ECONOMETRIC MODEL OF PRICE FORMATION IN THE UNITED STATES PAPER AND PAPERBOARD INDUSTRY[1]

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ABSTRACT

A model of price determination was proposed for the United States paper and paperboard industry. It assumed a generalized Cobb-Douglas production function, mark-up pricing, and cost minimization. The model was estimated for five commodity groups, over the period January 1967 to June 1979. The resulting equations accurately represented price behavior during the sample period. Coefficients had the expected sign and plausible magnitudes, except for the total paper and paperboard aggregate. Capital costs appeared to have a dominant importance in the setting of prices. Product prices did not appear to be related to capacity utilization rates, nor to the level of national production. Technological changes, other than those that were labor-saving, did not have a significant effect on paper and paperboard prices during the sample period. Derived demand equations for capital, labor, energy, pulp, and wastepaper were obtained.

Keywords: Paper, paperboard, prices, econometrics, economies of scale, derived demand, energy, wastepaper.

INTRODUCTION

Despite the central role played by prices in marketing, investment, and general resource allocation decisions, there have been few quantitative studies of price formation in the paper and paperboard industry. In his pioneering study, McKillop (1967) derived prices of paper, paperboard, and construction paper and paperboard from supply and demand equations for each one of these products, assuming competitive markets within the United States. The assumption of pure competition was lifted in a recent study of the pulp and paper industry by Buongiorno and Gilless (1980), which assumed monopolistic competition, coupled with cost-minimization by producers. However, this analysis dealt with international markets rather than with a specific country. Econometric analysis of price determination for the paper industry has also been done in studies of broad industrial sectors of the United States (Eckstein and Wyss 1972; Strazheim and Strazheim 1976; Chung 1979) but these studies deal with aggregate product classes, usually paper and paperboard taken as one industry. In addition, these three last studies use the producer price index for the lumber industry as an indicator of the price of material inputs in paper and paperboard manufacturing, an assumption that appears difficult to defend since the paper industry uses lumber residues, not lumber, as an input and only in small quantities.

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This paper reports results obtained with an econometric model of price formation based on a generalized Cobb-Douglas technology, mark-up pricing, and cost minimization by producers. The model has been estimated for three groups of commodities: paper excluding newsprint, newsprint, and paperboard. Two aggregated classes have also been investigated: paper (including newsprint), and total paper and paperboard. The results show that aggregation of products using different technologies may lead to biased econometric coefficients. Accurate estimates of monthly prices have been obtained using these models over the sample period January 1967 to June 1979. Generally accurate measures were also obtained of the partial elasticities of the price of paper and paperboard with respect to the price of energy, labor, materials, and capital. However, capacity utilization, scale effects, and capital or material-saving technological change did not appear to be important in determining paper and paperboard prices. The implied derived demand equations for inputs in paper and paperboard manufacture in the United States have also been computed.

THE MODEL

The market structure of the paper industry has long been recognized as one of price leadership (Guthrie 1972; Rich 1978) where certain large firms set prices that are generally adopted by smaller firms. We assume that leaders compute prices according to a mark-up procedure where the price of output at time t (P_t) is set over the average unit cost of production (UC_t) by a mark-up factor (m);

$$P_t = mUC_t \quad (1)$$

Mark-up pricing has been widely debated in the economic literature. Eckstein and Fromm (1968) provided the argument in support of mark-up pricing in non-competitive industries, while it was considered to conflict with profit maximization behavior by Machlup (1967). Nordhaus (1972) also argued that mark-up pricing is not optimal for a profit maximizing firm in less than perfectly competitive industries. Our hypothesis does not require profit maximization, but only a desire to regulate revenues. Because of large amounts of capital tied up in fixed assets, the investment return in the paper industry is highly sensitive to variations in sales. The price leadership system greatly reduces the sale revenue variations caused by price wars between producers. There are two reasons to believe that price leadership is of a regulatory nature in the paper industry rather than a collusive arrangement. First, attempts to maximize profits by collusion tend to occur only in industries concentrated among very few firms (Shinjo 1977). In contrast, the paper industry is moderately concentrated (in 1980, the five firms concentration ratio was about 28%). Second, the leadership position changes frequently among the industry participants (Guthrie 1972), which indicates that there are no monopolistic advantages associated with being a price leader.

