

## Reduced-Form Model of New Brunswick Lumber Production\*

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Use of staple theory to describe the economies of Canada's periphery regions has been discussed extensively in the literature (Brewis 1969; Economic Council of Canada 1977; Mansell and Copithorne 1986; Watkins 1963). In fact, much of Canada's effort to equalize regional disparity has taken the form of support for the staple sectors of the periphery provinces (see Savoie 1986; Lithwick 1985, 1986). And much of the funding supporting regional incentives to private industry (through the Regional Development Incentives and Industrial and Regional Development programmes) and social infrastructure (through General Development Agreements and Economic and Regional Development Agreements) has been directed toward helping the export staple-producing sectors. To a large extent, the federal government under the Progressive Conservatives has undertaken a policy of supporting large-scale staple development projects (for example, Newfoundland's Hibernia oil development, Nova Scotia's gas production, New Brunswick's pulp and paper industry). Thus, the rationale has been to strengthen key resource-producing sectors; provinces then specialize in industries in which they have a comparative advantage.

According to the standard explanation of staple development, output depends on world demand and provincial cost considerations. The structure of the staple industry within a province may be, but is not necessarily restricted to, one of perfect competition. Although each firm might be a price taker, the province's or region's total perceived demand curve may be downward sloping because of regionalized staple

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markets. Nonetheless, fluctuations in the world (or continent-wide) staple demand will carry through to generate similar fluctuations in the province's staple exports, resulting in part of the staple output being demand-driven. In addition, provincial sales will vary as factor costs and the technology of a province's staple production change. Such developments shift the province's staple supply curve. It is an empirical question as to what proportions of staple output can be attributed to supply and demand considerations.

This note measures the effects of supply and demand variables on New Brunswick's lumber industry. It will show that the largest share of output (60 per cent) can be attributed to demand-side considerations, with most of that share attributable to the Canada-U.S. exchange rate, while costs and productivity explain roughly 14 per cent of lumber production.

In the remainder of this paper, a brief description of the lumber industry in New Brunswick is followed by an outline of the derivation of the reduced-form model used in decomposing supply and demand effects and subsequently by presentation of the empirical results obtained from the application of this model.

## Recent Developments in the New Brunswick Lumber Industry

### Institutional Facts

In terms of output, employment, and exports, lumber production is the second most important forestry-related sector in New Brunswick, behind the paper and allied products industry. The wood industries sector represents about 7.5 per cent of shipments and value added of the province's goods-producing sector, 12.3 per cent of manufacturing employment, and 10 per cent of manufacturing wages and salaries.<sup>1</sup> Lumber exports to destinations outside Canada make up roughly one-third of New Brunswick's total lumber shipments, with another one-sixth shipped to other Canadian provinces.

Of the 101 lumber firms operating in the province in 1986, most were small. Roughly half of these firms employed fewer than 10 workers, and two-fifths employed between 10 and 50 individuals.<sup>2</sup> These statistics justify the assumption of industry-level perfect competition used in the model below.

<sup>1</sup>These wage, employment, and value-added statistics were taken from Canadian Forestry Service—Maritimes (1987) and are based on Statistics Canada data. The export information was drawn from Table 1 in: Statistics Canada, *Destination of Shipments of Manufacturers 1979*, Cat. No. 31-530, 24-25.

<sup>2</sup>Based on New Brunswick Commerce and Technology, *Directory of Products and Manufacturers*, 1988.

### Market Share and Cost Trends

It is useful to compare over the last decade and a half (1970-1985) the relative unit costs and market share trends of New Brunswick's lumber sector with those of the total non-British Columbia lumber industry (see Table 1).<sup>3</sup> Over this period New Brunswick exhibited higher overall unit variable costs than the industry taken as a whole (excluding British Columbia), perhaps stemming from the small scale of the province's firms. Nevertheless, in part because of federal and provincial policies directed at the forestry sector,<sup>4</sup> relative unit costs fell gradually over the period. Despite this cost trend, however, New Brunswick's market share of lumber did not increase. It even decreased slightly.

