

# Competitiveness in the Sawmills and Wood Preservation Industry in the United States and Canada

Rao V. Nagubadi and Daowei Zhang

**Abstract:** We examine relative prices, relative productivity levels, and competitiveness in the sawmills and wood preservation industry in the United States and Canada between 1958 and 2003 by using purchasing power parities and bilateral translog production function. Our results show that the competitiveness of the Canadian industry is facilitated by higher relative productivity levels and depreciation of the Canadian dollar relative to the US dollar on both inputs and outputs in earlier periods, and only due to depreciation of the Canadian dollar in later periods. The average annual rate of productivity growth was higher for the US industry. Although Canadian relative productivity levels were higher before 1994, the US industry's relative productivity level eventually surpassed the Canadian industry. *FOR. SCI.* 52(4):340–352.

**Key Words:** Relative prices, relative productivity levels, technical change, gap in technology, bilateral translog production function.

RESEARCHERS HAVE USED THE TERM “competitiveness” in different ways, such as comparative advantage, technical efficiency, productivity, or broad economic performance of countries. The President’s Commission on Industrial Competitiveness (1985) of the United States defines competitiveness as “the degree to which a country can, under free and fair market conditions, produce goods and services that meet the test of international markets while simultaneously maintaining and expanding the real incomes of its citizens.” Similarly, Porter (1990) defines it as the capacity to increase the real income by producing high-value products and services that meet the test of world markets. In other words, competitiveness means a good has a higher value than competing goods or it is produced at a lower cost and sold at an international price.

Lower cost comes from two sources: reduced cost of inputs and increased technical efficiency of transforming inputs to outputs. The importance of cost of inputs is obvious—any cost advantage would lead to competitiveness. In the long term, competitiveness of an industry in a country is determined by the technical efficiency. Productivity, defined as the ratio of output to input, is a measure of technical efficiency in production and a major source of competitiveness. For example, Choudhri and Schembri (2002) found that relative productivity ratio and the extent of trade liberalization have been important determinants of relative shares of Canadian firms in both Canadian and US markets. Thus, productivity growth plays an important role in the competitiveness of an industry over time. However, in the short term, competitiveness is influenced by fluctuations in the exchange rate that affect the value and cost of a good in the international markets.

This article addresses the issue of competitiveness in sawmills and wood preservation industry in the United States and Canada. The industry is relatively more important for Canada, as evidenced by its 2.06% share of the total manufacturing value of shipments compared to 0.67% for the United States in 2003. Between 1958 and 2003, the nominal value of shipments for the industry grew from US\$2.67 to US\$26.68 billion in the United States, while value added increased from US\$1.08 to US\$8.40 billion in the period. The rise of industry output was faster in Canada, growing from US\$0.55 to US\$11.27 billion in shipments and US\$0.24 to US\$3.55 billion in value added.

Earlier, regional studies suggested that total factor productivity growth in the Canadian sawmills industry was lagging behind its United States counterpart. For example, Abt et al. (1994) estimated that the total factor productivity (TFP) for the sawmilling industry in the United States’ western and southern regions grew at 1.6% and 1.3% per year, respectively, but –0.1% in the British Columbia (BC) coast and around 1.3% in other regions of Canada between 1965 and 1988. However, Buongiorno et al. (1988), Kaiser (1984), McCarl and Haynes (1985), and Adams et al. (1986) indicated that exchange rates influenced the imports and the share, thus competitiveness, of Canadian softwood lumber in the United States. Constantino and Haley (1989) concluded that higher wood quality in the Pacific Northwest (PNW) explained the higher sawmilling productivity levels in the region, but when wood quality differences were taken into account, British Columbia industry was 10% more efficient on average than the PNW industry between 1957 and 1982.

Furthermore, some US lumber producers alleged that

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material (mainly timber) input prices in Canada are lower than in the United States as Canadian softwood lumber producers have access to subsidized stumpage. Canadian producers disputed the allegation and claimed that its success in the American market reflected its competitiveness[1]. Although this article covers an industry that is much broader than softwood lumber, the results may have some implications in the lumber dispute.

Jorgenson and Nishimizu (1978) provide a theoretical framework for productivity comparisons between countries based on a bilateral translog production function. This framework has since been used by Jorgenson et al. (1987), Jorgenson and Kuroda (1990), Kuroda and Nomura (1999), and Lee and Tang (2002), among others, in assessing competitiveness at a national or industrial level. According to these studies, relative total factor productivity levels can be assumed to reflect differences in technology levels and thus influence competitiveness of industries between countries.

In this study we examine the relative competitiveness of the sawmills and wood preservation industry in the United States and Canada by estimating relative prices using purchasing power parities for outputs and inputs, relative levels of productivity, and annual rates of technical change using the Jorgenson and Nishimizu (1978) framework. We find that the Canadian lumber producers' competitiveness argument stems mainly from higher relative productivity levels in the Canadian industry in the earlier periods and exchange rate depreciation of the Canadian dollar in the later periods, and not due to higher productivity growth of the Canadian industry. The next section presents the methodology used in this study, followed by data and results in subsequent sections. The final section draws some conclusions.

## Methodology

### *Purchasing Power Parities and Relative Prices*

Purchasing power parity (PPP) is a theory of exchange rates whereby a unit of any given currency should be able to buy the same quantity of goods and services in all countries. PPP is a way of comparing average costs of goods and services between countries. In this article we follow Jorgenson and Kuroda's (1990) methodology in estimating PPP, which is based on linking time-series data on prices in two countries. Suppose  $q_i(\text{Canada})$  and  $q_i(\text{US})$  are the prices of each individual output or input of an  $i$ th industry in Canada and the United States in the base period in Canadian and US dollars, respectively. We define PPP for an output or input of an  $i$ th industry in the base period, say  $PPP_i(0)$ , as

$$PPP_i(0) = \frac{q_i(\text{Canada}, 0)}{q_i(\text{US}, 0)}. \quad (1)$$

The  $PPP_i(0)$  is the number of Canadian dollars required in Canada to purchase an amount of an output or input of the industry costing one dollar in the United States in the base period.

