MODELING AND FORECASTING IN
THE FOREST PRODUCTS INDUSTRY

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The inclusion of these basic sectors allow the model to both closely represent the reality of the marketplace and to reach an equilibrium solution. I would like to spend some time detailing the structure of each of the primary sectors in a typical model, concentrating on our Pulp and Paper models. Also, modeling problems that we have encountered in developing the equations incorporated in the sectors will be discussed.

CONSUMPTION

Forest products analysts mainly concentrate on demand modeling, usually to the exclusion of other components of the market. We at DRI have also devoted considerable effort to the demand sector, and have formulated some new approaches to demand modeling. First, we always try to break out true consumption from consumer inventory change. Usually the raw data at the disposal of the analyst only allows the construction of apparent consumption estimates. These apparent consumption numbers contain both true consumption levels and consumer inventory change. The consumer inventory element tends to make apparent consumption more volatile than true consumption and distorts the price elasticity estimates. We have formulated a methodology to break out consumer inventory change in the historical data. More detail on this methodology is included in the consumer inventory section of this paper.

A second improvement on traditional demand modeling is our end-use factor approach to modeling true consumption. A traditional demand equation for a paper grade is conventionally formulated as:

\[
C_A = a + b\times GNP + c\times P_A
\]

where,

- \( C_A \) = Consumption of Paper Grade A
- \( GNP \) = Gross National Product
- \( P_A \) = Price of Paper Grade A
Several problems were inherent to this traditional approach. First, consumption was usually apparent consumption instead of true consumption. Second, GNP was usually used as the indicator for paper demand instead of finding an end-use indicator more closely tied to a paper grade's end-use market. Third, the coefficient $b$ on GNP was fixed at its estimated level over the forecast period, even though it has become very apparent that that coefficient should be allowed to vary over time. Fourth, the glaring mistake of utilizing nominal prices is still being made by some analysts. Fifth, the coefficient $c$ on the price term usually came out insignificant because the explanatory power of GNP was so large that it masked the impact of price on demand, resulting in low price elasticity estimates.

The end-use factor approach used by the DRI Forest Products Group entails pulling an end-use indicator such as GNP to the left-hand side of the consumption equation by creating an end-use factor. This end-use factor is defined as the consumption of a particular paper grade per unit of activity in its major end-use market(s). For example, the end-use factor for form bond (a major grade of printing paper) is defined as the tons of form bond consumed per billion 1972 dollars of GNP, where real GNP is the end-use indicator for form bond. The use of GNP as an end-use indicator is atypical, and is used only because form bond is utilized on an economy-wide basis instead of being confined to a defined segment of the economy.

This end-use factor approach overcomes several of the problems encountered in the traditional demand equation. True consumption is used as the numerator of the end-use factor. End-use indicators closely tied to the end-use markets are utilized as the denominators for the various grades of forest products. The end-use factor is actually the usage rate of a forest product per unit of end-use market activity, which was estimated as the fixed coefficient $b$ in the traditional demand equation. Now the end-use factor is a dependent variable which can vary over time. Lastly, price elasticities can be estimated better with the end-use indicator excluded from the right-hand side of the equation.
The formulation of a typical end-use factor equation is:

\[(2) \quad \text{EUF}_A = a + b* P_A / P_I + c* P_A / P_S + d* T \]

where,

\[
\begin{align*}
\text{EUF}_A &= \text{End-use Factor for Paper Grade A} \\
P_A &= \text{Price of Paper Grade A} \\
P_I &= \text{Price of Goods Sold in Major End-use Market(s) for Paper Grade A} \\
P_S &= \text{Price of Substitute(s) for Paper Grade A} \\
T &= \text{Technological Change or Consumer Preference}
\end{align*}
\]

The first relative price term is usually called the real price, although our definition of the real prices is sometimes at odds with the general definition of real price. The real price of a good is usually defined as the nominal price of the good relative to a general inflation indicator such as the consumer or producer price index. The real price term included in our typical end-use factor equation is defined as the nominal price of the good relative to the prices of the goods sold in the end-use market(s). Forest products are often used in another production process, so the relevant real price relationship is to compare the price of the production input (the forest product) to the price of the production output (e.g., a magazine, or a newspaper, or a house). The real price term indicates the pressure for materials savings, e.g., using lighter basis weight paper, cutting down on waste, or using smaller dimension lumber.