This combination of falling relative unit costs and a declining market share is hard to explain under the assumption of a perfectly competitive market in eastern North America. But it provides empirical support for the assumption that the province has some monopoly power (because of transportation charges incurred by buyers), causing the demand for New Brunswick lumber to be downward sloping. It is assumed that the province is monopolistically competitive with the other provinces but that individual firms within New Brunswick cannot influence the New Brunswick price.

### Derivation of the Reduced-Form Model

This model of New Brunswick lumber production is based on standard staple theory (see Anderson 1988: 130-137; Bradfield 1988: 30-38; North 1955; Watkins 1963). The province is assumed to specialize in the production of lumber given (1) its comparative advantage, and (2) distance and transportation cost considerations. Perfect competition for firms in the lumber industry is also assumed. But, given

<sup>3</sup>The British Columbia lumber industry is structurally different from the lumber sector in the rest of Canada because of sharp differences in scale and firm size. Thus, British Columbia's numbers were subtracted from Canada's totals, and the "non-B.C. Canadian" lumber industry was used as a benchmark for comparison with New Brunswick's sector.

<sup>4</sup>The forestry sector formed the first Forestry Subsidiary Agreement under the Federal-Provincial General Development. The agreement financed major commercial timber operations and promoted technical and administrative capabilities in order to increase and diversify output and to increase value added (forward-linkage manufacturing) in the industry. The second Forestry Subsidiary Agreement further recognized supply strategies by promoting silviculture activities. The later Forest Renewal Agreement, 1984-1989, addressed supply considerations as well (silviculture, budworm spraying, harvesting in environmentally sensitive areas).

Table 1  
RELATIVE COSTS AND PRODUCTION OF LUMBER IN NEW BRUNSWICK  
(VIS-A-VIS EASTERN CANADA)

| Year | Costs                  |                          |                            |                 | Production (%) (5) |
|------|------------------------|--------------------------|----------------------------|-----------------|--------------------|
|      | Wages and Salaries (1) | Fuel and Electricity (2) | Materials and Supplies (3) | Total Costs (4) |                    |
| 1970 | 140                    | 144                      | 180                        | 166             | 7.8                |
| 1971 | 134                    | 135                      | 170                        | 157             | 7.6                |
| 1972 | 126                    | 129                      | 152                        | 144             | 7.0                |
| 1973 | 146                    | 138                      | 175                        | 160             | 5.8                |
| 1974 | 143                    | 167                      | 196                        | 178             | 6.2                |
| 1975 | 131                    | 151                      | 164                        | 152             | 7.0                |
| 1976 | 128                    | 145                      | 159                        | 149             | 6.6                |
| 1977 | 124                    | 147                      | 147                        | 140             | 5.7                |
| 1978 | 108                    | 135                      | 140                        | 130             | 6.1                |
| 1979 | 106                    | 126                      | 146                        | 133             | 6.5                |
| 1980 | 103                    | 123                      | 138                        | 127             | 6.8                |
| 1981 | 114                    | 123                      | 161                        | 146             | 5.9                |
| 1982 | 116                    | 111                      | 138                        | 121             | 5.3                |
| 1983 | 109                    | 92                       | 119                        | 112             | 6.7                |
| 1984 | 112                    | 111                      | 136                        | 127             | 5.9                |
| 1985 | 108                    | 123                      | 147                        | 140             | 6.5                |

Source : Statistics Canada. *Annual Census of Manufacturers, Sawmills and Planing Mills and Shingle Mills*, Ref. No. 35-204; *Wood Industries*, Ref. No. 35-250; *Wood Industries: Sawmill and Planing Products Industry (Except Shingles and Shakes)*, Ref. No. 35-250B.

Note: Columns (1), (2), (3), and (4) are unit-cost indexes, New Brunswick to Eastern Canada. An index of 100 means New Brunswick has unit costs equal to those of Eastern Canada; an index of over 100 means New Brunswick has higher unit costs. Column (5) is New Brunswick's share of the total production of lumber in Eastern Canada.

transportation charges (as transaction costs) to buyers, the province's demand curve for its product has a negative slope. A standard upward-sloping supply curve for lumber is assumed as well, constructed as: (1) a summation of the marginal cost curves of firms in the province, and (2) entry (and exit) of firms to (and from) the industry given fluctuations in lumber demand. Consequently, the model depicts a very standard explanation of lumber production, varying as a result of shifts in demand (caused by changes in macro demand variables) as well as shifts in supply (caused by changes in costs or productivity within the province).

