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Alaska Softwood Market Price Arbitrage

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Abstract

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This study formally tests the hypothesis that markets for Alaska lumber and logs are integrated with those of similar products from the U.S. Pacific Northwest and Canada. The prices from these three supply regions are tested in a common demand market (Japan). Cointegration tests are run on paired log and lumber data. Our results support the conclusion that western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) logs from Alaska share an integrated market with logs produced in the other two regions. Results are less clear for lumber. Given this evidence that markets are at least imperfectly integrated, Alaska production and exports of forest products will continue to be sensitive to international market conditions, including competition from other North American producing regions.

Keywords: Arbitrage, markets, cointegration, Alaska, softwood, prices.

Summary

In order to be effective, policies promoting industrial utilization of the forests of south-east Alaska require information on potential markets for products and, specifically, the degree to which Alaska products may be able to retain market share while commanding higher prices. Higher prices relative to competitors are needed by Alaska producers in order to compensate for higher operation costs that, among other factors, result from more difficult operation conditions (such as steep slopes and island geography), and diseconomies of small scale. Although the assumption that Alaska timber is uniquely valuable has been a long-standing premise of timber policies, this argument took on greater importance with the closure of the region's two pulp mills (in the mid-to late-1990s) and as competition in commodity-oriented markets increased. This study examines the degree to which Alaska logs and lumber have close substitutes—and therefore face greater competition—in key markets.

Our analysis supports the conclusion that western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) logs from Alaska share an integrated market (Japan) with logs produced in British Columbia and the U.S. Pacific Northwest. The evidence for an integrated market for lumber is strong but not unequivocal. Given the evidence of markets that are at least imperfectly integrated, Alaska production costs matter and are sensitive to international market conditions. High-cost producers, such as Alaska, are typically the last-in, first-out suppliers of commodity products that have close substitutes.

These results do not challenge the idea that Alaska does produce some unique (and high-value) products from old-growth Sitka spruce and Alaska yellow-cedar (*Chamaecyparis nootkatensis*). For both logs and lumber, however, this accounts for a very small portion of total production. In the commodity markets that make up the bulk of the end uses for Alaska's timber resources, these results lend support to the conclusion that Alaska is competing in integrated and competitive world markets.

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Introduction

It is a long-standing tenet of forest policy in Alaska that the abundant forests of the southeast can be the basis for economic development. Efforts to establish pulp mills occupied much of the 20th century (Durbin 1999 and Smith 1975 provide useful overviews of the development of the timber industry in southeast Alaska). The closure of the last remaining pulp mill in Alaska in 1997 has focused attention on softwood logs and softwood lumber as the basis for the region's industry.

Among the enduring challenges facing timber-based industries in Alaska are high operating costs, distance from markets, and diseconomies of small scale. Some argue, however, that Alaska's timber is unique and therefore less vulnerable to the pressures of highly competitive commodity markets. The McDowell Group (2000) summarizes this perspective: "These factors [appearance, rareness, and traditional preference] to some degree insulate products such as southeast Alaska old growth timber—Sitka spruce, red- and yellow-cedar, and western hemlock—from market declines and potential substitutes." In contrast, Brooks and Haynes (1997) assert that future timber production in Alaska will be quite sensitive to market cycles and continuing competition from other producing regions.

If it is possible to empirically examine these opposing points of view, the results will have important implications for forest policy in Alaska. Logging costs are directly affected by forest management and policy; Robertson and Brooks (2001) document Alaska's high logging costs compared to those in the U.S. Pacific Northwest (PNW) (western Oregon and western Washington) and Canada. If the Alaska timber resource is somehow unique and does not compete in world markets with timber from the Pacific Northwest or British Columbia, then the cost structure of the Alaska forest products industry vis-à-vis these other regions is less important. If, however, it can be shown that the law of one price¹ applies, then the demand for Alaska timber and forest products will be closely linked to the production decisions and cost structure of competing regions.

The objective of this study is to formally test the hypothesis that markets for Alaska lumber and logs are integrated with those of similar products from the Pacific Northwest (Oregon and Washington) and Canada (British Columbia). The prices from the three supply regions will be tested in a common demand market (Japan).