To estimate PPP for all outputs or inputs in the US industry, we first construct a time series of prices in domes-

tic currency. Price indexes for industry outputs or inputs in the United States are then obtained by normalizing the price, say  $q_i(\text{US}, T)$ , at unity in the base period. The corresponding price index for Canada,  $q_i(\text{Canada}, T)$ , is generated in the same fashion. Finally, we obtain estimates of PPP for all years, say  $PPP_i(T)$ , from these price indexes and  $PPP_i(0)$  for the base period from the equation

$$PPP_i(T) = PPP_i(0) \frac{q_i(\text{Canada}, T) q_i(\text{US}, 0)}{q_i(\text{Canada}, 0) q_i(\text{US}, T)}, \quad (2)$$

where  $PPP_i(0)$  is the PPP in the base period and  $q_i(\text{Canada}, 0)$  and  $q_i(\text{US}, 0)$  are the prices of the outputs or inputs in the  $i$ th industry in Canada and the United States in the base period.

The relative price of an output or input of an industry in Canada and the United States in US dollars, say  $p_i(\text{Canada}, \text{US}, T)$ , is defined as the ratio of the PPP for that output or input to the Canadian-to-US dollar exchange rate,  $E(T)$ ,

$$p_i(\text{Canada}, \text{US}, T) = \frac{PPP_i(T)}{E(T)}. \quad (3)$$

The relative price of output or input in Canada and the United States is the ratio of number of US\$ required in Canada to purchase an amount of the output or input costing one US\$ in the United States. This index is the measure of international competitiveness between Canadian industry and its US counterpart. This relative price was used as an indicator of competitiveness to assess international competitiveness by Jorgenson and Kuroda (1990) between Japan and the United States, and Lee and Tang (2002) between Canada and the United States. Using Equations 1–3, we construct relative prices for six outputs and four inputs for the industry in both countries.

### *Relative Productivity Levels*

Following Jorgenson and Nishimizu (1978) and Jorgenson and Kuroda (1990), the bilateral translog production function for sawmills and wood preservation industry in the two countries can be written as

$$\begin{aligned} \ln Q = & \alpha_0 + \sum_i \alpha_i \ln X_i + \alpha_T T + \alpha_D D \\ & + \frac{1}{2} \sum_i \sum_j \beta_{ij} \ln X_i \ln X_j \\ & + \sum_i \beta_{iT} \ln X_i T \\ & + \sum_i \beta_{iD} \ln X_i D + \frac{1}{2} \beta_{TT} T^2 \\ & + \beta_{TD} TD + \frac{1}{2} \beta_{DD} D^2, \end{aligned} \quad (4)$$

where  $\ln Q$  is the logarithm of output;  $\ln X_i$  are the logarithms of input quantities;  $i, j = \text{L (labor), K (capital), E (energy), and M (materials)}$ ;  $D$  is a dummy variable (equal to 1 for the United States, and 0 for Canada);  $T$  is the index of time; and  $\alpha$  and  $\beta$  are the coefficients. The above bilateral translog production function is characterized by constant

returns to scale. At the industry level, constant returns to scale are reasonable assumptions for both countries (Stier 1980, Martinello 1987). The industry is also close to competitive market conditions in the United States and Canada (Murray 1995).

Necessary conditions for producer equilibrium are given by equalities between the value share of an input and the corresponding elasticity of output with respect to that particular input. The value (compensation) shares of inputs,  $v_i$ , in the industry are equal to the logarithmic derivatives of the production function with respect to logarithms of input quantities:

$$v_i = \frac{\partial \ln Q}{\partial \ln X_i} = \alpha_i + \sum_j \beta_{ij} \ln X_j + \beta_{iT} T + \beta_{iD} D. \quad (5)$$

Under constant returns to scale, the elasticities and the value shares sum to unity.

The rate of technical change or productivity growth,  $v_T$ , the derivative of the production function with respect to time holding all inputs and country dummy variables constant, is defined as the rate of growth of output with respect to time:

$$v_T = \frac{\partial \ln Q}{\partial T} = \alpha_T + \sum_i \beta_{iT} \ln X_i + \beta_{TD} D + \beta_{TT} T. \quad (6)$$

The difference in technology in the industry between two countries,  $v_D$ , the derivative of the production function with respect to the country dummy variable holding all inputs and time constant, is defined as the logarithmic difference between levels of output between the countries:

$$v_D = \frac{\partial \ln Q}{\partial D} = \alpha_D + \sum_i \beta_{iD} \ln X_i + \beta_{TD} T + \beta_{DD} D. \quad (7)$$

Based on the production function (Equation 4), Jorgenson and Nishimizu (1978) show that the average productivity growth,  $\bar{v}_T$ , between two points of time  $T$  and  $T - 1$ , can be expressed as the translog index of the difference between the weighted average growth rates of  $j$  outputs and the weighted average growth rate of  $i$  inputs for an industry:

$$\begin{aligned} \bar{v}_T = & \sum_j \bar{v}_j [\ln Q_j(T) - \ln Q_j(T - 1)] \\ & - \sum_i \bar{v}_i [\ln X_i(T) - \ln X_i(T - 1)], \end{aligned} \quad (8)$$

where  $\bar{v}_T$  is the average rate of technical change between two periods  $T$  and  $T - 1$  given by

$$\bar{v}_T = 1/2[v_T(T) + v_T(T - 1)]. \quad (8a)$$

The weights,  $\bar{v}_j$ , are average of the revenue shares of outputs in the years  $T$  and  $T - 1$ , given by

$$\bar{v}_j = 1/2[v_j(T) + v_j(T - 1)], \quad (8b)$$

where  $v_j = P_{Q_j} Q_j / \sum_j P_{Q_j} Q_j$  are revenue shares,  $P_{Q_j}$  are prices of outputs, and  $Q_j$  are quantities of outputs (softwood lumber, hardwood lumber, wood chips, wood preservation products, wood-ties-shingles-shakes, and other products). The weights,  $\bar{v}_i$ , are the average value (compensation)

shares of inputs in the years  $T$  and  $T - 1$ , given by

$$\bar{v}_i = 1/2[v_i(T) + v_i(T - 1)], \quad (8c)$$

where  $v_i = P_{X_i} X_i / \sum_j P_{Q_j} Q_j$  are value (compensation) shares,  $P_{X_i}$  are prices of inputs, and  $X_i$  are quantities of inputs (L, K, E, and M). Equation 8 for the average rate of technical change,  $\bar{v}_T$ , is the translog index of technical change or rate of productivity growth for the respective countries. According to Diewert (1976) the translog index numbers are exact for the translog production function developed by Christensen et al. (1971, 1973). Furthermore, the continuous translog index of productivity growth can be approximated by discrete-time Tornqvist-Theil index.