On the supply side of this model, New Brunswick's lumber production (PROD) is specified as:

$$\text{PROD} = \alpha_0 + \alpha_1 P - \alpha_2 W - \alpha_3 \text{TAX} + \alpha_4 \text{SUB} + \alpha_5 \text{REF} - \alpha_6 F - \alpha_7 \text{RR} - \alpha_8 i - \alpha_9 \text{FE} - \alpha_{10} \text{MS} + e_1 \quad (1)$$

where  $P$  is the New Brunswick price of lumber,  
 $W$  is the unit cost of wages and salaries,

$\text{TAX}$  is the amount of taxes paid per unit by firms,  
 $\text{SUB}$  is the level of subsidies per unit paid to firms,  
 $\text{REF}$  is the number of hectares of past reforestation,  
 $F$  is the number of hectares lost to fires,  
 $\text{RR}$  is the royalty rate levied on firms,  
 $i$  is the rate of interest,  
 $\text{FE}$  is the unit cost of fuel and electricity,  
 $\text{MS}$  is the unit cost of materials and supplies, and  
 $e_1$  is a random disturbance term.

The exact definitions, methods of data estimation, and sources used can be found in the Appendix.

The *a priori* signing of the coefficients is shown in (1).  $W$ ,  $\text{TAX}$ ,  $\text{RR}$ ,  $i$ ,  $\text{FE}$ , and  $\text{MS}$  are pure cost variables that shift the supply curves upward, and  $\text{SUB}$  is a "negative" cost variable that shifts the supply curve downward.  $\text{REF}$  and  $F$  are backward-linkage production variables: as  $\text{REF}$  gets larger and  $F$  gets smaller, inputs into the lumber sector increase, thereby expanding lumber production. The coefficient on  $P$  indicates the slope of the supply curve.

On the demand side, New Brunswick's lumber shipments ( $\text{SHIP}$ ) are specified as:

$$\text{SHIP} = \beta_0 - \beta_1 P + \beta_2 \text{HS} - \beta_3 i - \beta_4 \text{TAR} - \beta_5 \text{EXCH} + \beta_6 \text{PCAN} + e_2 \quad (2)$$

where  $\text{HS}$  is the number of housing starts in Canada and the United States,  
 $\text{TAR}$  is the extent of tariffs levied by the United States on its lumber imports,  
 $\text{EXCH}$  is the Canada-U.S. exchange rate,  
 $\text{PCAN}$  is the average Canadian price of lumber, and  
 $e_2$  is a random disturbance term.

As in the case of the supply equation, the theoretical signs of coefficients are shown directly in (2). Clearly, the quantity of lumber demanded is inversely related to  $\text{TAR}$  and  $\text{EXCH}$ . It is also inversely related to  $i$  and directly related to  $\text{HS}$ . Finally, it is positively related to  $\text{PCAN}$ , given a beneficial terms-of-trade effect if  $\text{PCAN}$  rises in relation to  $P$ . Again, the coefficient on  $P$  indicates the slope of the demand curve.

The model is completed by the following identity stemming from the consolidation of lumber production and shipments:

$$\Delta \text{INV} = \text{PROD} - \text{SHIP} \quad (3)$$

where  $\Delta INV$  represents the change in inventories.<sup>5</sup> If production (PROD) increases faster than shipments (SHIP),  $\Delta INV$  is positive.