Market Integration

Murray and Wear (1998) describe three cases of market integration: homogeneous goods from two regions, homogeneous goods from more than two regions, and product heterogeneity. In the case of homogeneous goods, the price difference will equal the transportation costs. When two or more regions export to a third region, the differences in prices in the third region should equal the differences in each region's transportation costs to the third region. In either case, parallel price movement should be evidence of market integration. In the third case where products are heterogeneous but substitute for one another, the degree of parallel price movement may indicate either imperfect market linkages or imperfect substitution across products.

¹ The law of one price states that in the long-run equilibrium condition, efficient arbitrage and trade activity ensure that the prices of homogeneous products (such as softwood lumber and logs) supplied by different producers in different regions tend to uniformity (Jung and Doroodian 1994).

Failure to observe the law of one price in this study may come from a number of sources: (1) imperfect markets (for example, as a consequence of log export restrictions from Canada, U.S. federal land, and some state land), (2) imperfect substitution between products of the same species from different regions, or (3) a lack of integrated markets.

Two lines of inquiry from past research are relevant here: (1) a variety of studies using cointegration techniques and (2) market integration and trade studies testing the law of one price. Recently, time-series data stationarity and cointegration of price series have become important research topics (Hamilton 1994). Price time series are rarely stationary; that is, statistical properties are a function of time. A nonstationary process “floats” in the sense that once it has reached a level, it stays there until it moves to a new level (Johansen 1997). A series is said to be “difference stationary” if the first (or higher order) difference of the series is stationary. It is designated $I(d)$ where d is the order of integration. The process can be represented by:

$$y_t = \mu + \rho y_{t-1} + \varepsilon_t,$$

where μ and ρ are parameters and ε_t is assumed to be white noise. The series y is stationary if $-1 < \rho < 1$. If $\rho = 1$, y is a nonstationary series (a random walk with drift). If the absolute value of ρ is greater than 1, the series is explosive.

A linear combination of any two or more nonstationary series may be stationary. If such a stationary, or $I(0)$, linear combination exists, the nonstationary (with a unit root) time series are said to be cointegrated. The stationary linear combination is called the cointegrating equation and may be interpreted as a long-run equilibrium relationship between the variables. Johansen’s (1995) method of testing for cointegration tests the restrictions imposed by cointegration on the unrestricted vector autoregression (VAR) involving the series.

If cointegration is found to exist between economic variables, an error-correction model can be formulated that incorporates both the long- and short-run effects. Johansen (1997) called this the general equilibrium correction model and expressed it as:

$$\Delta X_t = \alpha \beta' X_{t-1} + \Gamma \Delta X_{t-1} + \mu + \Phi D_t + \varepsilon_t,$$

where the process $X_t = (X_{1t}, \dots, X_{pt})'$ contains the relevant set of $I(0)$ variables (in this case, pairs of log and lumber prices). The coefficients in the matrix α are the adjustment coefficients, and the columns of β are the cointegrating vectors and $\beta' X_{t-1} = c$, the long-run relations. Short-term coefficients are represented by β' because they express how the changes react to past changes. The processes are allowed a growth rate Γ and include the term D_t to allow for extra variables like seasonal dummies that can be included for modeling the data. The number of cointegrating vectors is determined by using Johansen’s maximum likelihood method (Johansen 1995). This is a trace test for cointegration rank, r , where the null hypothesis is $H_0: r = r_0$ against $r_0 < r \leq p$ (where p is the number of dimensions of the VAR model system). If the number of cointegrated equations equals zero, the price series are not cointegrated, and ordinary least squares in differences should be used in testing. In this paired study, if $r = 2$, the series are individually stationary or the model is misspecified. If $r = 1$ the price series are cointegrated.