For the price-leadership system to achieve its goal, which is to set a price that will be followed, the leader should set a price that meets two qualifications. First, given the cost-demand conditions, it should not be set too high as it might not be followed by other firms (the kinked demand argument). Second, if the price is set too low, some firms might be forced to resort to antitrust suits. Since it is unlikely that the price setter has full knowledge of the cost function of the industry participants, it is plausible to assume that the price is set over the average industry cost of production by a mark-up factor.

Rich (1978) has provided some historical evidence of full cost pricing, of which mark-up pricing is a variant, in the paper industry.

We posit the following behavioral equation relating the mark-up factor to capacity utilization rate, representing the market demand conditions:

$$m = e^{b_0 + b_1 \ln R_t} \tag{2}$$

where R_t is the capacity utilization rate at time t, defined as the ratio of production to available capacity, b_0 is a negative constant, and b_1 is a positive constant. The high capital intensity coupled with the time-consuming machinery set up procedures in the paper industry make it very important that production be maintained at a sustained high level. One way of achieving production stability for the industry is to lower output prices during periods of slack demand to increase sales, and to raise prices whenever high demand strains the productive capacity. Hence we hypothesize a direct relationship between demand for output and prices. This direct relation can be posited in different ways and the exponential form utilized here is for computational ease. Combining Eqs. (1) and (2) gives:

$$P_t = UC_t e^{b_0 + b_1 \ln R_t} \tag{3}$$

Equation (3) simply expresses the hypothesis that the long-term evolution of product price is set by unit cost of production, while short-term price changes are triggered by changes in capacity utilization.

In addition, the assumption was made that the paper and paperboard production technology can be represented by a generalized Cobb-Douglas production function similar to that used by Buongiorno and Gilless (1980):

$$Q_t = \alpha_0 e^{\delta t} L_t^{L} K_t^{K} M_t^{M} E_t^{E} u_t \tag{4}$$

where Q_t is the production of a particular commodity group in period t. L_t, K_t, M_t, and E_t are respectively labor, capital, materials, and energy input. The coefficients α_0, δ, α_L, α_K, α_M and α_E are constant. δ measures the rate of technological change, assumed to be Hicks neutral, i.e., leaving the marginal rates of substitution between inputs unchanged.

Returns to scale of national production are measured by

$$r = \alpha_L + \alpha_K + \alpha_M + \alpha_E \tag{5}$$

so that if all inputs increase proportionally, output increases more than proportionally if $r > 1$, proportionally if $r = 1$, less than proportionally if $r < 1$. Total industry cost for the production of a specific commodity group is:

$$C_t = P_{Lt}L_t + P_{Mt}M_t + P_{Kt}K_t + P_{Et}E_t \tag{6}$$

where P_{Lt}, P_{Mt}, P_{Kt} measure the price of labor, materials, capital, and energy used in that particular production process.

Minimization of cost subject to the production technology described by (4) and (5) leads to (Varian 1978, p. 38):

$$C_t = \beta_0 e^{-\delta t/r} Q_t^{1/r} P_{Lt}^{\alpha_L/r} P_{Kt}^{\alpha_K/r} P_{Mt}^{\alpha_M/r} P_{Et}^{\alpha_E/r} u_t^{-1/r} \quad (7)$$

$$\text{where } \beta_0 = r(\alpha_0 L^{\alpha_L} K^{\alpha_K} M^{\alpha_M} E^{\alpha_E})^{1/r}$$

The unit cost is then:

$$UC_t = \beta_0 e^{-\delta t/r} Q_t^{1/r-1} P_{Lt}^{\alpha_L/r} P_{Kt}^{\alpha_K/r} P_{Mt}^{\alpha_M/r} P_{Et}^{\alpha_E/r} u_t^{-1/r} \quad (8)$$