The model represented by equations (1)-(3) could be estimated directly using the two-stage least-squares method. Data exist for production, shipments, and inventory stocks. Moreover, when the change in inventories is generated from the stock data, identity (3) holds almost exactly. The problem with the direct estimation approach, however, is that price data by province are not available. Statistics Canada publishes a price index for lumber shipments only for the Atlantic Region and only for the most recent years of the 1970-1985 time period under consideration. But this problem is sidestepped by eliminating  $P$  between equations (1) and (2).<sup>6</sup> The resulting reduced-form equation for production is:

$$\begin{aligned} \text{PROD} = & \mu_1 - \mu_2 W - \mu_3 \text{TAX} + \mu_4 \text{SUB} + \mu_5 \text{REF} \\ & - \mu_6 F - \mu_7 \text{RR} - \mu_8 i - \mu_9 \text{FE} - \mu_{10} \text{MS} \\ & + \mu_{11} \text{HS} - \mu_{12} \text{TAR} - \mu_{13} \text{EXCH} + \mu_{14} \text{PCAN} + \mu_{15} \Delta \text{INV} + e \end{aligned} \quad (4)$$

where  $e = (\beta_1 e_1 + \alpha_1 e_2) / (\alpha_1 + \beta_1)$ , and

$$\begin{aligned} \mu_1 &= \frac{\alpha_0 \beta_1 + \alpha_1 \beta_0}{\alpha_1 + \beta_1} & \mu_2 &= \frac{\alpha_2 \beta_1}{\alpha_1 + \beta_1} & \mu_3 &= \frac{\alpha_3 \beta_1}{\alpha_1 + \beta_1} \\ \mu_4 &= \frac{\alpha_4 \beta_1}{\alpha_1 + \beta_1} & \mu_5 &= \frac{\alpha_5 \beta_1}{\alpha_1 + \beta_1} & \mu_6 &= \frac{\alpha_6 \beta_1}{\alpha_1 + \beta_1} \\ \mu_7 &= \frac{\alpha_7 \beta_1}{\alpha_1 + \beta_1} & \mu_8 &= \frac{\alpha_8 \beta_1 + \alpha_1 \beta_3}{\alpha_1 + \beta_1} & \mu_9 &= \frac{\alpha_9 \beta_1}{\alpha_1 + \beta_1} \end{aligned} \quad (5)$$

<sup>5</sup>The existence of inventories is not incompatible with price-taking firms. For example, there may be the prospect of financial gain because of an expected future price or cost increase. If the discounted price next period (net of storage costs) were expected to be above the current price, it would pay the firm not to offer its entire production for sale this period. Assuming increasing marginal storage costs, however, the discounted price, net of storage costs, would fall as more output is held as inventory. Only in extreme cases would production not occur at the intersection of current price and current marginal cost. Weintraub (1964: Chap. 16) contains a clear exposition.

<sup>6</sup>Substitute (3) into (2) to eliminate SHIP, and solve for  $P$  in (1) and (2) and equate to eliminate  $P$ . Then solve for PROD, yielding (4) and (5) in the text.

We experimented with the direct estimation approach using price data for New Brunswick obtained by dividing the total value of shipments by total volume. The resulting price series, however, was not a proper index, since the composition of lumber shipments could be expected to change over time. Moreover, the resulting estimates of the demand and supply functions were most unsatisfactory. We consistently found upward-sloping demand functions and downward-sloping supply functions.

$$\begin{aligned} \mu_{10} &= \frac{\alpha_{10} \beta_1}{\alpha_1 + \beta_1} & \mu_{11} &= \frac{\alpha_1 \beta_2}{\alpha_1 + \beta_1} & \mu_{12} &= \frac{\alpha_1 \beta_4}{\alpha_1 + \beta_1} \\ \mu_{13} &= \frac{\alpha_1 \beta_5}{\alpha_1 + \beta_1} & \mu_{14} &= \frac{\alpha_1 \beta_6}{\alpha_1 + \beta_1} & \mu_{15} &= \frac{\alpha_1}{\alpha_1 + \beta_1} \end{aligned}$$