Similarly, the average of the differences in the logarithms of the productivity levels between two countries,  $\hat{v}_D$ , can be expressed as the translog index of the weighted average of difference between logarithms of outputs minus a weighted average of difference between logarithms of inputs of the two countries:

$$\begin{aligned} \hat{v}_D = & \sum_j \hat{v}_j [\ln Q_j(\text{US}) - \ln Q_j(\text{Canada})] \\ & - \sum_i \hat{v}_i [\ln X_i(\text{US}) - \ln X_i(\text{Canada})], \end{aligned} \quad (9)$$

where  $\hat{v}_D$  is the average difference in productivity given by

$$\hat{v}_D = 1/2[v_D(\text{US}) + v_D(\text{Canada})], \quad (9a)$$

the weights,  $\hat{v}_j$ , are the average revenue shares of outputs for Canada and the United States, given by

$$\hat{v}_j = 1/2[v_j(\text{US}) + v_j(\text{Canada})], \quad (9b)$$

and the weights  $\hat{v}_i$  are the average value shares for Canada and the United States, given by

$$\hat{v}_i = 1/2[v_i(\text{US}) + v_i(\text{Canada})]. \quad (9c)$$

Equation 9 for the average difference in technology is referred to as the translog index of difference in technology or difference in productivity, which can also be approximated by a discrete-time Tornqvist-Theil index. In this study we use industry data to compute equations 8 and 9.

## Data

The industries included in this study for the United States are North American Industry Classification System (NAICS) codes 321113 (sawmills) and 321114 (wood preservation) [2]. Before 1997, these industries are listed under Standard Industrial Classification (SIC) codes 2421 (sawmills and planing mills), 2429 (special products sawmills), and 2491 (wood preserving). The data sources for the United States are the Annual Survey of Manufactures (ASM), and Census of Manufacturing (CM).

The corresponding industries for Canada are listed as NAICS 321111 (sawmills—except shingle and shake mills), 321112 (shingle and shake mills), and 321114 (wood preservation) [3]. Before 1997, these are listed under SIC 2512/2513 (sawmills and planing mill products), 2511

(shingle and shake mills), and 2591 (wood preservation). The data sources for Canada are Annual Census of Manufactures (ACM) and Statistics Canada publications Catalogues 35-204, 35-250, and CANSIM-II (CANadian Socio-economic Information Management system-II).

The Appendix provides details of data construction for quantities and prices of inputs and outputs for both countries. The quantities for six outputs, softwood lumber, hardwood lumber, wood chips, wood preservation products, wood-ties-shingles-shakes, and other products are imputed from the value of shipments using prices constructed from available quantities and values [4].

The unit for labor input is the hours worked. The capital stock is converted to constant 2001 dollars in their respective currencies using GDP deflators. The units for energy are British thermal units (Btu), and material inputs are in thousand board feet (mbf). Material inputs include nonwood materials such as chemicals and contract work and are represented as wood-material equivalent quantities by dividing the expenditure on nonwood materials with the wood material prices. Wherever data are unavailable, suitable interpolations are made to fill in the gaps. The average value (compensation) shares for labor, energy, and material inputs are estimated as the shares of respective input expenditures in the total revenue. The compensation for capital is derived by subtracting the compensation for labor, energy, and materials from the total revenue. The service price of capital is estimated by dividing the compensation for capital by the total capital stock.

## Results and Discussion

### *Relative Output and Input Prices*

Figure 1 shows the relative prices for Canada (US = 1), estimated from Equation 3, for all outputs in the industry along with annual average exchange rates in Canadian dollars for one US dollar over the period 1958–2003 (Federal Reserve Board, St. Louis, MO. <http://research.stlouisfed.org/fred2/series/DEXCAUS/94/Max>, accessed March 2005). The relative prices for softwood lumber and wood preservation products were lower in Canada than in the United States and declined gradually, except for brief periods, in accordance with the depreciation of the Canadian dollar. Softwood lumber prices started on nearly equal footing in 1958, but declined to 63% of the US softwood lumber price in 2003. The dominating influence of exchange rate is evident in relative prices for softwood lumber of the Canadian industry. Before 1973, the exchange rates and relative prices were relatively flat, reflecting the fixed exchange rate regime implemented at that time. As the Canadian dollar depreciated from 1973 to 1987, the relative price for softwood lumber declined. These relative prices increased between 1987 and 1991 and began on a declining trend mostly after 1992. However, Canadian prices of hardwood lumber, wood chips, and wood-ties-shingles-shakes increased from 84, 101, and 134% of the US prices in 1958 to 91, 124, and 151% in 2003.

Figure 2 presents the relative prices for inputs in the Canadian industry. The relative prices for labor in Canada were 89% of the US labor price in 1958, but gradually

increased until 1973. Canadian labor prices were above the US labor prices between 1974 and 1997 before declining to 90% of the US labor price in 2003. The relative service price for Canadian capital declined from 111% in 1958 to 37% of the US service price for capital in 1970, and then fluctuated and surpassed the US price after 1998. The relative prices for energy were higher in Canada than in the United States before 1976 and declined to 94% of the US energy price by 2003.

The relative material prices in the Canadian industry were equal to or higher than those in the United States between 1958 and 1968, and then fluctuated in the next 20 years in accordance with the swings in the exchange rate. After 1990, Canadian material prices dramatically declined to reach 56% of the US prices in 2003, under the impact of a 35% appreciation of US dollar relative to the Canadian dollar. However, we observe caution in interpreting these results as the material prices for the industry in the two countries were not estimated using the same criteria (see Appendix).

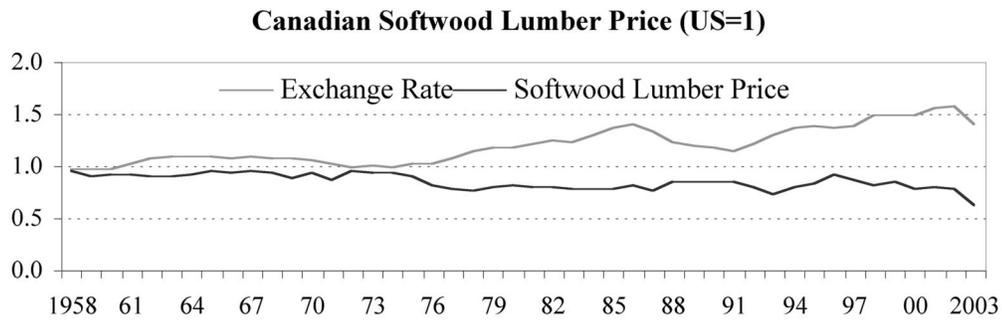
### *Relative Productivity Levels*

The average rates of technical change, estimated from Equations 8, for the industry in both countries reveal that the US industry experienced positive technical change in 26 of 45 years, as opposed to 24 years of positive technical change for the Canadian industry (Figure 3). More importantly, the overall productivity in the US industry grew at an annual compound rate of 1.15% as opposed to 0.68% in the Canadian industry [5]. In particular, large differences in annual rates of productivity growth between the United States and Canadian industries after 1993 led to the widening of gap in the productivity growth.

