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Acknowledgements

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Abstract

Employment in the wood products industry in Oregon has declined over the past decade despite a recent resurgence in demand for the industry's products. Reviewing employment and productivity data over the last decade, it is apparent that wood products employment in the state has been reduced as a result of productivity increases. Thus the industry processed more timber in 1986 than in 1979, but with about fifteen percent fewer workers. Continued reductions in wood products employment pose potentially serious adjustment problems because much of rural Oregon remains heavily dependent economically on the industry. There are also indications that timber supply reductions will occur in the future, which would limit the industry's output and further reduce employment.

This paper examines the dynamics of employment change in Oregon's wood products industry. We decompose the change in employment over the past decade into categories associated with structural and productivity factors. An input-output analysis of changes in the composition of the industry's output is also undertaken to estimate the economic consequences of structural change. Following the more general analysis, we then examine several issues of recent importance in the state, namely, a ban on the export of logs harvested from state forests and the economic impacts of harvest limitations in the federal forests associated with the spotted owl controversy.
Introduction

The structure of Oregon's rural economy continues to be characterized by a heavy dependence on the wood products industry, despite a long term trend of sectoral diversification. Employment in the industry provides a major source of income in the state's forested regions, and local government budgets reflect substantial sums received through property taxes or through various subventions from higher levels of government derived from timber harvests in federal and state forests.

Two issues have combined to form a generally pessimistic outlook for the state's wood products industry over the next two decades. First, projections of timber supplies show a considerable decline extending into the next century [16, 17]. Second, labor productivity projections indicate continuing increases in output per worker, attributable in part to a transition to processing second growth timber [10, 23]. As a result, wood products output in Oregon is expected to decline, and industry employment is expected to decline more sharply than output. The reduction in economic activity in this sector will have extensive multiplier impacts on the state's timber dependent regions, given the relatively high incomes earned by wood products employees and the dependence of local governments on timber harvesting and processing activities. Hence, the conventional wisdom is that the total employment outlook in the timber dependent regions is bleak, and that consequent economic adjustment problems will threaten the viability of many small rural communities in Oregon. This view persists despite the strong performance of Oregon's wood products industry following the severe recession of the early 1980's.

Major improvements in labor productivity accompanied the recent recovery in wood products output. Timber harvests in Oregon in 1986 exceeded 1979 levels, but 15 per cent fewer workers were required to process this raw material. While this change has been viewed positively from a competitive standpoint, it has also been a source of concern for residents of timber dependent communities who depend on the industry to provide jobs.
Other changes have also contributed to concerns about the conditions affecting the state's wood products industry. Proposals in the ten year management plans for the federal forests in the state have called for an approximate 25 per cent reduction in timber sales from the FY 1989 sales targets [17]. In 1988, selected timber sales in Oregon's national forests were halted by legal challenges of the Forest Service provisions protecting the habitat of the northern spotted owl. Raw log exports from the state in 1988 were 40 per cent over 1979 levels, which prompted a ballot measure banning such exports in regard to timber harvested from state-owned forests. This measure was passed in June, 1989 with the endorsement of 85 per cent of the voters, record support in a state with an historical proclivity for placing referendum measures on the ballot. It thus appears that significant structural changes have occurred in the 1980's, and that more loom on the horizon.

In this paper we analyze several of the structural changes experienced by the state's wood products industry over the past decade. We first review the performance of the industry over this period in relation to the national market, describe corresponding changes in the composition of economic activity in the state and identify patterns of labor utilization associated with timber processing activities. We then decompose the observed decline in wood products employment into elements associated with changes in product mix, timber harvests and labor productivity. Using an input-output model of the Oregon economy, we estimate the impacts of historical and simulated changes in the mix of the industry's products on state employment, output and income. On the basis of our findings regarding structural change, we then extend the analysis to two issues of contemporary importance in the state: a ban on the export of unprocessed timber harvested from state-owned forests and harvest limitations in the old growth forest domain of the spotted owl.