Note that the expected sign on  $\mu_{15}$ , the coefficient for the change in lumber inventories, must be positive and less than one<sup>7</sup>: part of production in the current period must go into inventories, while part goes directly into shipments. More important, the value of  $\mu_{15}$  represents a "weight",  $\alpha_1 / (\alpha_1 + \beta_1)$ , that forms part of the shift parameter for the demand-side variables HS, TAR, EXCH, and PCAN. Thus in general, one can estimate indirectly the  $\beta_1$  coefficients in (2). Also, the estimate for  $\mu_{15}$  (by subtracting from unity) yields  $\beta_1 / (\alpha_1 + \beta_1)$ , the "weight" that enters into the shift parameter for the cost-side variables W, TAX, SUB, REF, F, RR, FE, and MS. In a similar fashion the parameter  $\alpha_1$  in (1) can be indirectly estimated from the value of  $\mu_{15}$ . But one cannot obtain values for  $\alpha_8$  and  $\beta_3$ —the supply/demand coefficients for the interest rate  $i$  (although it is known that  $\mu_8$  must have an *a priori* negative sign). Furthermore, estimated values for  $\alpha_1$  and  $\beta_1$ —the price elasticities of the supply and demand for lumber—cannot be obtained separately. If a variable enters into (1) and (2) simultaneously, its coefficients in both the supply and demand equations cannot be determined indirectly from information in the reduced form.

The weights  $\alpha_1 / (\alpha_1 + \beta_1)$ , and  $\beta_1 / (\alpha_1 + \beta_1)$  can be explained intuitively by discussing the two polar cases for  $\mu_{15}$ :

CASE I:  $\alpha_1 = 0$ , so that  $\mu_{15} = 0$  and  $\beta_1 / (\alpha_1 + \beta_1) = 1$

In this situation the lumber supply curve is vertical. Thus, changes in the macro demand variables will not influence PROD, since output is assumed to be at full capacity at all times. As supply increases, equilibrium output PROD is increased by the full  $\beta_1 / (\alpha_1 + \beta_1) = 1$  effect.

CASE II:  $\beta_1 = 0$ , so that  $\mu_{15} = 1$  and  $\alpha_1 / (\alpha_1 + \beta_1) = 1$

In this case the province's lumber demand curve is vertical. Thus, any shift in supply yields no change in output PROD, and no cost variables "matter". Shipments increase by the full  $\alpha_1 / (\alpha_1 + \beta_1) = 1$  effect.

In general, one would expect a value for  $\mu_{15}$  that lies somewhere between Cases I and II, such that part of production is absorbed into inventories and both cost and both cost and demand shift variables determine output of lumber. Estimates of  $\mu_{15}$  and the relative

<sup>7</sup>By definition, all  $\alpha_i$  and  $\beta_i$  symbols are algebraically set to be greater than zero.

contributions of the supply and demand variables are undertaken in the next section.

## Empirical Results

### Estimation of the "Full" Regression and Diagnostic Tests

Equation (4) was estimated using raw quarterly data for 1970(1)-1985(4). Three dummy variables for the final three-quarters of each year were also included to account for seasonal variation. Based on the factors outlined in the preceding section, all variables were specified for the current time period only. The model-fitting procedure began with the most general version of the reduced form, so that insignificant variables were subsequently dropped, one at a time. Variables significant in earlier versions, but which became only marginally significant (that is, at the 10 per cent level) in the final weeding-out process, were retained. In this way the variables MS, W, TAR, F, i, SUB, PCAN, and TAX were eliminated.<sup>8</sup> The final estimated results of the "full" regression—where all remaining variables are significant at least at the 10 per cent level—appear in the first column of Table 2. There, three cost-side variables remain (REF, RR, FE), as well as two demand-side variables (HS, EXCH), the inventory change variable,  $\Delta INV$ , and the three seasonal dummy variables. The adjusted  $R^2$ -coefficient suggests a reasonable goodness of fit given the volatility of the lumber production data. The estimated value of  $\mu_{15}$  equals 0.557, from which one can obtain the  $\alpha_i$  and  $\beta_j$  estimates shown in column (1) of Table 3.