Literature Review

A number of recent studies have used cointegration techniques to examine market integration and trade in forest products. Three studies investigate the integration of U.S. softwood lumber markets. Uri and Boyd (1990) apply pairwise Granger causality tests that could not reject the hypothesis of a single U.S. softwood lumber market. Jung and Doroodian (1994) apply multivariate cointegration tests to account for potential simultaneity biases caused by the use of more than one endogenous variable at the same time. They found the presence of a single long-term equilibrium price and U.S. softwood lumber markets were efficiently linked. Murray and Wear (1998) compare prices of PNW softwood lumber with prices of lumber produced in the U.S. South by using cointegration and Granger causality analysis. They found that the hypothesis of no cointegration could not be rejected. They further tested for and found a structural break in the price relationship based on changes in legislation restricting the sale of federal timber in the PNW. Granger causality tests showed that price feedback exists across regional markets, and although the causal effects of PNW prices on Southern prices appear stronger, after 1988 the markets became more tightly linked.

European studies have tested wood products market integration. Riis (1996) found that Danish and Swedish timber prices were cointegrated. Toppinen (1998) tested Finnish roundwood market integration, and Toivonen et al. (2000) examined the integration of markets in Finland, Sweden, and Austria. They conclude that European roundwood markets are "at least somewhat integrated" based on the degree of price co-movement. Thorsen et al. (1999) and Thorsen (1998) tested the extent to which Danish timber markets are integrated with surrounding markets. In both studies, the law of one price is found to generally hold.

Cointegration techniques also have been used extensively to test the law of one price in trade relationships. Buongiorno and Uusivuori (1992) tested the law of one price for U.S. pulp and paper exports by using cointegration tests of Engle and Granger (1987). Hanninen (1998) used Johansen's cointegration method to test the law of one price for sawnwood imports for the United Kingdom from four exporting countries. The results did not support the law of one price but rather supported the use of a differentiated goods (i.e., Armington type) model. Hanninen et al. (1997) tested the law of one price for British and German imports of newsprint and found that cointegration tests rejected the simultaneous law of one price among the three import prices. When tested pairwise, it was found to hold for only two exporters to one market (United Kingdom).

Data

There are three independent data sources that allow comparison of Alaska log and lumber prices with similar products from other regions. The U.S. Department of Commerce (USDC) collects value and volume data of softwood exports from U.S. ports by species and destination (compiled by Warren 2000). The valuation definition used in the export statistics is the value at the seaport or border port of exportation (freight alongside ship). It is based on the selling price and includes inland freight, insurance, and other charges to the port of exportation. Average quarterly value in nominal dollars per million board feet of western hemlock lumber (1st quarter 1990 through 4th quarter 1997) and log (1st quarter 1989 through 4th quarter 1997) exports to Japan from the Anchorage Alaska Customs District (all Alaska ports) are compared to the average value of hemlock lumber and log exports to Japan from the Seattle and Columbia-Snake River Customs Districts (all Washington and Oregon ports) (see figs. 1 and 2 and app.).