The second relative price term is the substitute price relationship. In general, forest products have numerous substitutes. The impact of these substitutes has sometimes been downplayed, especially in the case of substitution by other forest products. This intra-industry substitution has been almost ignored in traditional econometric work in the paper industry, resulting in underestimates of total price elasticity estimates. It has been our experience that the cross-price elasticities are as large or larger than the own-price elasticities for most forest products. Important substitutes outside of the forest products industries are plastics, electronics, and non-wood building products.
The final term in the typical end-use factor equation is an indicator of changes in technology or consumer preference. Usually the term is indicative of technological change, since most forest products are consumed in other production process instead of by final users. It is difficult in many situations to find a specific variable associated with the technological changes occurring in an end-use market for forest products, making it necessary to use a time variable as a proxy. It is possible in some instances to isolate a specific variable associated with the technological change, such as the stock of copiers in the end-use factor equation for xerographic copier paper.

CONSUMER INVENTORY

Data on consumer inventories for most forest products, especially paper and board, is usually nonexistent or at least very difficult to obtain. Exceptions to this data problem are found in the lumber, plywood, newsprint, and container-board markets.

The difficulty in finding data on consumer inventories does not obviate the need for including a sector on consumer inventories in forest products models, especially if short-term analysis is important. Swings in consumer inventories can be violent, as shown by the 1974-1975 experience in the paper and board industry. Even now, when high interest rates are limiting inventory building, the newsprint industry is suffering under high inventory levels at publishers. Short-term swings in consumer inventories can amount to 10% of actual consumption levels, providing much of the volatility in shipments.

We have developed a methodology to estimate consumer inventory changes over history, by relying on economic assumptions and subjective analysis of the apparent consumption data. Briefly, the methodology is based on several assumptions:

1. A "normal" level of the consumer inventory-to-consumption ratio can be set in some base time period.
(2) The consumer inventory-to-consumption ratio always returns to this "normal" level after a cyclical fluctuation.

(3) The "normal" level does not change over time. This assumption can be relaxed without impinging on the validity of the methodology if empirical considerations point to a changing "normal" level.

(4) True consumption per unit of end-use activity (the use factor) does not fluctuate dramatically over the short run. Under special circumstances, this assumption can also be relaxed, e.g., the reclassification of some newsprint imports from Canada, as uncoated groundwood papers, which drove up true consumption substantially in 1978 and the first half of 1979.

A detailed discussion of our consumer inventory methodology was published in our September 1979 Pulp and Paper Review. We have been able to develop estimates of consumer inventories using this methodology that conform very well to the reality of the marketplace as experienced by the companies engaged in selling paper and board.

The consumer inventory equation takes the functional form of:

(3) \[ ICH = f(C, INV, UCAP, RI) \]

where,

- **ICH** = Consumer Inventory Change
- **C** = True Consumption Level
- **INV** = Lagged Level of Consumer Inventories
- **UCAP** = Shipments Relative to Capacity
- **RI** = Real Interest Rates

Consumption is the most important element in determining the long-run level of consumer inventories, since consumers try to maintain an optimal inventory to
consumption ratio. This implies that growing consumption will require a rising level of inventories, and not including this behavior in a model will result in an underestimate of total demand over a long-run forecast.

The lagged level of consumer inventories is included to represent the consumer's adjustment process to keep an equilibrium level of inventories relative to consumption. As inventories become out of line relative to consumption, either on the high or low side, consumers react to bring inventories back to an optimal level. This adjustment process, at least in the paper and board industry, usually takes three to four quarters to complete.

A variable representing market tightness must be included to capture the consumer inventory behavior in a cyclical situation. As supplies tighten, consumers try to build inventories to protect themselves against supply shortages. In a weak period, consumers will draw down inventories because of being assured about supply availability and to shift the burden of carrying inventory onto the supplier. The market tightness variable has an associated lag structure, with a negative relationship in the nearby time period and a positive relationship in the further removed period. This lag structure is consonant with the market behavior that does not allow consumers to immediately fulfill their plans but then conditions change to allow their completion. We use shipments relative to capacity as the market tightness term.

Real interest rates are included to represent the depressing influence of high real interest rates on the inventory-to-consumption ratio. This variable was not very significant in consumer inventory behavior up to the recent period of very high real rates of interest.