Combining (3) and (8) and taking logarithms leads then to the price equation:

$$\ln P_t = b_0 + \ln \beta_0 + b_1 \ln R_t + \left(\frac{1}{r} - 1\right)\ln Q_t + \frac{\alpha_L}{r}\ln P_{Lt} + \frac{\alpha_K}{r}\ln P_{Kt} + \frac{\alpha_M}{r}\ln P_{Mt} + \frac{\alpha_E}{r}\ln P_{Et} - \frac{\delta}{r}t + V_t \quad (9)$$

where $V_t = -(1/r)\ln u_t$.

Equation (9) is the empirical price equation used in this study. It may be noted that because of constraint (5), the coefficients of the variables in (9) cannot be estimated as if they were independent.

THE DATA

In order to minimize the problems associated with aggregation over time (Maddala 1977, p. 374), and to maximize degrees of freedom, monthly data were used to estimate the price equation (9). Data were collected for the period January 1967 to June 1979, and covered five commodity groups: paper (SIC 2621), paper excluding newsprint (SIC 2621 excluding 26211), newsprint (SIC 26211), paperboard (SIC 2631), and paper and paperboard (SIC 2621 and 2631). Monthly price indices for each commodity group were obtained from the Bureau of Labor Statistics[2], except for the price index for paper and paperboard, which was obtained from the American Paper Institute (API)[3]. The API publishes monthly data on capacity utilization for paper, newsprint, and paperboard. The capacity utilization indices for paper excluding newsprint and paper and paperboard were computed from these indices and from API's statistics on monthly production.

An index of unit labor cost was constructed by dividing the average hourly earning of production worker by the index of labor productivity. Because of data limitations only two unit labor cost indices were constructed, one for pulp and paper mills, and one for paperboard mills. The former was used in estimating the price model for paper, paper excluding newsprint, and newsprint. The second labor cost index was used for estimating the price model for paperboard. A weighted average of these two indices was constructed for the paper and paper-

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[2] U.S. Bureau of Labor Statistics, Producer prices and Price Indexes, Washington, D.C., 1967–1979.

[3] American Paper Institute, Industry Fact Sheet and Industry Data, New York, N.Y., 1967–1979.

board aggregate with weights corresponding to the production and employment in pulp and paper and paperboard mills. Average hourly earning data were obtained from Bureau of Labor Statistics[4]. Labor productivity indices were constructed using production data published by the American Paper Institute[3] and employment data from the Bureau of Labor Statistics[4].

Data on the price of all material inputs used in paper and paperboard manufacture were difficult to obtain. Only two indices were used in the final price equations, the monthly price index of wood pulp, and that of wastepaper, as published by the Bureau of Labor Statistics[2]. Some experiments were also carried out by adding the price index for industrial chemicals as an explanatory variable. But the results were very poor, most likely because of the high correlation between the price of industrial chemicals and that of energy, which is also used as an explanatory variable in the model.

The price of energy was represented by a weighted average of the price indices for natural gas, electricity, and fuel. The weights correspond to the proportion of the industry's energy bill spent on each source in 1972. Price data for different sources of energy are from the Bureau of Labor Statistics and the weights were obtained from the 1972 Census of Manufactures[5].

The price of capital was calculated as $P_K = k(i + d)$, where k is the aggregate price index for machinery and equipment obtained from the Bureau of Labor Statistics, i is the long-term interest rate (Moody's Aaa industrial bond yield), and d is the depreciation rate taken to be 0.4% per month using the straight line depreciation method, an economic life of about 20 years for machinery was assumed. A full discussion of the rental price of capital formula can be found in Hall and Jorgenson (1971).