Recent Sectoral Trends

The wood products sector is comprised of a diverse collection of manufacturing activities. As defined by its Standard Industrial Classification code (SIC 24), this sector is
responsible for logging and the production of lumber and plywood, but also contains millwork, particleboard, wood kitchen cabinets, mobile homes and prefabricated wood buildings. The first three of these activities comprise what is termed "primary processing," accounting for about 80 per cent of wood products employment in Oregon. Most of our attention will be devoted to primary processing activities in the following analysis.

Data on state lumber and plywood production levels and log exports for recent years are provided in Table 1. The production figures reveal the cyclical nature of the industry. Both lumber and plywood production fell more than 35 per cent from their 1970's highs to their 1982 levels. The subsequent economic recovery then drove output back to levels exceeding the previous peaks.

Changes in the state's share of national lumber and plywood production over the last decade indicate noticeable differences in performance. Regarding lumber, Oregon's share of U.S. production at the beginning and end of the period was about 23 per cent. During the recession the state's share fell below 20 per cent, indicating that production patterns in the state were more cyclical than at the national level. Several explanations have been offered as to why this was the case [11, 15, 23]. First, construction markets more geographically accessible to Oregon were particularly hard hit during the recession years, leaving wood products producers in Oregon relatively worse off as a result. Second, longer term analysis of lumber production cycles shows a similar pattern, suggesting that Oregon serves as a "residual producer," analogous to the core oil producing countries of OPEC, but for different reasons. Oregon's lumber, processed primarily from Douglas fir and Ponderosa pine, is of relatively high quality, but harvesting costs are also comparatively high, and production costs exceeding those observed in the Southern U.S. by as much as 45 per cent [1] place the region at a competitive disadvantage. Given higher costs, producers in this region require higher product prices to maintain output, and are more sensitive to downturns and their accompanying low prices.
### Table 1

<table>
<thead>
<tr>
<th>Year</th>
<th>Lumber % of U.S.</th>
<th>Plywood2 % of U.S.</th>
<th>Log Exports3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>7,509 23.3</td>
<td>8,109 41.9</td>
<td>881</td>
</tr>
<tr>
<td>1978</td>
<td>7,416 22.8</td>
<td>8,226 41.2</td>
<td>931</td>
</tr>
<tr>
<td>1979</td>
<td>7,312 22.9</td>
<td>7,929 40.3</td>
<td>984</td>
</tr>
<tr>
<td>1980</td>
<td>5,784 21.2</td>
<td>6,179 37.5</td>
<td>933</td>
</tr>
<tr>
<td>1981</td>
<td>5,115 20.5</td>
<td>5,562 32.7</td>
<td>671</td>
</tr>
<tr>
<td>1982</td>
<td>4,682 19.4</td>
<td>5,114 31.2</td>
<td>971</td>
</tr>
<tr>
<td>1983</td>
<td>6,579 21.9</td>
<td>6,719 32.4</td>
<td>852</td>
</tr>
<tr>
<td>1984</td>
<td>7,202 23.1</td>
<td>6,779 30.9</td>
<td>933</td>
</tr>
<tr>
<td>1985</td>
<td>7,211 23.0</td>
<td>6,750 29.6</td>
<td>1,125</td>
</tr>
<tr>
<td>1986</td>
<td>8,149 23.1</td>
<td>7,826 30.5</td>
<td>1,041</td>
</tr>
<tr>
<td>1987</td>
<td>8,846 23.1</td>
<td>8,381 31.0</td>
<td>1,104</td>
</tr>
<tr>
<td>1988</td>
<td>8,601 22.6</td>
<td>7,850 28.9</td>
<td>1,387</td>
</tr>
</tbody>
</table>

Source: U.S. Forest Service [22].

1 The units of measurement in Table 1 are as follows: lumber production is in million board feet, lumber tally; plywood production is in million square feet, 3/8 inch basis; and log exports are in million board feet, Scribner log scale.

2 Since 1983, the plywood production figures include waferboard and oriented strand board.

3 Log export volumes are for the Columbia-Snake Customs District, which includes Longview and Vancouver, Washington in addition to all Oregon ports.