**INTERNATIONAL TRADE**

International trade continues to become more important in the forest products industry, as demand growth occurs in world regions not endowed with forest resources. The United States, the European Economic Community, and Japan all have large import needs for forest products, especially pulp and paper. Major
countries in Asia are also developing large appetites for forest products imports. The forest products industry is becoming more interdependent on a worldwide basis, and we expect further growth in world forest products trade in the future.

Developing models that represent the worldwide nature of the forest products industry constitutes a great challenge for model builders. Data problems abound, definitions of grade breakdowns vary between countries, tariffs and subsidies must be taken into account, and exchange rates rapidly change the relative cost position of producing regions. The problems inherent in developing international models with functioning trade sectors must not discourage their development, since these sectors provide significant information about the future path of the world forest products industry.

We have concentrated on developing pulp and paper models that are worldwide in scope, with a focus on the competition between the United States, Canada, Scandinavia, and Brazil in the export market. We have developed worldwide models for newsprint, other printing and writing papers, tissue, other paper and board, total wood pulp broken down into five pulp grades, and chemical paper grade market wood pulp broken down into four grades. These models incorporate 13 regions or countries: United States, Canada, Sweden, Finland, Norway, Brazil, other Western Europe, Japan, other Asia, Africa, other Latin America, Oceania, and Eastern Europe and the U.S.S.R.

The trade sectors of these worldwide models concentrate on the shares of the total export market for each of the Norbrascan countries (United States, Canada, Sweden, Finland, Norway, and Brazil). The export market is defined as the summation of the net import demands of the non-Norbrascan regions plus the import demand of the Norbrascan region excluding U.S.-Canadian trade. The shares of this export market are developed for each country using the formulation:
(4) \[ MS_A = f\left(\frac{C_A}{C_{NOR}}, \frac{EC_A}{EC_{NOR}}\right) \]

where,

- \( MS_A \) = Market Share of Country A
- \( C_A \) = Delivered Cost for Country A
- \( C_{NOR} \) = Average Delivered Cost for Norbrascan Region
- \( EC_A \) = Export Capacity for Country A
- \( EC_{NOR} \) = Sum of Export Capacity for Norbrascan Region

The first term, relative production costs, is actually a proxy for relative prices charged by the various suppliers in the export market. It is extremely hard to obtain data on discounts offered by individual suppliers and, in many cases, the suppliers offer the commodity grade at very nearly the same price. Therefore, we have used production cost as a proxy to indicate the movements in relative prices that would probably be associated with changes in costs. This cost term is mainly relevant in weak demand periods.

The second term, relative export capacity, is the most important element in determining market shares. (Of course, relative capacity growth is based heavily on profit margins in each producing region.) Export capacity is defined as total capacity less domestic shipments, implying that domestic demand is filled first before looking at export markets. The relationship between export capacity and market share is highly significant for every grade and country; the problem is to be able to estimate capacity growth.

**PRODUCTION COSTS**

A sector devoted to production costs is a necessity in a fully structured forest products model. No serious effort of forecasting prices can be made without a good approximation of the variable production costs incurred by the producers in the industry. This statement is especially true in long-term price forecasting, where production cost inflation almost entirely determines the long-run average inflation in prices. Production costs are also important in short-run price analysis, although market tightness becomes a much more prominent deter-
minant. Production costs are especially important in short-term pricing analysis when markets are very weak, since average variable production costs set the floor for prices. Production costs are also extremely important in investment analysis, since a primary component of investment decisions is the internal rate of return which must include estimates of both direct costs and capital costs.

The production cost sector of the models incorporates more than economic variables and theory, since the mechanics of the physical production process must be represented. Thus, a large amount of engineering data is incorporated in the cost sector and technological developments in the production process must be anticipated when forecasting. A typical equation in the production cost sector includes both the unit cost of an input to the production process and the number of unit inputs consumed in the process to produce a unit of output. A sample equation from the market pulp model cost sector is:

\[(5) \quad ACLAB@BSSS@BCC = (AHEP&P@BC*\]
\[\quad (1+PAYADD@BSSS@BCC)) *MH@BSSS@BCC\]

where,

\[ACLAB@BSSS@BCC = \text{Average labor cost per ton of bleached softwood kraft pulp in B.C. Coast}\]

\[AHEP&P@BC = \text{Average hourly earnings of pulp and paper workers in B.C.}\]

\[PAYADD@BSSS@BCC = \text{Payroll additions in the B.C. pulp and paper industry}\]

\[MH@BSSS@BCC = \text{Average operating man hours per ton of output in the B.C. Coast bleached softwood kraft pulp industry}\]
In the typical paper model, nine cost components are estimated. Six of the components are included in variable costs: fibre, energy, chemicals, labor, other materials and maintenance, and transportation of the finished product. Three fixed costs are estimated: mill and corporate overhead, depreciation, and interest. The cost components are estimated on an industry-average basis. (The FORSIM Group also estimates high and low production costs, mainly based on timber costs.) Capital costs for new capacity are also estimated in the models for use in the investment sector.