MODEL ESTIMATION

Equation (9) is the basic model employed for estimation. Although the data were monthly, the cost variables were represented by their normal (standard) rather than actual values. As pointed out by Eckstein and Wyss (1972) in noncompetitive industries, variations in the price of inputs are not reflected in the output prices unless they represent a permanent change. This is because in noncompetitive industries prices are set according to long-term considerations. These could include, among others, discouraging new entries into the industry, avoiding excessive uncertainty in the marketplace caused by frequent price changes, and costs of price adjustments. Among the independent variables in Eq. (9), prices of energy and wood pulp show a steady pattern of increase over the sample period, i.e., almost all price movements for these two inputs have been in the upward direction. Hence it is very plausible that any increase in these prices would be considered as permanent by industry participants. As a result it was assumed that the price indices for pulp and energy represent their standard or normal level, and no smoothing was done on these two prices. Unit labor cost and capacity utilization rate show a cyclical pattern, with highs for the unit labor cost and lows for the capacity utilization occurring in late December and early July. To remove

[4] U.S. Bureau of Labor Statistics. Employment and Earnings. Washington, D.C., 1967–1979.

[5] U.S. Bureau of the Census. Census of Manufactures. U.S. Department of Commerce, Social and Economics Statistics Administration, Bureau of the Census, Washington, D.C.

this seasonal pattern, these two variables were represented by their six-month moving averages. Price of capital showed a cyclic pattern for some parts of the sample period and a six-month moving average was applied to eliminate these fluctuations. The price of wastepaper shows a very erratic pattern with no apparent seasonality; it was smoothed by a six-month moving average. The highly seasonal pattern of production series was removed by a twelve-month moving average.

Preliminary estimates of the model in Eq. (9) showed very high residual autocorrelation. A plausible explanation for this result is the general pattern of price rigidity in the industry as evidenced by Fig. 1. Such price rigidities can be caused by the existence of uncertainties about the form of the demand or cost function, oligopolistic interdependencies and costs of price adjustment. Eckstein (1964) argued that in noncompetitive industries, price adjustments occur only when the desired prices, dictated by the cost-demand conditions, deviate from the actual prices by some threshold amount. The price model (9) forecasts the desired price for a given market condition and this price will remain below or above the actual price until the threshold difference between the two is reached; only then does the actual price adjust. To correct for the serial correlation we postulate

$$V_t = wV_{t-1} + e_t \tag{10}$$

where e is a random disturbance term with mean zero and w is a constant. Combining Eqs. (9) and (10) leads to:

$$\begin{aligned}\ln P_t = {} & a_0 + b_1 \ln R_t - wb_1 \ln R_{t-1} + (1/r - 1)\ln Q_t - w(1/r - 1)\ln Q_{t-1} \\ & + \frac{\alpha_L}{r} \ln P_{L,t} - w\frac{\alpha_L}{r} \ln P_{L,t-1} + \frac{\alpha_K}{r} \ln P_{K,t} - w\frac{\alpha_K}{r} \ln P_{K,t-1} \ldots \\ & + \frac{\alpha_M}{r} \ln P_{M,t} - w\frac{\alpha_M}{r} \ln P_{M,t-1} + \frac{\alpha_E}{r} \ln P_{E,t} - w\frac{\alpha_E}{r} \ln P_{E,t-1} \\ & - \frac{g}{r}t + w\frac{g}{r}(t - 1) + w \ln P_{t-1} + e_t\end{aligned} \tag{11}$$

Efficient maximum likelihood estimates of the parameters in (11) were obtained by nonlinear estimation. This estimation was done under the constraint, imposed by (5) that:

$$\frac{\alpha_L}{r} + \frac{\alpha_K}{r} + \frac{\alpha_M}{r} + \frac{\alpha_E}{r} = 1 \tag{12}$$

EMPIRICAL RESULTS

The results of estimation of Eq. (11) by maximum likelihood, using the data described above, are reported in Table 1. The statistical results appear adequate for all commodity groups, except for total paper and paperboard. In this last equation, the coefficient of t is positive and highly significant, which would imply that technological improvements in the industry tend to increase prices. This result is not only inconsistent with what is generally known regarding the effect of technological advance, it is also in contradiction with the coefficients of t obtained for all other equations. In addition, the magnitudes of the input price