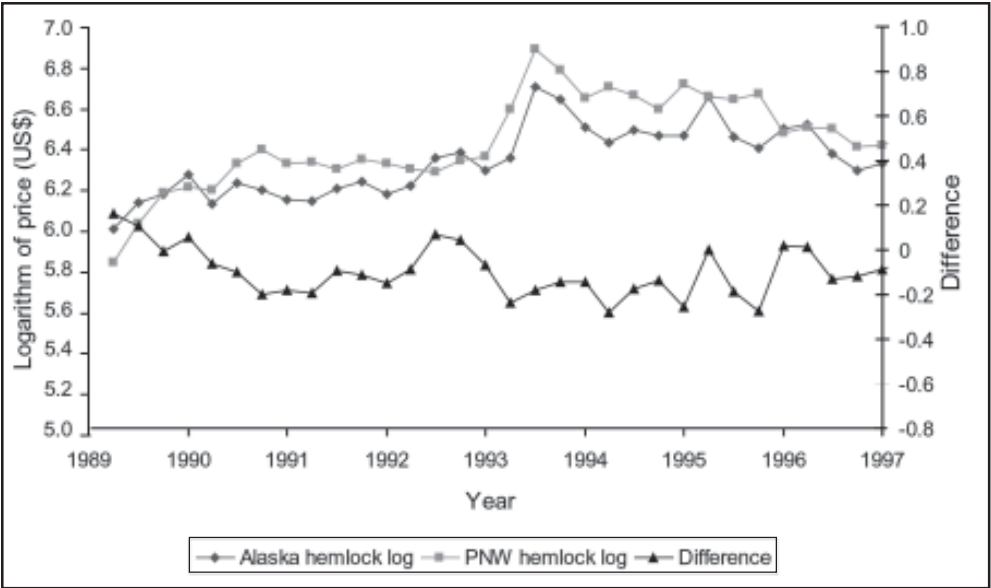


Figure 1—Quarterly prices for Alaska and Pacific Northwest hemlock logs (Warren 2000).

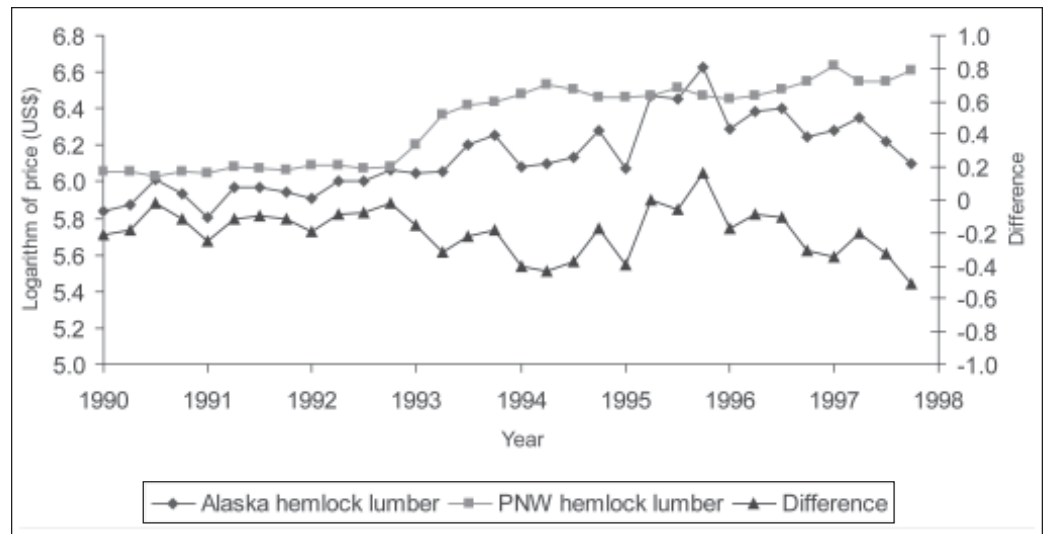


Figure 2—Quarterly prices for Alaska and Pacific Northwest hemlock lumber (Warren 2000).

The Japan Lumber Journal (JLJ 1971-99) reports annual import values and volumes of foreign logs and lumber by species and country of origin. Using JLJ data, we are able to compare prices for U.S.-origin Sitka spruce logs and Canadian Sitka spruce logs (1979-98). Sitka spruce logs exported to Japan from the United States originate almost exclusively from Alaska (over the past 5 years, Alaska accounted for almost 98 percent of spruce logs exported to Japan from U.S. ports (Warren 2000)). Data reported by the JLJ also allow us to compare U.S. (predominantly Alaska) spruce lumber exports and Canadian (primarily British Columbia,) spruce exports (1974 through 1998) (see figs. 3 and 4).

Finally, the Japan Lumber Reports (JLR 1986-99) provides semimonthly log and lumber prices (freight on board Japan) for North American timber, by region of origin. Alaska hemlock (regular sort) log prices are compared to British Columbia (regular sort) hemlock logs (monthly prices from September 1986 to March 1997). These five data sets, from three sources, are shown in figures 1 through 5. Each figure shows the original data converted to logarithmic form and the difference series for each pair of data (see fig. 5).