PRICING

The price sector of the models is probably the most important model sector, both from a modeling and forecast-user perspective. Product prices feed into end-use factor, market share, production, and investment equations. Forecast users incorporate price forecasts into production scheduling, short-term budgeting, and investment decisions. Prices may be extremely difficult to forecast, especially in volatile markets, but excluding an integrated price sector from a model precludes having an adequate model structure and a useful forecast for model users.

The functional form of a price equation is:

\[ P_A = f(AVC_A, D_A/S_A) \]

where,

\[ P_A = \text{Price of Product A} \]
\[ AVC_A = \text{Average Variable Production Cost for Product A} \]
\[ D_A/S_A = \text{Demand Relative to Supply of Product A} \]

A log-log relationship is always postulated for price and average variable production costs. In other words, there is assumed to be a percentage relationship. In fact, the percentage relationship is always very close to one-to-one. That is, a one percent change in costs will give a one percent change in
price, given that demand/supply conditions remain unchanged. Average variable costs are defined as labor, energy, fibre, chemicals, and other materials. These mill or cash costs are used on the right-hand side of the equation if the price term reflects net price at the mill. If the price term is a delivered price, then transportation costs are incorporated into variable production costs. Only variable production costs are used in the price equation because fixed costs are not relevant in the pricing decision. Fixed costs impact the pricing decision only through the supply term in the demand/supply variable. If prices are not high enough to make investment attractive, then supply will shrink over time relative to demand and then feed back into the price decision into higher prices relative to costs.

Variable production costs are the primary determinant of prices over the long run, unless there is a long-term shift in demand/supply balances or in the structure of an industry. As can be seen from the price equation structure, prices will become entirely a function of costs as demand/supply reaches a long-run equilibrium.

Several demand/supply variables can be used in the price equations, depending on data availability and industry structure. In our paper models, shipments relative to capacity is used most frequently as the demand/supply variable. Other commonly used demand/supply variables are producer inventories relative to shipments and unfilled orders relative to producer inventories. In the Timber model, removals relative to timber inventory is the demand/supply variable used to estimate stumpage prices.

The function of the demand/supply variable(s) in the price equation is to estimate the margin of price over average variable costs. In a volatile market, the demand/supply variable appears to be the only determinant of prices since prices move so erratically relative to underlying costs. However, the importance of costs can be seen in weak markets since prices stop declining when variable production costs are reached. Also, the influence of costs can be seen over an investment cycle as new capacity is drawn into an industry if profit margins expand to attractive levels. Our functional relationship between prices, costs, and demand relative to supply is applicable only if the industry operates in a competitive environment (as defined in neoclassical economics).
INVESTMENT

An investment sector is extremely important for doing longer-run analysis, beyond three years for the pulp and paper industry and beyond two years for the solid wood industry. Even within the two- to three-year period when an analyst can usually depend on announced expansion plans, it is helpful to have an investment sector to assess the probability of postponements of announced projects or closures of existing facilities during a weak market.

Investment sectors are relatively uncommon in sub-industry models, with almost all of the published work being done on complete industry groupings such as steel or autos or on a macroeconomic level. Also, the published work tends to focus on dollar investment instead of physical investment such as yearly tons of paper capacity. We have taken our basic investment framework from the literature, using the neoclassical approach as the base for our work. We have then modified the neoclassical approach to fit it to a sub-industry analysis.