TABLE 1. *Estimated models of paper and paperboard prices in the United States, January 1967–June 1979.*

	R	Q	Input prices					t	R^2	w (Q_N)
			P_E	P_L	P_{M1}	P_{M2}	P_K			
PAPER (SIC 2621)	0.091 (0.064)	−0.028 (0.107)	0.071** (0.032)	0.155*** (0.043)	0.176*** (0.030)	0.049** (0.021)	0.548*** (0.056)	−0.00005 (0.00004)	0.99	0.22 (2.46)
PAPER EXCEPT NEWS-PRINT (SIC 2621 except 26211)	0.092 (0.051)	−0.053 (0.103)	0.036 (0.033)	0.147*** (0.044)	0.172*** (0.031)	0.047*** (0.022)	0.587*** (0.058)	−0.00006 (0.00004)	0.99	0.23 (2.51)
NEWSPRINT (SIC 26211)	−0.002 (0.006)	0.187 (0.180)	0.213*** (0.054)	0.192*** (0.074)	0.189*** (0.049)	0.034 (0.026)	0.372*** (0.095)	−0.00011 (0.00008)	0.99	0.01 (0.11)
PAPERBOARD (SIC 2631)	−0.0007 (0.073)	0.191 (0.116)	0.114** (0.049)	0.099** (0.048)	0.249** (0.048)	0.077** (0.032)	0.146** (0.092)	−0.00023** (0.00010)	0.99	0.13 (1.45)
PAPER AND PAPER-BOARD (SIC 2621 and 2631)	0.071 (0.048)	0.510 (1.04)	0.051* (0.028)	0.512*** (0.059)	0.200*** (0.025)	0.018 (0.019)	0.218*** (0.063)	0.00013*** (0.00004)	0.99	0.07 (0.78)

Notes: R is the capacity utilization ratio, Q is the output, P_E, P_L, P_{M1}, P_{M2}, and P_K are the price of energy, labor, woodpulp, wastepaper, and capital, respectively. t is time, R^2 is the coefficient of multiple correlation, w is the first order autocorrelation, and Q_N is the normalized Von Neumann ratio (Theil 1971, pp. 218–219) which for large samples is distributed as a standard normal deviate and therefore the hypothesis of zero serial correlation is rejected if $|Q_N| > 1.96$, using a 0.95 confidence level two-tailed test. ***, and ** indicate coefficients different from zero at 99% and 95% confidence level, respectively.

coefficients for paper and paperboard are also irreconcilable with the magnitudes of the corresponding coefficients for the component commodities. There may be several reasons for these results. The theory of price formation that has been proposed may not be valid for the aggregate sector, although it seems adequate for its parts. But the validity of this explanation is doubtful, given previous results (Buongiorno and Gilless 1980). The results may be due instead to data inadequacies, especially to the manner in which price indices for various input were computed for the purpose of this study, or to the way in which the API computes the price index for total paper and paperboard from price indices for component commodities. Because of these poor characteristics of the price equation for total paper and paperboard, it is not used in the remainder of the study.

The remaining four models explain very well the evolution of prices over the sample period, as indicated by the high coefficients of determination, R^2. Sudden price increases are well traced by the model, without using the threshold regression technique suggested by Dagenais (1976). Despite the autoregressive model used for V_t, some serial correlation remains in the price equations for paper and paper except newsprint, as shown by the Von Neumann statistics. Still, the serial correlation indicated by the statistics and by visual examination of observed and computed values in Fig. 1 is small and no attempt was made to do any additional correction. The coefficients are unbiased, although standard errors may be somewhat underestimated (Johnston 1972, p. 246).