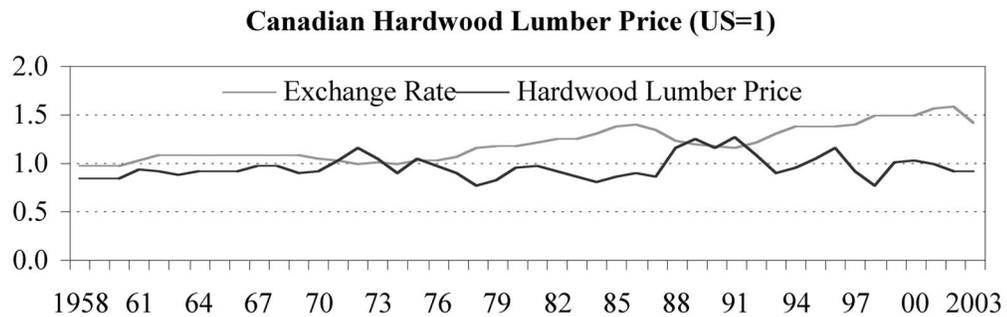
The trend of difference or proportional gap in relative productivity levels in the industry for both countries, as estimated from Equations 9, is shown Figure 4. Before 1994, the relative productivity or technology level in the US industry was mostly below that of the Canadian industry. Between 1958 and 1994, on average, the productivity level of the US industry was 11% lower than that of the Canadian industry. However, due to sustained productivity growth over time, the productivity level of the US industry overtook that of the Canadian industry in the subsequent period. As a result, the productivity level of the US industry between 1995 and 2003 was, on average, nearly 10% higher than that of the Canadian industry.

To understand the contribution of the differences in technology and inputs to the differences in industry output between the United States and Canada, we provide the logarithmic differences in outputs between the United States and Canada and the percentage contributions due to the differences in the technology and input quantities (Table 1). These contributions are obtained by rearranging Equations 9. Each of these contributions is defined as the ratio of respective logarithmic differences in technology and input quantities between the United States and Canada to the logarithmic difference in output quantities between the

(a) Softwood Lumber:



(b) Hardwood Lumber:



(c) Woodchips:

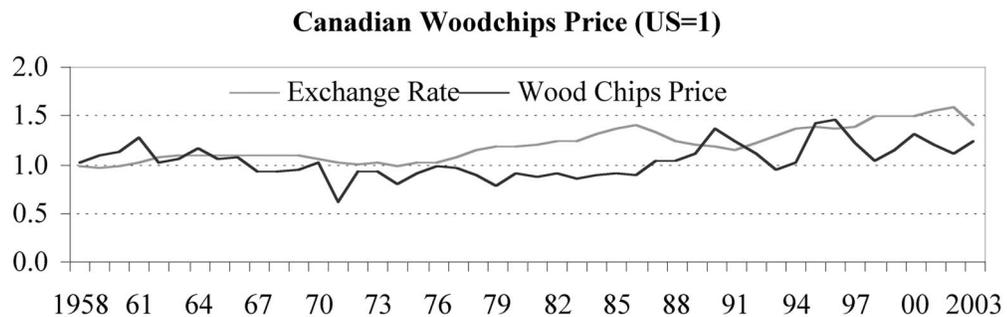


Figure 1. Relative prices of Canadian outputs in the sawmills and wood preservation industry (NAICS 3211).

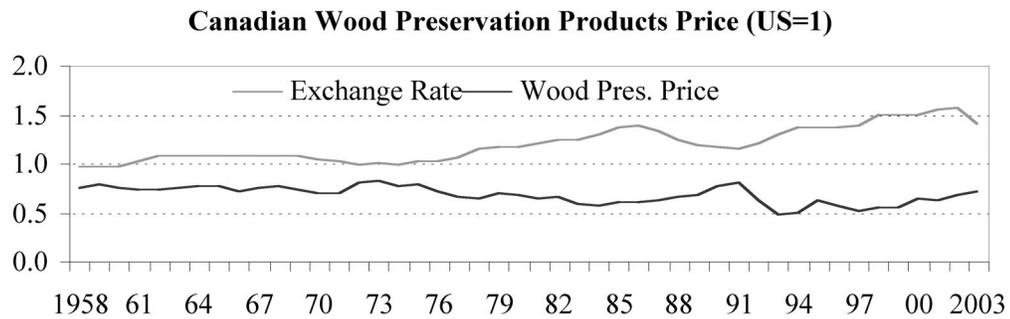
United States and Canada. Column 2 shows that the logarithmic difference in the industry output between the United States and Canada over the period declined steadily from 1.50 to 0.41.

The difference in industry output between the two countries could be attributed to differences in lower relative productivity or technology level (-12%) in the United States during the period 1958-94. However, the contribution to difference in the industry output could be attributed to higher relative productivity or technology level (16%) of the US industry over the Canadian industry during the

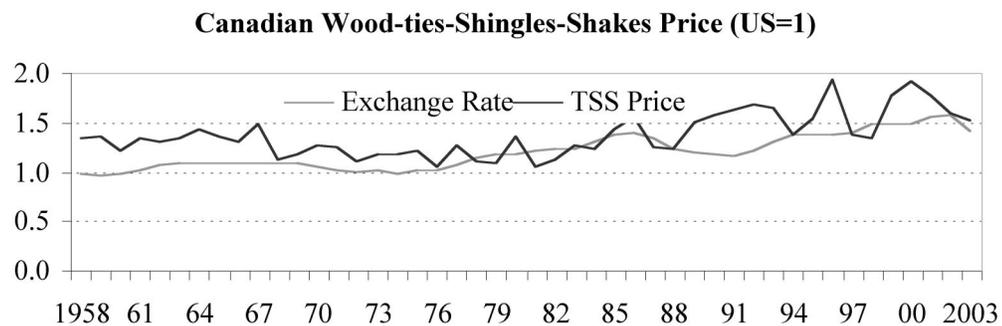
period 1995-2003. The higher productivity level in the Canadian industry compared to the US industry before 1995, shown in this analysis, is in line with the observations of Constantino and Haley (1989) mentioned earlier in this article. After 1995, however, it may not be true anymore.