Oregon’s share of U.S. plywood production fell from 42 to 29 per cent between 1977 and 1988, continuing an even longer term decline. The reasons for this can be attributed to inter-regional competition in plywood production and increased competition with substitute types of structural panels (which are included in the production figures). New inter-regional competition was established in the early 1960’s with the adoption of smaller diameter log peeling technology in the South. The subsequent decline in Oregon’s
plywood market share was then exacerbated by the successful penetration of waferboard and oriented strand board panels in the U.S. market in the 1980's. These new panels are produced from hardwoods ("weed species"), and the locational pattern of the manufacturing plants - given the relative ubiquity of the raw material - is more market oriented. Only one of these plants (a relatively small producer) is located in Oregon.

Raw log exports from the state held fairly steady at about 900 million board feet annually through the latter 1970's. Following a brief decline in the early 1980s, exports grew rapidly, more than doubling between 1981 and 1988. This pattern basically reflects parallel trends in the exchange value of the U.S. dollar. The exchange weighted price of Douglas fir logs (the principal export species from this region) has been relatively attractive in international markets since 1985, particularly with respect to Japanese demand.

Mitigating the instability associated with the highly cyclical performance of the wood products sector and its multiplier effects on the rest of the Oregon economy is a gradual longer term decline in the sector's share of total state employment. In 1985 the industry accounted for seven per cent of total covered employment in Oregon, down from over 20 per cent in 1956 [19]. At the national level the industry's share of total employment has also declined. Location quotients [7] thus show that the relative importance of the wood products sector to the state has not changed appreciably over the past 30 years (see Table 2). In fact, the location quotients show that the wood products industry actually grew in relative importance in the state between 1956 and 1975. Apart from the wood products industry, however, sectoral diversification has been occurring in the state's economy. The diversification index [7] grew at an annual rate of .7 per cent over the 30 year period, which indicates that the other sectors of the state's economy were on a development path in convergence with the structure of the national economy.
Table 2
Wood Products Sector Location Quotients and Sectoral Diversification Index Values, 1956-1985

<table>
<thead>
<tr>
<th>Year</th>
<th>Location Quotient</th>
<th>Diversification Index¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>1956</td>
<td>20.2</td>
<td>.745</td>
</tr>
<tr>
<td>1959</td>
<td>22.4</td>
<td>.772</td>
</tr>
<tr>
<td>1965</td>
<td>23.4</td>
<td>.804</td>
</tr>
<tr>
<td>1970</td>
<td>24.2</td>
<td>.842</td>
</tr>
<tr>
<td>1975</td>
<td>24.2</td>
<td>.874</td>
</tr>
<tr>
<td>1980</td>
<td>18.3</td>
<td>.883</td>
</tr>
<tr>
<td>1985</td>
<td>19.6</td>
<td>.907</td>
</tr>
</tbody>
</table>

¹ The sectoral basis for calculating the diversification index was comprised of the following categories: Agriculture, Forestry, Fisheries and Mining; Construction; Wood Products; Other Manufacturing; Transportation, Communications and Utilities; Wholesale and Retail Trade; Finance, Insurance and Real Estate; Services; Activity Not Elsewhere Classified.

Labor Utilization in the Wood Products Industry

We now examine patterns of labor utilization in the state's wood products industry. This includes consideration of changes in labor intensity with respect to the amount of timber harvested and processed, as well as the use of labor in relation to product output. The former approach provides a view on the general intensity with which labor is employed in converting timber into the industry's numerous end products, allowing us to determine the extent to which processing has become more labor intensive in recent years. The latter approach provides a product-specific perspective of trends in labor intensity, consistent with conventional treatment of labor productivity. By combining these two approaches we can then examine how changes in the allocation of timber among alternative end uses -
specifically, lumber, plywood and log exports - alters the level of labor intensity at the sectoral level.