In all equations, capacity utilization appears to have no statistically significant impact on prices. This is consistent with Rich's (1978) observation that the industry does not generally change prices to spur demand. On the other hand, one would expect that strong demand and high capacity utilization would trigger price increases. Dagenais (1976) found a significant effect of capacity utilization rates on the price of newsprint. It is possible that the effect of capacity utilization is asymmetric, causing price increases but not price decreases. The model would have to be changed to test this hypothesis. In none of the equations of interest is the coefficient of output significantly different from zero. This would tend to indicate constant returns to scale at the national level.

There is a substantial body of literature arguing for increasing returns to scale for pulp and paper plants (Entrican 1950; Sandwell 1960; Sutton 1973; Guthrie 1972). Analysis of price data from different countries has given some support to increasing returns to scale at the national level (Buongiorno and Gilless 1980), but there have been several opposing views (Worrell 1959; King 1977; Grant 1978). Buongiorno et al. (1981) found some evidence of constant productivity for plants with 500 or more employees in the United States paper and paperboard industry. Since the 1972 Census data indicate that some 70% of the value of shipments of paper mills and more than 50% of those from paperboard mills come from plants with 500 or more employees, the results obtained here agree to some extent with these latter findings.

All input price coefficients have the expected positive sign, and most are highly significant at the 95% or 99% confidence level. In terms of partial elasticities, paper prices appear to be most responsive to changes in capital costs. Other things equal, a 10% increase in the cost of capital would increase the price of paper by some 5.5%, paper less newsprint by 5.9%, newsprint by 3.7% and