Among the inputs, difference in material inputs accounted for 59% of the difference in outputs between the two countries during 1958-94, but only for 38% during 1995-2003. This may indicate that the differences in the quality of the timber resource between the two countries may be declining steadily. Likewise, the difference in labor

(d) Wood Preservation Products:



(e) Wood-ties-shingles-shakes:



(f) Other Products:

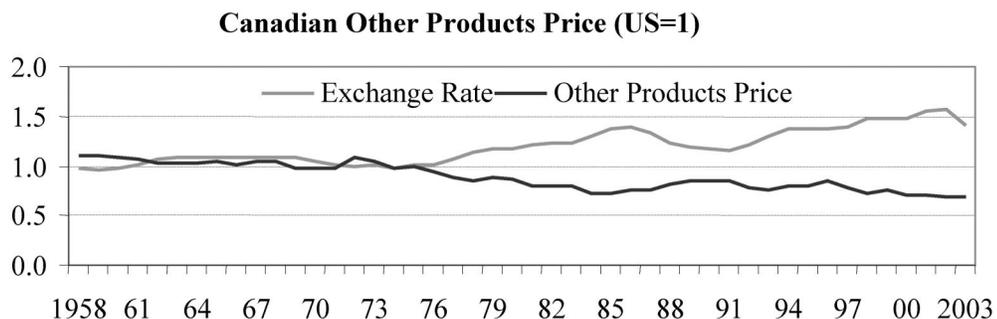


Fig. 1. Continued

and capital inputs, contributed 25% each to the difference in industry output between the two countries during 1958–94. During 1995–2003, the contribution of difference in labor input declined to 19%, while that of energy declined from 3% in the earlier period to 2% in the later period. However, the contribution of differences in capital input increased slightly from 23% to 26%.

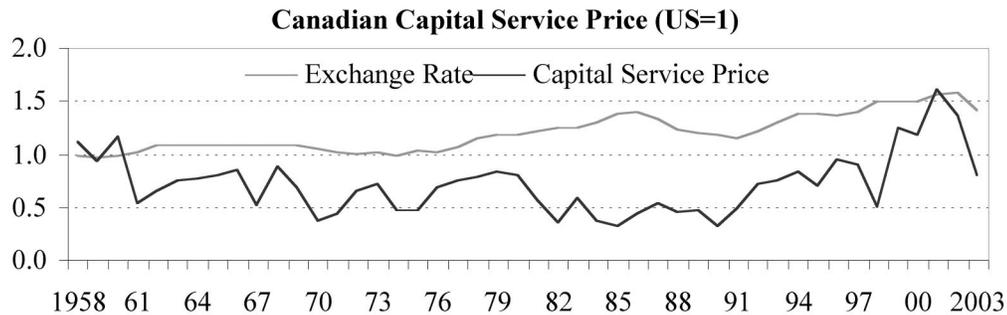
Although the relative productivity levels in Canada were higher before 1994, the productivity growth in the Canadian industry was always lagging behind that of the US industry, as evident from Figure 3. The major reason for the Canadian

industry's lagging productivity growth lies in the lagging capital formation in the Canadian industry. The total capital stock, in 2001 constant US dollars per worker, increased more than double from \$40,279 to \$109,749 in the US industry compared to an increase from \$26,904 to \$48,925 in the Canadian industry for the period 1958 and 2003. Over the same period, the capital stock, in 2001 constant US dollars per mbf of material input handled, increased from \$209 to \$245 in the United States but declined from \$158 to \$76 in Canada. During the same period, the value of shipments in 2001 constant US dollars increased by 79% from

(a) Labor Wages:



(b) Capital Service Price:



(c) Energy Price:

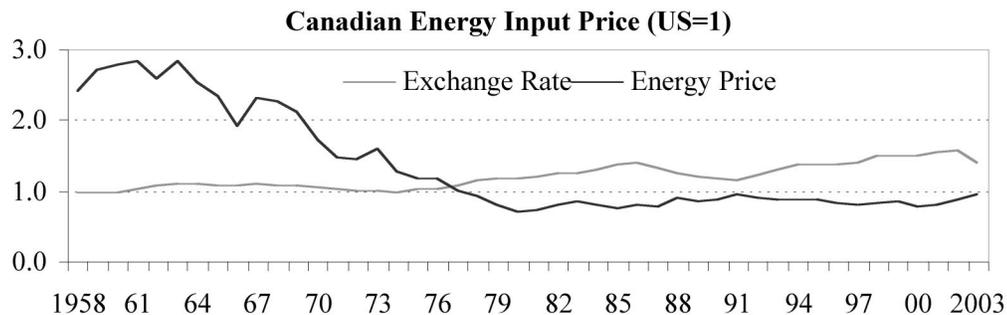


Figure 2. Relative prices of inputs for the Canadian sawmills and wood preservation industry (NAICS 3211).

\$13.7 to \$24.5 billion for the industry in the United States, whereas it increased by 219% from \$3.4 to \$10.8 billion for the Canadian industry.

The productivity advantage of the Canadian industry appears to be declining as the source of Canada's comparative advantage is waning, which is consistent with the observation by Binkley (1995). Before 1994, the Canadian industry held its competitiveness due to higher levels of productivity and lower relative prices of inputs and outputs induced by the depreciation of the Canadian dollar. However, with a declining productivity advantage, the Canadian

industry has to rely solely on the depreciation of its dollar after 1994. This could have disastrous consequences for the Canadian industry if the Canadian dollar gains strength relative to the US dollar. In fact, the share of other countries in the US market is increasing at the expense of Canada (Turner et al. 2005).