The relationship between timber harvests and wood products employment is distinguished by two contrasting phases encompassing the 1970's and 1980's (see Figure 1). During the 1970's, timber harvests in the state were on a generally declining trend, while wood products employment was moving upward. In combination, these trends indicate an increase in labor intensity for the industry during the period. Both the harvest level and employment then fell sharply from 1979 to 1982. The post-1982 recovery in the industry demonstrates a reversal of the 1970's trend of increasing labor intensity. By 1986 the timber harvest was more than one billion board feet larger than 1979 (an increase of about 14 per cent), while employment fell by more than 11 thousand jobs (a decline of 15 per cent).
Figure 1
Oregon Timber Harvests and Wood Products Employment, 1970-1987

The left axis in Figure 1 represents timber harvests, in billion board feet. The right axis represents employment, in thousands.

Labor utilization per million board feet of timber processed is illustrated for primary processing activities in Figure 2. The rates for lumber and plywood are based on employment as related to the total amount of timber consumed - whether harvested in-state or imported - as reported in periodic mill surveys conducted by the Forest Service [18]. Rates for the logging sector are based on state timber harvests.
As Figure 2 indicates, labor intensity increased between 1968 and 1982 for the state's logging and lumber producing sectors, while it declined in the plywood sector. The annual percentage rates of change for the three activities for this period were 3.0, 1.4, and -0.8, respectively. Between 1982 and 1985, labor intensity declined in all three sectors. For logging, the annual rate of decline was 1.4 per cent, while for lumber and plywood it was 8.8 and 5.5 per cent, respectively.

While labor intensity rates provide a useful picture of employment in the industry in relation to resource utilization, they do not represent the productivity of wood products workers. Nominal labor productivity estimates, alternatively, relate employment to sectoral output. Given that the output of the state's lumber and plywood sectors is fairly homogeneous, we can derive labor productivity figures on the basis of the quantities produced. We would expect that labor productivity improvements over time would be greater than the reductions in labor intensity as related to timber usage because the rate of product recovery from timber has been increasing [1].
The measures of labor utilization in relation to lumber and plywood output are presented in Figure 3. For lumber production, labor intensity still shows an upward trend between 1968 and 1982, but its .8 per cent annual gain is only one fourth the rate of change based on the amount of timber consumed. Labor intensity in the plywood sector declined at a 1.4 per cent annual rate over the same period. Between 1982 and 1985 labor intensity declined at a rapid rate in both sectors: 10.4 per cent annually for lumber and 7.9 per cent annually for plywood. Over the entire period labor productivity improved at an annual rate of 1.0 per cent in the lumber sector and 2.1 per cent in the plywood sector. When compared with changes at the national level [20] covering roughly the same time period, lumber and plywood sector labor productivity in Oregon improved at a relatively slower rate during the 1970's and at a relatively faster rate following the recession.

Figure 3
Employment Per Million Board Feet of Lumber and Million Square Feet of Plywood Produced in Oregon, 1968-85

It is important to distinguish between the effects of technical progress and factor substitution in evaluating the nominal changes in labor productivity in the industry.
Jorgenson [8] reports that from 1948 to 1979 virtually all of the growth in output in the wood products sector was accounted for by increases in capital and intermediate inputs. After controlling for factor substitution effects, labor productivity growth was found to be negligible. Thus the observed changes in labor intensity can be considered the result of factor substitution induced by changes in the relative prices of labor, capital and stumpage.

Regarding the labor-capital relationship, one way of viewing the factor substitution effect on labor productivity is to estimate the effect on labor use resulting from an increase in the capital stock. By this method a one per cent increase in capital stock was found to lead to a .18 per cent increase in labor usage and a .28 per cent increase in lumber production [5]. Thus a .1 per cent increase in the output-labor ratio results. Regarding stumpage, it was also found that a one per cent increase in the input price would lead to a 1.13 per cent decline in lumber output and a .52 per cent reduction in labor use [5]. Thus labor input per unit of output would increase by about .59 per cent.