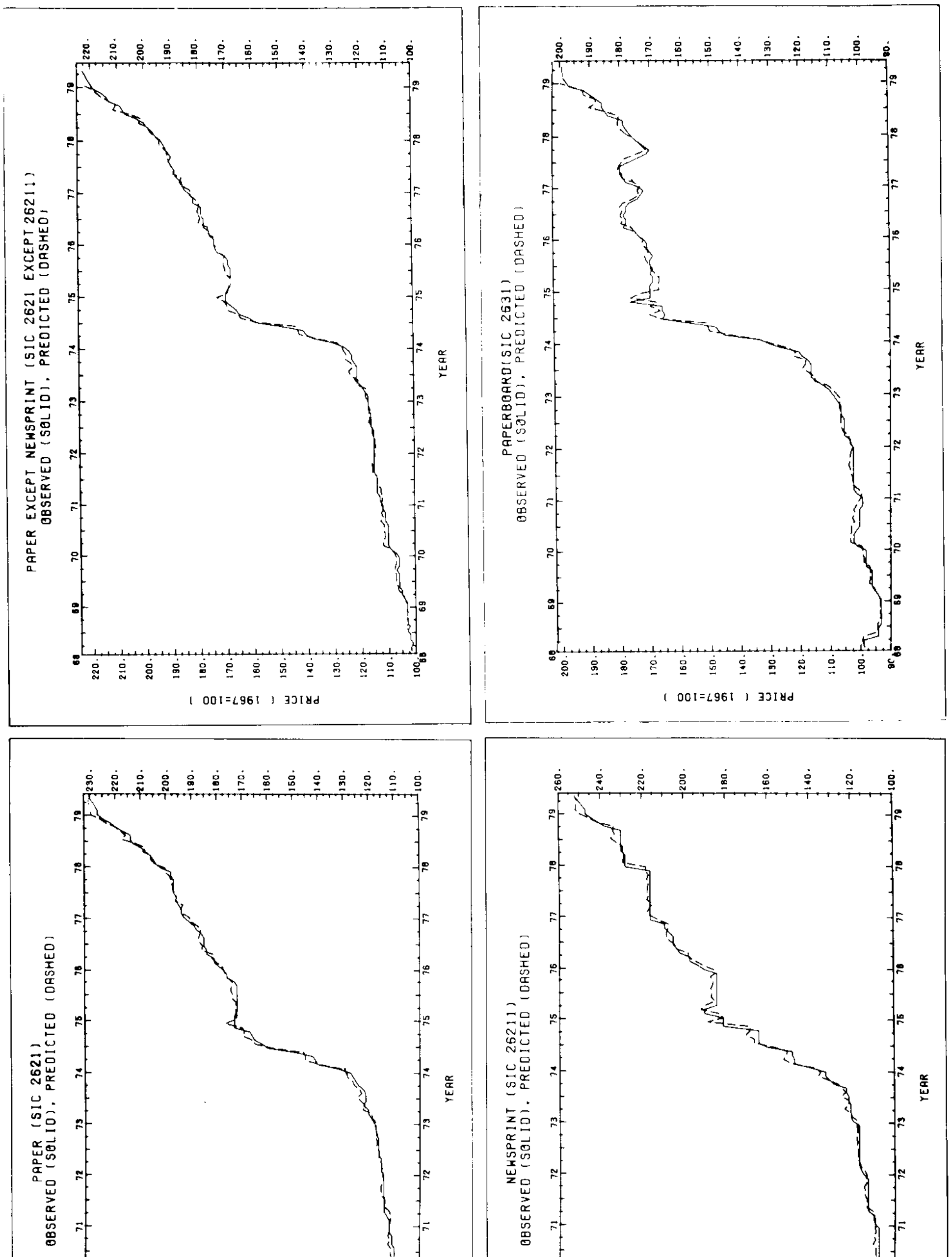

FIG. 1. Observed and computed prices of paper and paperboard in the United States, January 1968–June 1979. Computed prices were obtained from equation in Table 1.

paperboard by 4.6%. As expected, paper and paperboard prices are least responsive to the price of wastepaper.

As indicated earlier, the time variable in the price model is used to capture technological change effects. However, since labor cost data were adjusted for variations in labor productivity, the time trend should reflect technological changes that decreased the amount of materials and capital needed per ton of paper and paperboard produced, but not the amount of labor. The coefficients of t in the price equations of interest have all the expected negative signs, but none is significantly different from zero except for paperboard. For that group of commodities, material and capital saving improvements have led to a small decline in price of some 0.3% per year.

CONDITIONAL DEMAND FOR INPUTS

The first order conditions for minimization of the cost function in Eq. (6) result in the conditional (derived) demand equations for the inputs. For example, the first order condition for minimization of C with respect to materials input (M) would yield:

$$M = a^{(-1/r)} P_M^{(\alpha_M/r)-1} P_L^{(\alpha_L/r)} P_K^{(\alpha_K/r)} P_E^{(\alpha_E/r)} Q^{(1/r)} u^{(1/r)} e^{-\alpha_t} \quad (13)$$

where $a = (\alpha_0 u)^{-1/r}$.

Equation (13) shows how the amount of materials demanded depends on the price of materials as well as on the price of other inputs that can serve as a substitute and on the level of production. Equation (13) is fully defined by the parameters of the production function and it shows the consequences of the assumptions inherent in the production function of Eq. (4), namely homogeneity of degree r and unitary elasticity of substitution among inputs. Estimates of the parameters of the conditional demand functions for the inputs are presented in Table 2 for paper, paper excluding newsprint, newsprint, and paperboard. For example, this table shows that a 1% increase in production of paper would increase the demand for energy by 0.972% because of increasing returns to scale. A 1% increase in price of energy reduces the demand for energy by 0.929% (own-price elasticity), while a 1% increase in unit labor cost would increase the demand for energy by 0.155% because of the substitution possibility between the two inputs. Nonlabor-saving technological improvements show a very small and insignificant reduction in inputs demand for all inputs and product groups. Capital shows the lowest own-price elasticity among the inputs for all product groups, indicating a rather inelastic demand for capital while demand for wastepaper seems to be highly elastic with respect to its price.