This result is largely consistent with Pearse (2001), who reported that low returns on capital had deterred investment in Canada. For the Canadian industry to maintain its competitiveness, it needs to increase productivity growth through reductions in the total costs of inputs or through

(d) Material Input Price:

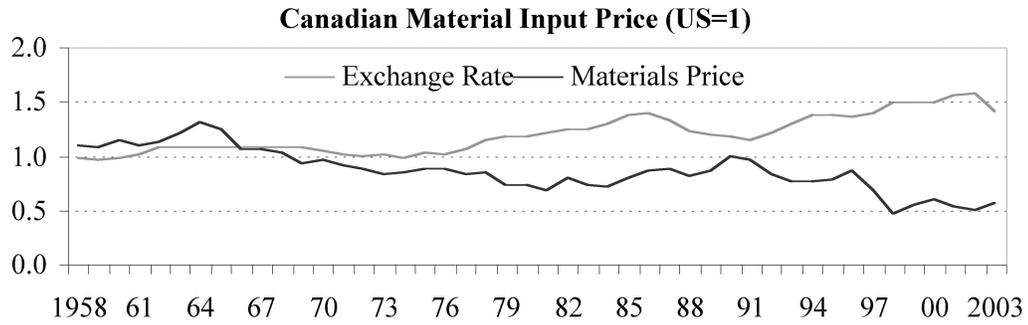


Fig. 2. Continued

increases in the value of outputs. Binkley (1993, 1995) pointed out that a transformation of the Canadian forest industry from a resource-based to a knowledge-based sector is an economic, social, and political necessity and calls for increased investment in research and development in the Canadian forest industry.

### Conclusions

This article examines competitiveness in sawmills and the wood preservation industry (NAICS 3211) between the

United States and Canada using relative prices and relative productivity levels. The results indicate that, initially, the competitiveness of the Canadian industry over its counterpart in the United States is facilitated by its higher relative productivity levels. However, this advantage is disappearing as higher productivity growth in the US industry is leading toward higher relative productivity levels over the Canadian industry. A limitation of this study is that it has not taken into consideration the differences in quality composition of various lumber and lumber-related products.



Figure 3. Total factor productivity growth (Törnqvist-Theil) indexes for NAICS 3211 in the United States and Canada (1958 = 1).

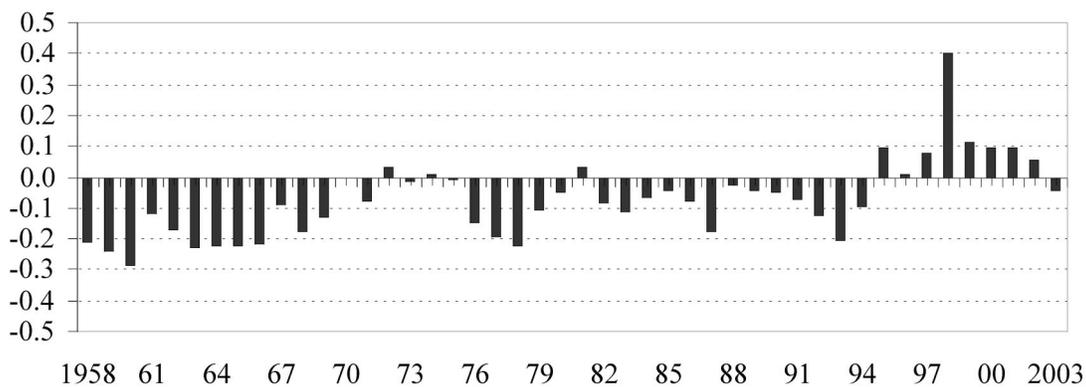


Figure 4. Proportional gap in technology for NAICS 3211 between the United States and Canada.

**Table 1. Contributions due to differences in technology and inputs to the logarithmic difference of output in NAICS 3211 between the United States and Canada, 1958–2003**

Year	Logarithmic differences in output between US and Canada	Percentage contribution due to differences in				
		Gap (US–Canada) in technology ( $\hat{v}_D$ )	Labor input	Capital input	Energy input	Materials input
1958	1.5020	-0.14	0.27	0.23	0.04	0.61
1959	1.5122	-0.16	0.26	0.25	0.04	0.61
1960	1.4258	-0.20	0.29	0.22	0.04	0.65
1961	1.3642	-0.08	0.28	0.16	0.05	0.60
1962	1.3118	-0.13	0.27	0.19	0.05	0.62
1963	1.2756	-0.18	0.25	0.23	0.05	0.64
1964	1.2616	-0.18	0.25	0.24	0.04	0.64
1965	1.2041	-0.19	0.25	0.25	0.04	0.64
1966	1.1218	-0.19	0.27	0.31	0.04	0.58
1967	1.2331	-0.07	0.24	0.24	0.04	0.56
1968	1.1241	-0.15	0.23	0.35	0.04	0.53
1969	1.0566	-0.12	0.24	0.31	0.04	0.54
1970	1.1070	0.00	0.28	0.18	0.04	0.51
1971	0.9619	-0.08	0.28	0.25	0.04	0.51
1972	1.0708	0.03	0.20	0.27	0.02	0.48
1973	0.9056	-0.01	0.20	0.36	0.02	0.43
1974	0.9358	0.01	0.25	0.24	0.03	0.47
1975	0.9971	-0.01	0.26	0.19	0.03	0.52
1976	0.8028	-0.18	0.28	0.29	0.03	0.59
1977	0.7911	-0.24	0.27	0.32	0.02	0.63
1978	0.7250	-0.31	0.24	0.39	0.03	0.66
1979	0.7011	-0.15	0.26	0.36	0.02	0.51
1980	0.7052	-0.07	0.26	0.27	0.02	0.52
1981	0.7546	0.04	0.28	0.17	0.02	0.49
1982	0.7338	-0.11	0.28	0.15	0.02	0.66
1983	0.5889	-0.19	0.30	0.27	0.03	0.59
1984	0.6293	-0.11	0.28	0.24	0.02	0.56
1985	0.6621	-0.07	0.25	0.19	0.02	0.61
1986	0.7311	-0.11	0.23	0.23	0.03	0.62
1987	0.6151	-0.29	0.27	0.30	0.02	0.70
1988	0.6609	-0.04	0.25	0.22	0.02	0.55
1989	0.6530	-0.07	0.24	0.22	0.02	0.59
1990	0.7746	-0.06	0.23	0.13	0.02	0.69
1991	0.7692	-0.09	0.23	0.16	0.02	0.68
1992	0.6803	-0.18	0.25	0.26	0.02	0.65
1993	0.5684	-0.36	0.26	0.33	0.03	0.75
1994	0.6182	-0.16	0.20	0.28	0.02	0.65
1995	0.7291	0.13	0.17	0.16	0.02	0.52
1996	0.6939	0.01	0.16	0.21	0.01	0.60
1997	0.6195	0.13	0.17	0.21	0.01	0.48
1998	0.6590	0.61	0.17	0.13	0.02	0.07
1999	0.5780	0.20	0.17	0.29	0.02	0.31
2000	0.5728	0.16	0.18	0.25	0.01	0.39
2001	0.5681	0.16	0.20	0.29	0.02	0.32
2002	0.4613	0.12	0.21	0.38	0.02	0.27
2003	0.4100	-0.11	0.26	0.40	0.03	0.42

Note: The numbers in the last five columns add up to 100 percent.

