs, we adopted a 2-year moving average, lagged 1 year, because it gave the best least squares statistical fit.

Pallets per man-hour is the productivity variable selected for the revised model. Productivity measures are usually combined with the labor cost variable to give a "unit labor cost" measure because most economists feel that productivity changes influence production costs via changes in labor costs. The pro-

ductivity variable is really a proxy measure of both productivity and utilization of plant capacity. A "unit labor cost" variable was tested, but it was strongly correlated with the lumber cost variable, and the lumber cost became statistically not significant. However, since lumber cost accounts for over 50 percent of pallet production cost, it was kept in the supply equation. Furthermore, there was not a significant difference in R^2 between the models with either variable.

This improved model is stronger statistically than the previous models; all variables are significant at the 7 percent level (versus 40 percent in the 1980 model). In addition, the standard errors in the revised model are consistently smaller

Table 4.—A comparison of the estimated coefficients and their associated standard errors (SE) for the revised model and the previous model developed by Schuler and Wallin (1980)

Variable	Revised model			Previous model		
	Coefficient	SE	Associated t-statistic	Coefficient	SE	Significance level of t-statistic
<i>Demand equation</i>						
Pallet price	- 61741	18925	3.26	- 65137	22174	0.01
Industrial production index	2914	173	16.81	3147	305	0.0001
Pallet substitute	- 97131	63866	1.53	- 126268	72912	0.10
Constant	152364	110924	1.38	181962	89000	
<i>Supply equation</i>						
Pallet price	428484	122515	3.50	517553	254989	0.06
Red oak lumber price	- 3055	1479	2.10	- 3464	4006	0.40
Pallet industrial labor cost	- 493492	155680	3.17	- 641145	368441	0.10
Productivity	131319	32508	4.04	NA		
Constant	- 584119	198238	2.94	- 154359	101000	

(Table 4). Consequently, we feel that the projection potential of the consumption and price equations, (3) and (4), is enhanced. A comparison of the "goodness of fit" measures in Table 3 substantiates this conclusion, particularly for the consumption equation.

The demand equation, (1), of the improved model is basically the same as the 1980 version. The same variables were used as demand shifters—pallet price, industrial production index, and pallet substitute; and the Durbin-Watson D-statistics are similar. However, the revised model does have smaller standard errors for each variable (Table 4).

Concluding Comments

This revised econometric model of the domestic pallet market is superior to the ones reported in 1979 and 1980. The structure of the supply equation, with the use of lagged relationships, is more realistic. The model incorporates the latest data. The variables are stronger in their least squares statistical fit. We believe these improvements provide equations that are better suited to projecting pallet consumption and price levels in the short term (1 to 5 years).

Literature Cited

Hardwood Market Report. **Lumber Newsletter (Weekly)**. Memphis, TN; 1960-1980.

Schuler, Albert T.; Wallin, Walter B. **An econometric model of the U.S. pallet market**. Res. Pap. NE-449. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1979. 11 p.

Schuler, Albert T.; Wallin, Walter B. **Report on an econometric model for domestic pallet markets**. For. Prod. J. 30(7):27-29; 1980.

U.S. Bureau of the Census. **Census of manufactures: Vol. 2, industry statistics**. Washington, DC: U.S. Department of Commerce; 1954, 1958, 1962, 1968, 1972, 1977.

U.S. Bureau of the Census. **Statistical abstract of the United States (Annual)**. Washington, DC: U.S. Department of Commerce; 1960-1980.

U.S. Bureau of the Census. **Annual survey of manufactures: industry statistics**. Washington, DC: U.S. Department of Commerce; 1970-1980.

Zellner, A.; Theil, H. **Three stage least squares: simultaneous estimation of simultaneous equations**. *Econometrica* 30(1):54-78; 1962.

Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories are maintained at:

- **Amherst, Massachusetts, in cooperation with the University of Massachusetts.**
 - **Berea, Kentucky, in cooperation with Berea College.**
 - **Burlington, Vermont, in cooperation with the University of Vermont.**
 - **Delaware, Ohio.**
 - **Durham, New Hampshire, in cooperation with the University of New Hampshire.**
 - **Hamden, Connecticut, in cooperation with Yale University.**
 - **Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.**
 - **Orono, Maine, in cooperation with the University of Maine, Orono.**
 - **Parsons, West Virginia.**
 - **Princeton, West Virginia.**
 - **Syracuse, New York, in cooperation with the State University of New York College of Environmental Sciences and Forestry at Syracuse University, Syracuse.**
 - **University Park, Pennsylvania, in cooperation with the Pennsylvania State University.**
 - **Warren, Pennsylvania.**
-

Schuler, Albert T.; Wallin, Walter B. A revised econometric model of the domestic pallet market. Res. Pap. NE-522. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1983. 5 p.

The purpose of this revised model is to project estimates of consumption and price of wood pallets in the short term. The model is intended to provide reliable estimates of the quantity of pallets required and their real price over a relatively short term of 1 to 5 years. It is not intended to be used in determining policy concerning the growth or decline of palletization in materials handling.

ODC 721.1

Keywords: Demand, supply, consumption, projections