SUMMARY AND CONCLUSIONS

A simple model of price determination was proposed for the United States paper and paperboard industry. The model assumed a generalized Cobb-Douglas production function, mark-up pricing, and cost minimization. The model was estimated for five commodity groups: paper, paper excluding newsprint, newsprint, paperboard, and total paper and paperboard. Monthly data covering the period January 1967 to June 1979 were used for estimation. The estimation meth-

TABLE 2. *Conditional demand elasticities for energy, labor, woodpulp, wastepaper, and capital in the U.S. paper and paperboard industry, January 1967–June 1979.*

Product and input	Elasticities with respect to						
	P_E	P_L	P_{M1}	P_{M2}	P_K	Q	t
PAPER (SIC 2621)							
Energy	−0.929	0.155	0.176	0.049	0.548	0.972	−0.00005
Labor	0.071	−0.845	0.176	0.049	0.548	0.972	−0.00005
Woodpulp	0.071	0.155	−0.824	0.049	0.548	0.972	−0.00005
Wastepaper	0.071	0.155	0.176	−0.951	0.548	0.972	−0.00005
Capital	0.071	0.155	0.176	0.049	−0.452	0.972	−0.00005
PAPER EXCEPT NEWSPRINT (SIC 2621 except 26211)							
Energy	−0.964	0.147	0.172	0.047	0.587	0.947	−0.00006
Labor	0.036	−0.853	0.172	0.047	0.587	0.947	−0.00006
Woodpulp	0.036	0.147	−0.828	0.047	0.587	0.947	−0.00006
Wastepaper	0.036	0.147	0.172	−0.953	0.587	0.947	−0.00006
Capital	0.036	0.147	0.172	0.047	−0.413	0.947	−0.00006
NEWSPRINT (SIC 26211)							
Energy	−0.787	0.192	0.189	0.034	0.372	1.187	−0.00011
Labor	0.213	−0.808	0.189	0.034	0.372	1.187	−0.00011
Woodpulp	0.213	0.192	−0.811	0.034	0.372	1.187	−0.00011
Wastepaper	0.213	0.192	0.189	−0.966	0.372	1.187	−0.00011
Capital	0.213	0.192	0.189	0.034	−0.628	1.187	−0.00011
PAPERBOARD (SIC 2631)							
Energy	−0.886	0.099	0.249	0.077	0.461	1.191	−0.00023
Labor	0.114	−0.901	0.249	0.077	0.461	1.191	−0.00023
Woodpulp	0.114	0.099	−0.751	0.077	0.461	1.191	−0.00023
Wastepaper	0.114	0.099	0.249	−0.923	0.461	1.191	−0.00023
Capital	0.114	0.099	0.249	0.077	−0.539	1.191	−0.00023

Notes: P_E, P_L, P_{M1}, P_{M2}, and P_K are the price of energy, labor, woodpulp, wastepaper, and capital, respectively. Q is output. t is time in months.

od was nonlinear least squares. The resulting models accurately represented price behavior during the sample period, coefficients had the expected signs and plausible magnitudes, except for the total paper and paperboard aggregate. Partial elasticities indicated that capital costs had a dominant importance in the setting of prices, confirming the international results of Buongiorno and Gilless (1980).

Demand conditions, as measured by capacity utilization rates, did not affect product prices significantly. However, this does not rule out mark-up pricing behavior in the industry; it merely states that the mark-up formula does not seem to be affected by capacity utilization rates. The level of national output did not appear to influence prices. Technological changes, other than those which were labor-saving, did not appear to have had a significant effect on paper and paperboard prices during the sample period.

The method used allowed for the determination of derived demand equations for each major input in paper and paperboard manufacturing. It should be noted that this analysis has only determined how paper and paperboard prices are affected by pulp prices. In subsequent research, it would be of interest to determine how pulp prices are themselves related to the price of basic raw materials such as pulpwood and chips. There is, however, one major difficulty in this possible extension, in that no price index of pulpwood is readily available at the national level. Finally, it was assumed throughout this study that the Cobb-Douglas production function is an adequate representation of production in the paper and paperboard industry. More general functional forms could be investigated in the future. However, given the very good fit provided by the Cobb-Douglas function (see Table 1), only marginal improvements might result, at the cost of much complication.

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