Relative prices for the industry's major outputs, softwood lumber and wood preservation products, were lower in Canada relative to the United States throughout the study period under the impact of depreciation of the Canadian dollar relative to the US dollar. Relative prices of materials, capital, and energy inputs were also lower for the same reason. Competitiveness of the Canadian industry might have been facilitated by both lower relative prices and higher relative productivity levels over the US industry in the earlier periods.

However, after 1994, the US industry's relative productivity levels exceeded those of the Canadian industry. In other words, the Canadian industry's relative productivity levels are declining. Consequently, its competitiveness is also declining. Since 1995, the Canadian industry's competitiveness relied predominantly on the declining value of the Canadian dollar relative to the US dollar. If the value of the Canadian dollar relative to the US dollar increases (which has happened recently), the Canadian industry could be hurt. To remain competitive, the Canadian industry needs

long-term measures for increasing its productivity growth. These measures could include transforming a resource-based forest industry into a knowledge-based forest industry (Binkley 1993), increasing capital intensity, promoting higher value-added products, and enhancing innovations through intensified research and development activities.

## Endnotes

- [1] For instance, Bob Rae, legal counsel and leading lobbyist for Canadian lumber producers remarked, "It is about price and market share and competitiveness. . . . We have more wood, our cost of production is lower, and our productivity is higher than in the U.S. . . . and that is our competitive advantage" (The Gazette 2003).
- [2] We have chosen to aggregate these two industries since the wood preservation industry also produces lumber that is chemically treated and used mainly in outdoor applications (Nagubadi et al. 2004).
- [3] There is a slight difference in the NAICS codes for the industry. Canada preferred to have two codes separately for sawmills and planing mills (321111) and shingle and shake mills (321112), while in the United States this industry is represented as one group (321113).
- [4] For example, there are 7 and 5 subcomponents in softwood lumber under the two classification systems before and after 1997. For two subcomponents after 1997, their values of shipment are available but not quantities. So the weighted price for softwood lumber after 1997 is computed using only the three subcomponents for which both value and quantity data are available.
- [5] Annual compound rates of productivity growth are estimated using the equation  $\ln Y_t = a + b * T + u$ , where  $\ln Y_t$  is the natural logarithm of productivity growth index at time  $t$ ,  $T$  is time in years,  $a$  and  $b$  are coefficients, and  $u$  is random error; from this equation the annualized growth rates are computed using the formula  $(e^b - 1) * 100$ .

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## Appendix

### *NAICS and SIC Data Bridge, United States*

A bridge between Standard Industrial Classification (SIC) and North American Industry Classification System (NAICS) based on value of shipments (84% of SIC 2421—sawmills and planing mills, 21% of SIC 2429—special product mills, and all of SIC 2491—wood preserving) in 1997 was applied. The data were assembled from Census of Manufacturing (CM) and Annual Survey of Manufactures (ASM) of the United States.

### *Output Quantities and Prices*

#### *Softwood Lumber*

Data for value of shipments (VOS) were 84% of VOS for SIC 24212, 24217, and 24218 for 1958–96, and NAICS 3211133 for 1997–2003. A weighted average price (\$/mbf) was constructed for the years 1958–96 using production in nine regions as weights, and prices for seven regions obtained from Darius Adams (personal communication, Department of Forestry, Oregon State University, Corvallis, OR; Nov. 2003). For the years 1997–2003, price series were extended using percentage changes in producer price index (PPI) for softwood lumber. The quantity of softwood lumber production was imputed by dividing the VOS for softwood lumber with the weighted average price for softwood lumber.

#### *Hardwood Lumber*

The data on VOS were for SIC 24211 for 1958–96 and NAICS 3211131 for 1997–2003. Weighted average prices for hardwood lumber (\$/mbf) for 1958–2003 were developed using details of species proportion and lumber grade composition within species obtained from Luppold (personal communication, USDA Forest Service, Northeastern Research Station, Princeton, WV; Nov. 2003). The quantity of hardwood lumber production was imputed by dividing the VOS for hardwood lumber with the weighted average prices for hardwood lumber.

#### *Wood Chips*

The output of wood chips was derived by dividing the VOS for SIC code 24215 for 1958–96 and NAICS code 3211135 for 1997–2003 with price series for wood chips constructed for the purpose. Data on value of shipments for 1959–62 and 1964–66 were interpolated using compound growth rates. Prices (\$/bone-dry ton) for wood chips for

1958–80 were from Adams et al. (1988). For 1981–82, percentage changes in average prices of wood chips and residues for the southcentral and southeast regions, and for 1983–2003 percentage changes in PPI for wood chips were used.

### *Wood-Ties-Shingles-Shakes*

This product group was listed under SIC 2429 for 1958–96 and NAICS 3211137 for 1997–2003. Prices of western redcedar for shingles (5X, #2) products (\$/square) from Random Lengths (various years) were used for years 1961–2003 and for 1958–60 prices were imputed using percentage changes in PPI for lumber, and these prices were used for deriving output quantities from value of shipments.

### *Wood Preservation Products*

The shipment values were derived from SIC code 2491 for 1958–96 and NAICS code 321114 for 1997–2003. Prices reported for Treated Southern Yellow Pine for 2 × 4-12' lumber by Random Lengths were used for years 1989–2003, and for the remaining years prices were derived using percentage changes in PPI for Southern Pine dressed lumber. The output quantities were implicitly derived using this price series.

### *Other Sawmill Products*

These are nsk (not specified by kind) under SIC 24219 and 24210 for 1958–96, and NAICS 321113W for 1997–2003. The prices were constructed using 2003 prices of lumber framing composite (Random Lengths) and working backward to 1958 by percentage changes in the PPI for lumber. Implicit quantities of output were developed using value of shipments and price series constructed for this purpose. Since shipment values for the period 1959–62 were unavailable, the values were linearly interpolated.