Our analysis is based on pairwise cointegration tests that compare long-run movements of prices in Alaska and the U.S. PNW, and Alaska and British Columbia. The objective is to determine if these markets are efficiently linked and, as a result, if there is a single long-term equilibrium price. Because of the absence of comparable products from a single data source for all three regions, simultaneous, multivariate cointegration testing of all three prices was not attempted.

Results

Although the stationarity of individual series is checked within the Johansen model, the unit root test also was run prior to the cointegration test. The appropriate lag length for the augmented Dickey Fuller (ADF) test (Dickey and Fuller 1981) was determined by minimizing the Akaike information criterion for each variable. The ADF tests (table 1) indicate that all the levels of prices are nonstationary, whereas their first differences are stationary.

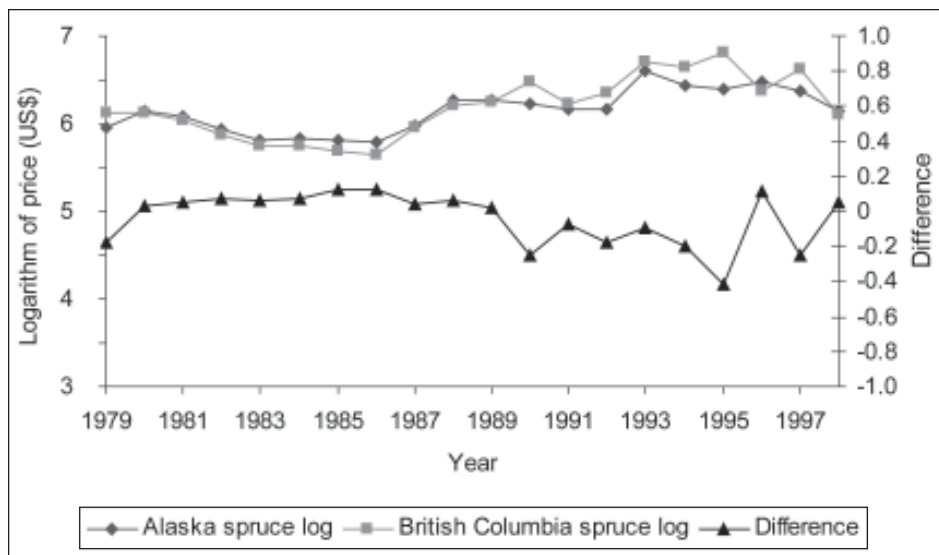


Figure 3—Annual prices for Alaska and British Columbia Sitka spruce logs (JLJ 1971-99).

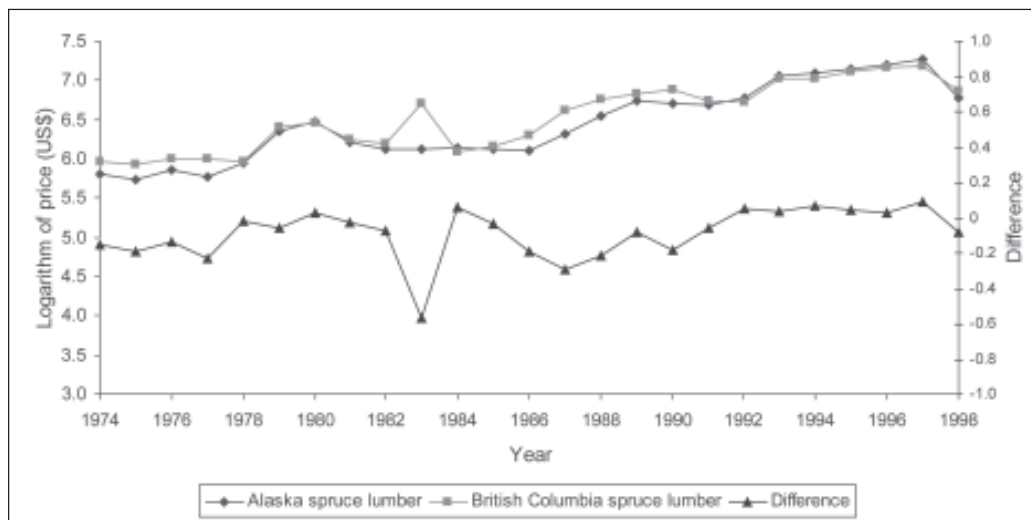


Figure 4—Monthly prices for Alaska and British Columbia Sitka spruce lumber (JLJ 1971-99).