The full regression was subjected to several diagnostic tests. The reported 1.5 Durbin-Watson statistic indicated no first-order autocorrelation; a Lagrange Multiplier test also indicated an absence of fourth-order (AR4) autocorrelation (Stewart and Wallis 1981: 230-231). A standard Breusch-Pagan test was run to test for possible heteroskedasticity, and the result supported the null hypothesis for heteroskedastic errors. An Engle's ARCH test run to check for possible autoregressive conditional heteroskedasticity (ARCH) errors showed insignificant errors (Maddala 1988: 218-219). Finally, a Chow test on the data suggested little or no structural change for the estimated parameters.

<sup>8</sup>Because of multicollinearity, the significance of some variables in the regression may be dependent on the choice of other variables included with them. Consequently, different mechanical stepwise selection criteria may result in very different final functional forms. Thus, we sensitivity-tested our "backward elimination" technique against a "forward selection" technique. Happily, this alternative selection criterion resulted in the elimination of broadly the same variables.

Table 2  
OLS RESULTS OF THE FULL REGRESSION AND DEMAND- AND SUPPLY-SIDE-ONLY REDUCED-FORM REGRESSIONS

| Variable     | Full Regression    | Demand-side Regression | Supply-side Regression |
|--------------|--------------------|------------------------|------------------------|
| INTERCEPT    | -66,938.6<br>(2.8) | -15,145.7<br>(9.3)     | 96,948.5<br>(11.1)     |
| REF          | 5.15<br>(4.2)      | —                      | 12.6<br>(14.3)         |
| RR           | -8,423.1<br>(2.6)  | —                      | -2.6<br>(3.7)          |
| FE           | -3.47<br>(4.7)     | —                      | -13,243.3<br>(3.1)     |
| HS           | 0.007<br>(1.7)     | 0.021<br>(4.7)         | —                      |
| EXCH         | 143,160.6<br>(6.4) | 176,426.2<br>(14.1)    | —                      |
| $\Delta INV$ | 0.557<br>(3.8)     | 0.897<br>(4.9)         | —                      |
| DUM2         | 13,548.8<br>(3.6)  | 20,593.5<br>(4.3)      | 13,073.8<br>(2.5)      |
| DUM3         | 17,084.2<br>(4.4)  | 25,843.1<br>(5.3)      | 14,658.5<br>(2.9)      |
| DUM4         | 11,356.9<br>(3.0)  | 14,138.3<br>(2.8)      | 17,976.3<br>(3.5)      |
| SEE          | 51.0 <sup>8</sup>  | 104.3 <sup>8</sup>     | 113.4 <sup>8</sup>     |
| $R^2$        | 0.90               | 0.82                   | 0.79                   |
| DW           | 1.51               | 0.96                   | 0.83                   |

Note: Numbers in parentheses are t-statistics; SEE = sum of squares of the residuals;  $R^2$  = coefficient of determination; DW = Durbin-Watson statistic.

### Estimating Supply/Demand Variable Contributions

To test whether the supply and demand variables—taken as separate variable groups—contribute significantly to the full model, PROD was run as a function of the statistically significant demand-side variables (HS, EXCH,  $\Delta INV$ )<sup>9</sup> and then regressed as a function of the significant supply-side variables (REF, RR, FE). In both truncated regressions the seasonal dummy variables were included. The OLS results also appear in Table 2. Note that the estimated intercepts—significant in both restricted regressions—have opposite signs<sup>10</sup> and that both regressions show signs of first-order autocorrelation.

<sup>9</sup>In the nested-model exercise,  $\Delta INV$  was treated as a demand-side variable: production varies according to demand factors (HS, EXCH) but is subject to changes in  $\Delta INV$  because of timing factors.