The rapid run-up in stumpage prices that occurred in the Pacific Northwest during the latter half of the 1970's can thus be considered a principal cause of the labor productivity declines reported for the lumber and plywood sectors between 1976 and 1982. The late 1970's also yielded favorable profit margins in the industry, translating into sizable increases in capital stock. The engagement of the improved capital stock, coupled with lower stumpage prices, provided major contributions to the rapid increase in labor productivity observed between 1982 and 1985.

Explanations of changes in labor productivity are clouded by several considerations. First, estimates of the elasticities of substitution among the industry's factor inputs vary widely [14]. Second, recent evidence suggests that labor usage is also very sensitive to changes in the quality of timber inputs [5], with increases in labor intensity resulting from declines in timber quality. With the decline in timber quality in the Pacific Northwest over time, the labor productivity gains estimated in studies that assume homogeneous timber inputs are likely to be understated.
A final issue at the industry level concerns changes in the mix of products processed from timber inputs. Increases in timber consumption for lumber production and log exports relative to plywood production (see Figure 4) have resulted in changes in industry level employment and productivity that are unrelated to the various determinants discussed above. These changes can be interpreted as a shift from more to less labor intensive processing of timber in the state. Thus, apart from other factors affecting nominal labor productivity in the wood products sector, changes in the mix of outputs produced from the timber inputs has had the effect of overestimating productivity gains in the industry.

Figure 4

Composition of Timber Consumption in Oregon, 1976-88
(percentage of total timber consumption)

1 The lumber and plywood percentage values for 1976, 1982 and 1985 are based on mill survey data [18]. For intervening years prior to 1985, the percentages are estimated by converting output using Forest Service data on production overruns [1]. For the years after 1985 the production overrun factors for 1985 are used.
Analysis of the Decline in Employment

To this point, we have discussed changes in employment in Oregon's wood products industry in relation to changes in timber consumption, labor productivity and product mix. In this section we decompose the observed decline in employment between 1977 and 1986 consistent with these three factors to determine their relative importance. These two years were chosen for the following reasons. First, the amount of timber processed was roughly equivalent, which mitigates against effects that could be associated with the scale of production. Second, the time span is long enough to discount the possibility that observed changes are the result of short term adjustments. Third, the two years are at similar points on their respective business cycles, allowing for some control over changes associated with cyclical adjustments. Following the decomposition of the employment decline, we then estimate the more general economic consequences of changes in the disposition of timber within the wood products sector. This effort is based on an input-output analysis of the inter-industry linkages involving various wood products processing activities and other sectors of Oregon's economy.

The decline in wood products employment between 1977 and 1986 is decomposed using a methodology that is similar to the shift-share technique [3]. A "share" component identifies the change in employment associated with the change in the industry's consumption of timber. An "industrial mix" component identifies the change in employment attributable to changes in the mix of products produced by the industry. Lastly, "differential shift" components isolate changes in industry employment attributable changes in labor intensity in lumber and plywood production, and "other" industry production activities.

The change in wood products employment associated with the change in timber consumption is defined as follows:

\[
E_c = \left[ \frac{C_{86}}{C_{77}} - 1 \right] \cdot E_{77},
\]

where

\[C_{86} = \text{the total amount of timber processed in 1986;}\]
\[C_{77} = \text{the total amount of timber processed in 1977;}\]
E_{77} = \text{wood products industry employment in 1977.}

The changes in employment resulting from changes in the shares of total timber consumption by lumber and plywood processing activities is

\[ E_{i\,m} = (S_{i\,86} - S_{i\,77}) \cdot C_{86} \cdot L_{i\,77}, \quad \text{where} \]

\[ S_{i\,86} = \text{the proportion of total timber consumption in 1986 devoted to the production of product } i \text{ (lumber, plywood);} \]

\[ S_{i\,77} = \text{product } i\text{'s proportion of total timber consumption in 1977;} \]

\[ L_{i\,77} = \text{employment per unit of timber consumed in the production of product } i \text{ in 1977} \]