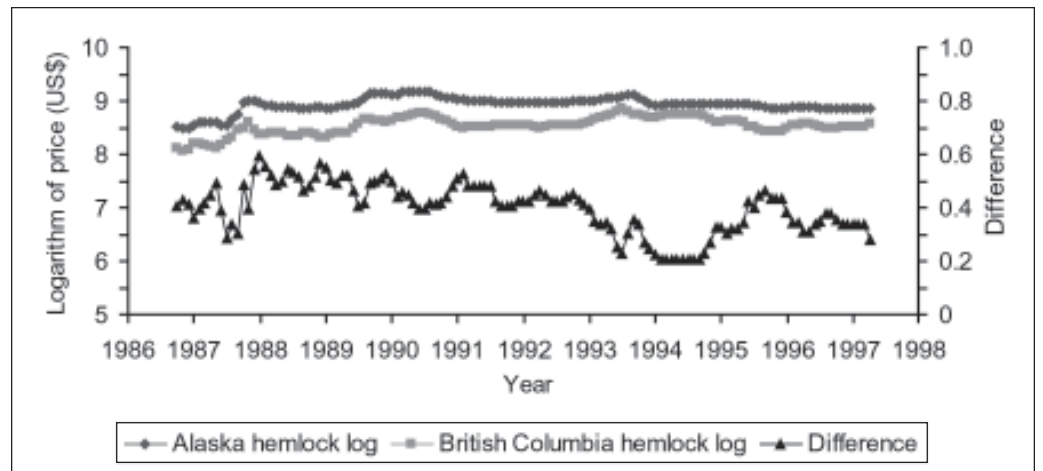


Figure 5—Monthly prices for Alaska and British Columbia hemlock logs (JLR 1986-99).

Table 1—Augmented Dickey Fuller (ADF) statistics

Series	ADF test statistic		Lags	
	Levels	1 st differences	Level lag	1 st difference lags
AK hemlock logs	-2.67	-4.30 ^a	3	4
BC hemlock logs	-2.70	-6.60 ^a	3	2
AK spruce logs	-2.67	-3.56 ^b	2	1
BC spruce logs	-1.78	-2.68 ^c	1	1
AK hemlock logs	-1.47	-6.27 ^a	2	1
PNW hemlock logs	-1.89	-4.87 ^a	1	1
AK spruce lumber	-1.44	-4.17 ^a	2	1
BC spruce lumber	-1.70	-4.74 ^a	1	1
AK hemlock lumber	-1.77	-4.64 ^a	1	2
PNW hemlock lumber	- .72	-4.00 ^a	1	1

Note: Critical values for rejection of hypothesis of a unit root at 5-percent level (MacKinnon 1991).

AK = Alaska, BC = British Columbia, PNW = Pacific Northwest.

^a Significant at 1-percent level.

^b Significant at 5-percent level.

^c Significant at 10-percent critical value (-2.65).

Table 2—Cointegration tests for hemlock and spruce logs

Relation	Null hypothesis	Likelihood ratio	5-percent critical value	Lags
AK hemlock logs and BC hemlock logs	$r = 0$	17.01	15.41	3 ^a
	$r \leq 1$	3.66	3.76	
AK spruce logs and BC spruce logs	$r = 0$	20.17	15.41	2 ^a
	$r \leq 1$	2.00	3.76	
AK hemlock logs and PNW hemlock logs	$r = 0$	19.06	15.41	1 ^a
	$r \leq 1$	3.39	3.76	

Note: AK = Alaska, BC = British Columbia, and PNW = Pacific Northwest.

^a Lag length that minimizes Akaike criterion.