<sup>10</sup>The estimated value of the intercept for the demand-side regression is (significantly) negative, and the estimated value of the supply-side regression is (significantly) positive. These results make sense, since the estimated intercepts

Table 3  
CONTRIBUTION ANALYSIS OF FULL REGRESSION

| Variable     | $\alpha_i$ or $\beta_i$<br>Value<br>(1) | Variable<br>Mean<br>(2)    | $\mu_i$<br>(3)          | Value of<br>Contribution<br>(4) = (2) x (abs 3) |
|--------------|---|----------------------------|-------------------------|---|
| INTERCEPT    | —                                       | 1.0                        | -66,938.6<br>(24,299.9) | 66,938.6  |
| REF          | 11.62                                   | 1,925.1<br>(2,247.4)       | 5.15<br>(1.24)          | 10,010.5  |
| RR           | -19,006.7                               | 1.74<br>(0.435)            | -8,423.1<br>(3,265.5)   | 14,656.2  |
| FE           | -7.82                                   | 4,633.6<br>(2,829.8)       | -3.47<br>(0.73)         | 16,217.6  |
| HS           | 0.01295                                 | 1,567,194.0<br>(392,299.0) | 0.007<br>(0.004)        | 10,970.4  |
| EXCH         | 257,097.0                               | 1.14<br>(0.136)            | 143,160.6<br>(22,344.5) | 163,203.1                                       |
| $\Delta$ INV | —                                       | 163.9<br>(11,179.0)        | 0.557<br>(0.147)        | 91.3  |
| DUM2         | —                                       | 0.25                       | 13,548.8<br>(3,764.4)   | 3,387.2   |
| DUM3         | —                                       | 0.25                       | 17,084.2<br>(3,895.7)   | 4,271.1   |
| DUM4         | —                                       | 0.25                       | 11,356.9<br>(3,784.2)   | 2,839.2   |

Note: Numbers in parentheses are standard errors.

Nested-model tests were then run to determine whether the restrictions put on the full regression were valid.<sup>11</sup> F-statistics equal to 23.3 were calculated for the supply-side regression and 19.9 for the demand-side regression. For this test the critical  $F^{05}$  value equals 4.15, and the null hypothesis that the restrictions are true is rejected. The restrictions are invalid, and the demand- and supply-side-only regressions are misspecified in that they ignore the "other" side's variables. We therefore accept the full model's explanation that both supply and demand phenomena explain variations in PROD.

Finally, the contribution share that each side (supply and demand) makes in explaining New Brunswick's lumber output can be

contain information from neglected variables for each truncated model. The omitted supply-side variables in the demand-side regression would have introduced cost into the model had they been included; thus, the intercept for this regression is negative. Likewise, the neglected demand-side variables in the supply-side regression would have added positive explanatory power; thus, the intercept for this estimated equation is greater than zero.

<sup>11</sup>That is, the restricted models were the demand- and supply-side-only regressions in that they restricted the respective coefficients of the variables on the other side to zero.

quantified. Multiplying the mean of each significant explanatory variable  $j$  in equation (4) by the associated coefficient  $\mu_j$  yields the contributing share of each variable. The results are shown in column (4) of Table 3. According to this table, when negatively valued contributions are treated as absolute numbers and  $\Delta$ INV is treated as a demand-side variable, the demand-side variables account for about 60 per cent of New Brunswick's lumber production as against 14 per cent for supply-side factors. The Canada-U.S. exchange rate itself accounts for a very large 56 per cent of total output.

## Conclusions

The demand side of New Brunswick's market largely dictates the province's equilibrium lumber output. This explains why, even though the province's unit variable costs showed a relative improvement from 1970 to 1985, the province still saw its relative share of lumber output decline. To be sure, government regional policies to improve the province's forestry sector may have helped the province's small lumber industry, but demand factors, overall, mitigated the beneficial effects of such policies. A rising Canada-U.S. exchange rate, in particular, was very important in reducing New Brunswick's lumber exports. A standard crowding out of exports by rising government deficits (with interest rate pressures raising the value of the Canadian dollar) appears to have hindered any beneficial effects of improvements in the industry's productivity.