The changes in employment resulting from changes in labor intensity in lumber, plywood and "other" processing activities are given as

\[ E_{i\,l} = (L_{i\,86} - L_{i\,77}) \cdot C_{i\,86}, \quad \text{where} \]

\[ L_{i\,86} = \text{employment per unit of timber consumed in the production of product } i \text{ (lumber, plywood and "other") in 1986;} \]

\[ L_{i\,77} = \text{the labor intensity value for 1977.} \]

The decline in wood products industry employment between 1977 and 1986 totaled 6,643 jobs. Decomposition of this total gave the following results (see Figure 5): reductions in labor intensity in lumber and plywood production accounted for about 55 per cent of all jobs lost; the shift in timber consumption from plywood to lumber production accounted for 26 per cent of the job losses; and reductions in the total amount of timber processed by the industry were responsible for 19 per cent of the job losses. "Other" wood processing activities experienced an increase in employment due to an increase in labor intensity.
The components of employment change provide a general view of the role of selected factors associated with recent structural adjustments in the wood products industry. Given the important role that the industry plays in the state economy, these adjustments can also generate extensive changes in economic activity in other sectors. To explore these linkages in greater detail, we used the Forest Service IMPLAN model [2] to estimate the effects of changes in the mix of wood products on output, income and employment in the state economy. IMPLAN's input-output framework is well suited for this purpose because it is capable of providing a very detailed representation of the inter-industry linkages between the wood products sector and other sectors of the state's economy.

Four scenarios were defined for the input-output analysis, each reflecting an alternative pattern of timber allocation among the lumber, plywood and log export sectors. In the first scenario ("1976 Mix"), the total amount of timber processed in 1986 (9.3 billion
board feet) was reallocated among the three sectors on the basis of their 1976 timber consumption shares to derive the net changes in timber consumption and sectoral outputs. The remaining three scenarios were represented by reallocations of about one per cent of 1986 timber consumption (94 million board feet) among selected pairs of sectors ("Plywood to Lumber;" "Log Exports to Lumber;" and "Log Exports to Plywood").

In the input-output analysis log exports are treated as the product of the logging sector. In reality, this activity is comprised of logging, transportation, brokering and port services, which suggests the adoption of a "bill of goods" approach. The associated price margins for the transportation, brokering and port functions pertaining to log exporting have not yet been developed, however. Also, logs dedicated for export have commanded a substantial price premium over logs dedicated for domestic processing [4]. Differences in log quality may explain only part of this price differential. Thus the model is likely to overstate somewhat the reduction in economic activity associated with shifting timber consumption from log exporting to the lumber and plywood sectors.

In order to execute the input-output analysis, changes in the values of the underlying sectoral final demands had to be derived from the stated changes in sectoral timber consumption. This process involved three steps. First, the timber consumption values were converted to sectoral employment changes using sectoral employment data in the model and timber consumption data from the Forest Service mill surveys [18]. The employment values were then converted to changes in sectoral output using the model's estimates of the values of output per employee. Lastly, the sectoral final demand values were derived from the values of sectoral outputs by application of the familiar input-output relationship,

\[ Y = (I - A) \cdot X, \]

where

- \( Y \) = the vector of sectoral final demand changes;
- \( X \) = the vector of changes in sectoral gross outputs;
- \( A \) = the matrix of direct purchase coefficients;
\[ I = \text{an identity matrix.} \]

Changes in sectoral timber consumption and corresponding final demand changes for the four alternative scenarios are presented in Table 3. In the first scenario the amount of timber processed into plywood increases by 440 million board feet, offsetting reductions of 204 and 236 million board feet dedicated to lumber production and log exports. The remaining scenarios comprise the marginal reallocations discussed previously. In terms of changes in final demand, the first scenario generates a net increase of $42 million. Among the three "marginal" scenarios, only the "export to plywood" alternative generates a net increase in the value of final demand. That the "export to lumber" trade-off produces a net reduction in final demand was unexpected. This outcome was the result of differences in inter-industry linkages for the two sectors rather than differences in their individual contributions to gross output.