The functional form of an investment equation is:

\[
I_A = f(I_{RR_A}, OC_A, D_A)
\]

where,

- \(I_A\) = Investment in Product A
- \(I_{RR_A}\) = Internal Rate of Return on Product A
- \(OC_A\) = Opportunity Cost of Investing in Product A
- \(D_A\) = Demand for Product A

As alluded to above, the investment variable is the physical increment (or drop) in capacity. Thus, tonnage changes in capacity is the investment term for pulp and paper, while board foot and thousand square foot changes in capacity are used for lumber and plywood. Data on historical capacity changes and levels are relatively accessible for paper and plywood, but capacity estimates for lumber are much less precise due to the use of single-shift operations and the number of very small sawmills.
The internal rate of return and the opportunity cost terms are combined in the investment equation to develop a real rate of return variable. The internal rate of return term is actually pseudo-IRR term, since a discounted cash flow is necessary to develop a true IRR calculation. Since we incorporate the investment sector inside a model used to forecast cash flows, a discounted cash flow cannot be developed. The pseudo-IRR term is developed using the current price, average variable production cost, per-ton depreciation charge on an expansion, overhead cost, profit tax rate, and capital cost of the expansion. A current per-ton-after-tax profit is developed using all the variables listed above except for the capital cost. This profit is then divided by a unit capital cost term which is defined as the total capital cost divided by the effective lifetime of the investment in years. (The development of this pseudo-IRR term is explained in detail in the October 1981 Pulp and Paper Review.)

A real rate of return is developed by subtracting the opportunity cost from the pseudo-IRR term. We usually define the opportunity cost as the interest rate on new commercial paper. Thus, the opportunity cost term both indicates the rate of return on alternative uses of the money being considered for use in the forest products investment and the cost of borrowing money for use in the investment. The real rate of return variable is then incorporated into the investment equation with a three-to-four-year distributed lag to account for the time required to initiate an investment decision and then the construction time after the investment decision has been made.

The real rate of return variable has been proven to be very significant in explaining investment behavior, even though a true IRR term cannot be used. However, several problems have arisen in the implementation of the rate of return variable. First, government subsidies must be taken into account, especially when analyzing investment behavior in countries other than the United States. Secondly, net investment appears to react to real rate of return more quickly on the upside than the downside, i.e., capacity does not close down in weak markets even though low profitability would suggest closures.
The second term in the investment equation is change in demand for the product. Demand growth must be included in the capacity expansion determination to set the actual level of expansion and to provide a possible offset to rate of return. For example, capacity will continue to expand at some constant attractive rate of return if demand continues to grow. Without the demand term, capacity would stagnate with a constant rate of return, even if it were high enough to actually draw investment.

**USING THE MODELS FOR FORECASTING**

Econometric models have gained an enormous amount of popularity over the past decade. Major reasons for the rising popularity have been the ability to quantify economic relationships, the rapidity of generating alternative scenarios, the growing need to plan in the face of a volatile economy, and the ability to include many important variables in a computer modeling framework. Recently, econometric models and forecasts based on econometric models have been greeted with a less fervent response as the economy has been impacted by radical changes in government policies. I would like to take some time to discuss the merits and pitfalls inherent in econometric models in general and forest products models in particular.

Part of the recent criticism econometric models have incurred is healthy and justified. Many people assumed that forecasts based on econometric models were close to infallible. This rather naive assumption was based on the comprehensiveness of the forecasts and the apparent exactitude of the numbers generated by a computer. This assumption was also encouraged by some forecasters, to the detriment of the economic forecasting profession. A dose of skepticism on econometric forecasts is justified on several bases.

First, all econometric models require assumptions on government policy or random shocks to the economic environment such as political turmoil or weather-induced food shocks. The quality of the forecast is heavily dependent on the assumptions fed into the model. Second, econometric models are based on
historical data and relationships. If these relationships change significantly relative to history, such as occurred with the recent radical shift in U.S. monetary policy, then econometric models may not be able to respond completely to the new environment. Third, econometric models are based almost entirely on economic relationships and tend to disregard market psychology. The short-term operations of a market may be ruled more by expectations and psychology than rational economic logic, rendering the outputs of an econometric model less useful in the very short-term environment.

Problems with forecasts based on econometric models should not preclude the enlightened use of these forecasts in planning applications. Users of forecasts based on econometric models have the responsibility to become acquainted with and comfortable with the structure of the models and the assumptions being put into the models. Once the user has become informed on the characteristics of econometric models, then the capabilities of the models can be fully used with an appreciation also for the limitations of the models. A full range of rational uses for the models is then opened up for the user:

- Using the economic relationships in the model to teach people about the interrelationships inherent in the economic environment in which they operate.
- Quantifying the economic relationships occurring in an industry or economy.
- Generating forecasts to show the anticipated movement of an industry or economy under a given set of assumptions.
- Using the models to logically assess a change in fundamental relationships.
- Generating forecasts under alternative sets of assumptions to identify forecast risks.