### *Input Quantities and Prices*

#### *Labor*

The labor input was represented as person-hours worked available from CM and ASM. The total compensation includes payroll and fringe benefits (Social Security, other legally required payments, and employer payments). For the years 1958–66 data on fringe benefits were not available. Hence, these were imputed by estimating the total compensation by percentage changes in the payroll.

#### *Capital*

We used capital stock data available from the NBER-CES Manufacturing Industry Database (<http://www.nber.org/nberces/nbprod96.htm>, March 2005) developed by the National Bureau of Economic Research and Center for Economic Studies of the US Census Bureau. Data were available separately for machinery and equipment (M&E), and plants and structures (P&S) by SIC codes for the years 1958–96. For 1997–2003, data were obtained by the perpetual inventory

method using 8.33% depreciation for M&E, and 5% depreciation for P&S on the previous year's capital stock and adding the current year's new capital expenditure. These were converted to real 2001 dollars using the GDP deflator for the United States. The compensation for capital was derived by subtracting the compensation for labor, energy, and materials from the total revenue. The service price of capital was estimated by dividing the compensation for capital by the total capital stock.

### *Energy*

The energy cost was assembled from ASM, CM, and the US Census Bureau's publication, "Fuels and Electric Energy Consumed." For missing years (1959–61, 1964–66, and 1968–70) data were linearly interpolated using proportions of energy cost available for upper level 3- or 2-digit SIC codes. The total quantity of energy, in Btu, used in the industry was estimated using appropriate conversion factors for the various fuels and electric power used in the industry, and the price of energy was estimated by dividing the total energy cost with the total quantity of energy (Btu) used in the industry.

### *Materials*

Data reported as cost of materials included the cost of wood, nonwood materials, and purchased fuels and electric power. The cost of materials was derived by subtracting the cost of fuels and electric power. The price of materials could not be estimated from the detailed manufacturing census data for the US industry as there were significant gaps related to information on quantities of materials used, although values of materials used were available. Hence, the price for material inputs was calculated as a weighted Louisiana delivered stumpage prices for pine and oak from Timber-Mart South using softwood and hardwood lumber production as weights (Howard 2003, Norris Foundation 2003). Thus, implicit quantities of wood-equivalent material inputs were derived.

### *NAICS and SIC Data Concordance, Canada*

Data on inputs and outputs were obtained from Catalog 35-204 for 1958 to 1989 and from CANSIM-II for 1990 to 1997 (Statistics Canada). The series was merged using average proportions developed from data reported for the same years 1990–97 under NAICS and SIC classifications. This resulted in downward scaling of all data from 1958 to 1989 by 1.8%.

### *Output Quantities and Prices*

#### *Softwood Lumber*

The quantity of softwood lumber was derived by dividing the total VOS for softwood lumber with softwood lumber price for years 1958–85, 1988–90, and 1992–95. For the years 1986–87, 1991, and 1996–2003, prices were derived using percentage changes in industry selling price

index for softwood lumber and ties and then quantities were imputed from by dividing the VOS with the derived prices. In the absence of figures for VOS for the years 1996 to 2003, the softwood lumber production numbers from Statistics Canada were used, and price series were extended using percentage changes in the industry selling price index for softwood lumber and ties.

#### *Hardwood Lumber*

The quantities for hardwood lumber were imputed using total VOS and prices for hardwood lumber for 1958–84, 1988–90, and 1992–95. Hardwood lumber prices were derived by dividing the VOS shipments and quantities provided by ACM. For the years 1996–2003, data on hardwood lumber production were taken from Statistics Canada. For the years 1985–87, 1991, and 1996–2003, prices were derived using percentage changes in the industry selling price index of hardwood lumber and ties.

#### *Wood Chips*

The quantities for wood chips were taken from the ACM and the prices were derived by dividing the VOS with quantities for the period 1958 to 1992. For the period 1993 to 2003, VOS for wood chips was assumed to be 12% (average of previous five years) of total VOS of entire sawmills and wood preservation industry.

#### *Wood-Ties-Shingles-Shakes*

This product was listed in both sawmills (SIC 2513) and shingle and shake mills (SIC 2511), and a weighted price, using value of shipments as weights, was constructed for 1958–81 and for the remaining period prices were extended by percentage changes in industry selling price index for this group. The quantity of wood-ties-shingles-shakes was imputed by dividing the VOS with the price constructed.

#### *Wood Preservation Products*

The price index for this group of products was derived from the industry selling price index for preserved and treated wood from 1981 to 2003 and extended back to 1958 by percentage changes in the lumber price index. Using this price index and an approximate price for major quantity of wood preservation products in 1984, the entire price series was constructed and used in deriving the output quantity for this group of products.

#### *Other Sawmill Products*

Although this product group consists of several outputs including contract work and miscellaneous products, quantity equivalents were derived by dividing the value of shipments by price series developed for this product group. The price series was developed using the 1958 price of wood preservation product group and then extending forward up to 2003 by percentage changes in the overall lumber price index.

## *Input Quantities and Prices*

### *Labor*

In contrast to the United States data on production workers' compensation, which was "hours worked," the Canadian data were related to "hours paid," which includes paid vacation time. The number of nonproduction employees reported in thousands was used. Since data on supplementary wages and fringe benefits paid to the production workers in the industry were unavailable, compensation was added using percentage of supplementary wages and fringe benefits at the national level.

### *Capital*

Capital stock data were taken from Table 31-0002 (Flows and stocks of fixed nonresidential capital, by NAICS; Canada; 1997 constant prices; Sawmills and wood preservation—3211). These were computed using a straight line method of depreciation, taken from Statistics Canada. Data were converted to 2001 constant dollars using the GDP deflator for Canada. The service price of capital was esti-

mated using a similar procedure adopted for estimating the service price of capital for the United States.

### *Energy*

The cost of purchased fuels and electricity was assembled from Catalogues 35-204 and 35-250, and 57-208 for the years 1958–84. For Canada, data do not include own-generated electricity consumed in the industry. Energy quantities, in Btus, were estimated using appropriate conversion factors for fuels and electric power used in the industry.

### *Materials*

Materials included wood and nonwood materials. Available quantities in mbf and their dollar values were used to determine price. The total quantity of wood material was imputed using this price and the total cost of material inputs. Thus nonwood materials were also reflected as wood-equivalent quantities. The price of materials was extended to 2003 using percentage changes in the raw materials price index for logs and bolts for NAICS 3211.