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### Appendix: Mnemonics and Sources of Data

- EXCH U.S. noon spot rate in Canadian dollars from the Bank of Canada. Data obtained from: International Department, 1987 Cansim Directory, Ref. No. 926, pu b 3400.
- F Number of hectares lost from forest fires in New Brunswick. Information received from: Wayne G. Clowater, Director, Forest Fire Protection Branch, Department of Natural Resources and Energy, Canada.
- FE Price of fuel and electricity to New Brunswick sawmills and planing mills per unit of output. Data taken from: Statistics Canada, *Annual Census of Manufacturers, Sawmills and Planing Mills and Shingle Mills*, Ref. No. 35-204.
- HS Housing starts for Canada and the United States, combining number of building permits for Canada with number of new housing units authorized for the United States. Canadian housing starts provided by: Statistics Canada, *Building Permits, Total Number of Dwelling Units*, Ref. No. 64-001. Housing starts for the United States found in: U.S. Bureau of the Census, *Statistical Abstracts of the U.S., Construction Reports*, 1973, 1977, 1979, 1980, 1984, 1985, 1986, and 1988.
- i Existing U.S. conventional home mortgage interest rate, net of the inflation rate. Interest rate taken from: *Statistical Abstracts of the U.S.* 1975-1988 U.S. consumer price index tables taken from: 1987 Cansim Directory, Ref. No. 336, pu b 134010.

Throughout the analysis, a sensitivity analysis was conducted with interest rates of less significance such as the Canadian chartered bank prime business loan rate from *Bank of Canada Review*, 1987 Cansim Directory, Ref. No. 2560, pu b 14020; the Canadian chartered bank 90-day deposit receipts from *Bank of Canada Review*, 1987 Cansim Directory, Ref. No. 2560, pu b 14018; the five-year Canadian mortgage lending rate from *Bank of Canada Review*, 1987 Cansim Directory, Ref. No. 2560, pu b 14024; the U.S. conventional new home mortgage rate from *Statistical Abstracts of the U.S.*, 1975, 1988; the FHA insured home mortgage rate from *Statistical Abstracts of the U.S.*, 1975, 1988; with the Canadian consumer price index from the 1987 Cansim Directory, Ref. No. 1922, pu b 484000.

- $\Delta$ INV Change in inventory, calculated as the annual change in the inventory stock held by sawmills and planing mills in New Brunswick. Data obtained from: Statistics Canada, *Production, Shipments and Stocks on Hand of Sawmills East of the Rockies*, Ref. No. 35-002.
- MS Cost of materials and supplies to New Brunswick firms per unit of output. Data obtained from: Statistics Canada, *Annual Census of Manufacturers, Sawmills and Planing Mills and Shingle Mills*, Ref. No. 35-204.
- PROD Lumber production of sawmills and planing mills in millions of cubic board feet. Data obtained from: Statistics Canada, *Production, Shipments and Stocks on Hand of Sawmills East of the Rockies*, Ref. No. 35-002.
- REF Number of hectares planted or reforested (number of trees planted did not provide as significant a result). Data taken from: *Silviculture Statistics, Crown Lands, 1987-88*, Timber Management Branch, Department of Natural Resources, April 1988.
- RR Royalty rates, a measure of the cost of stumpage associated with the use of land for harvesting lumber. Data obtained from: Marilyn Daley, Queen's Printer, Fredericton, New Brunswick.
- SHIP Shipments of lumber to Canada and the United States. Data found in: Statistics Canada, *Production, Shipments and Stocks on Hand of Sawmills East of the Rockies*, Ref. No. 35-002, as well as from export commodity worksheets from the New Brunswick Statistics Agency, Fredericton, New Brunswick.

- SUB Subsidies, defined as direct loans or guarantees to sawmills and planing mills. Information collected from: Department of Commerce and Technology, Fredericton, New Brunswick.
- TAR Tariff levied on lumber entering the United States. Data obtained from: "The Tariff Schedules of the U.S.", Annotated, Department of Commerce and Technology, Fredericton, New Brunswick.
- TAX Effective tax rate measured as the ratio of the amount of taxes paid to total taxable income for individual forestry operators. Data provided by: Revenue Canada Taxation, *Taxation Statistics*, "Returns by Province and Occupation for New Brunswick Forestry Operators", Table 9.
- W Wages paid per unit of output, calculated from wages paid by sawmills and planing mills in New Brunswick divided by production of lumber in New Brunswick. See: Statistics Canada, *Annual Census of Manufacturers, Sawmills and Planing Mills and Shingle Mills*, Ref. No. 35-204.