Table 3—Cointegration tests, lumber

Relation	Null hypothesis	Likelihood ratio	5-percent critical value	Lags
AK spruce lumber and BC spruce lumber	$r = 0$	15.66	15.41	1 ^a
	$r \leq 1$	2.32	3.76	
AK hemlock lumber and PNW hemlock lumber	$r = 0$	18.93	15.41	5
	$r \leq 1$	1.42	3.76	

Note: AK = Alaska, BC = British Columbia, and PNW = Pacific Northwest.

^a Lag length that minimizes Akaike criterion.

Cointegration tests were then run on the paired log data and the lumber data. The test of the null hypothesis that there are no cointegrating equations ($r = 0$) was followed by a test of the alternative hypothesis that there is no more than one cointegrating equation. The log market results (table 2) yielded robust results with all the relationships identified as having one cointegrating equation. All the tests were based on the lag value that minimized the Akaike criterion in the vector autoregression equation.

The lumber market results (table 3) were slightly less robust. Whereas the Sitka spruce lumber from British Columbia and Alaska yielded results of one cointegrating equation, this was not true for the hemlock lumber at the number of lags with the lowest value for the Akaike criterion (table 3). This criterion was met at a two-period lag rather than five. The equation was respecified to capture the changes that took place in the Alaska market since the closure of the first pulp mill in 1994 (the second closed in 1997). Closure of

Table 4—Cointegration test with a dummy variable to account for the pulp mill closure

Relation with dummy variable	Null hypothesis	Likelihood ratio	5-percent critical value	Lags
AK hemlock lumber and PNW				
hemlock lumber + dummy	$r = 0$	42.12	29.68	
1 st quarter 1994 through	$r \leq 1$	9.24	15.41	2 ^a
4 th quarter 1997	$r \leq 2$	1.08	3.76	

Note: AK = Alaska, PNW = Pacific Northwest. Data based on Warren (2000).

^a Lag length that minimizes Akaike criterion.

the Alaska pulp mills affected both hemlock log and lumber markets, especially for lumber produced from lower grade logs.² Using a dummy variable to account for the change pre- and post-1994, we reran the equation, and the results showed one cointegrating equation (table 4).

Conclusion

Our analysis supports the conclusion that western hemlock and Sitka spruce logs from Alaska share an integrated market (Japan) with logs produced in British Columbia and the U.S. Pacific Northwest. The evidence for an integrated market for lumber is strong but not certain. As was mentioned earlier, the absence of statistical evidence for an integrated market may be because the markets are truly not integrated; however, structural reasons, or the absence of perfect substitution between the products also may explain the results for lumber. Similar to the results reported by Thorsen et al. (1999), our results may be affected by weak product homogeneity. It is important to note, however, that data from three independent sources confirmed similar findings of integrated markets.

Given the evidence that markets are at least imperfectly integrated, Alaska production costs matter; that is, Alaska producers will be limited in the degree to which they incorporate their relatively higher costs in product prices and retain market share. It is not surprising, therefore, that Alaska production and exports are quite sensitive to international market conditions. High-cost producers are typically the last-in, first-out suppliers of commodity products that have close substitutes.

These results do not challenge the idea that Alaska does produce some unique (and high-value) products from old-growth Sitka spruce and Alaska yellow-cedar. For both logs and lumber, however, this accounts for a very small portion of total production. In the commodity markets that make up the bulk of the end uses for Alaska's timber resource, these results lend support to the conclusion that Alaska is competing in integrated and competitive world markets.

² The closure of the Alaska pulp mills coincided with structural changes in Japanese lumber markets; starting in the mid-1990s, European-origin, kiln-dried lumber began substituting for green hemlock lumber produced in North America.

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**Appendix—
Data Sources**

Product	Source	Published	Range
Hemlock lumber	U.S. Dept. of Commerce	Quarterly	1 st quarter 1990 through 4 th quarter 1997
Hemlock logs	U.S. Dept. of Commerce	Quarterly	1 st quarter 1989 through 4 th quarter 1997
Spruce logs	Japan Lumber Journal	Annual	1971 through 1998
Spruce lumber	Japan Lumber Journal	Annual	1974 through 1998
Hemlock logs	Japan Lumber Reports	Monthly	September 1986 through March 1997

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