Table 3
Net Changes in Sectoral Timber Consumption and Final Demand for Alternative Scenarios
(million board feet; millions, 1982 dollars)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Timber Consumption</th>
<th>Final Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lumber</td>
</tr>
<tr>
<td>1. &quot;1976 Mix&quot;</td>
<td>-204</td>
<td>440</td>
</tr>
<tr>
<td>2. &quot;Plywood to Lumber&quot;</td>
<td>94</td>
<td>-94</td>
</tr>
<tr>
<td>3. &quot;Export to Lumber&quot;</td>
<td>94</td>
<td>0</td>
</tr>
<tr>
<td>4. &quot;Export to Plywood&quot;</td>
<td>0</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. &quot;1976 Mix&quot;</td>
<td>-98.5</td>
<td>283.5</td>
</tr>
<tr>
<td>2. &quot;Plywood to Lumber&quot;</td>
<td>44.6</td>
<td>-60.7</td>
</tr>
<tr>
<td>3. &quot;Export to Lumber&quot;</td>
<td>43.8</td>
<td>0</td>
</tr>
<tr>
<td>4. &quot;Export to Plywood&quot;</td>
<td>0</td>
<td>60.5</td>
</tr>
</tbody>
</table>
The input-output model estimates of the changes in output, income and employment in the state resulting from the four scenarios are summarized in Table 4. For the "1976 Mix" scenario, the results indicate that had the timber processed in 1986 been converted into the product mix in the same relative proportions as in 1976, gross output in Oregon would have been nearly $153 million higher, total income would have increased by $56 million and 2,400 more jobs would have been added. For the three trade-off scenarios, the "plywood to lumber" shift produces reductions in gross output, income and employment totaling $35 million, $12 million and 380 jobs. The "export to plywood" scenario results in increases of roughly the same magnitude. The "export to lumber" scenario shows only a slight increase in output and income, and a 300 job increase in employment. The changes in economic activity associated with this scenario are unusual, in that the increases in output and income generated within the wood products sector are almost completely offset by declines in the other sectors of the state's economy. This indicates that the inter-industry linkages are much more extensive in the log export sector than they are in the lumber sector.

Table 4
Input-Output Results for Alternative Scenarios
(millions, 1982 dollars; person-years employment)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Wood Prods.</th>
<th>Other Sectors</th>
<th>Total</th>
<th>Wood Prods.</th>
<th>Other Sectors</th>
<th>Total</th>
<th>Wood Prods.</th>
<th>Other Sectors</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;1976 Mix&quot;</td>
<td>123.2</td>
<td>29.5</td>
<td>152.7</td>
<td>41.1</td>
<td>14.6</td>
<td>55.7</td>
<td>1667.1</td>
<td>760.7</td>
<td>2427.8</td>
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<td>Scen. multipliers</td>
<td>3.60</td>
<td></td>
<td></td>
<td>3.40</td>
<td></td>
<td></td>
<td>1.57</td>
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<td>&quot;Plywd. to Lumb.&quot;</td>
<td>-21.6</td>
<td>-13.4</td>
<td>-35.0</td>
<td>-6.2</td>
<td>-6.0</td>
<td>-12.2</td>
<td>-169.0</td>
<td>-211.7</td>
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<td>Scen. multipliers</td>
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<td></td>
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<td>2.75</td>
<td></td>
<td></td>
<td>1.81</td>
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<td>&quot;Exp. to Lumb.&quot;</td>
<td>8.9</td>
<td>-8.9</td>
<td>.02</td>
<td>4.8</td>
<td>-3.8</td>
<td>1.0</td>
<td>349.8</td>
<td>-55.8</td>
<td>294</td>
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<tr>
<td>Scen. multipliers</td>
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<td></td>
<td></td>
<td>-.99</td>
<td></td>
<td></td>
<td>1.26</td>
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<td></td>
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<tr>
<td>&quot;Exp. to Plywd.&quot;</td>
<td>30.9</td>
<td>3.3</td>
<td>34.2</td>
<td>11.1</td>
<td>1.8</td>
<td>12.9</td>
<td>519.9</td>
<td>151.9</td>
<td>671.8</td>
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<tr>
<td>Scen. multipliers</td>
<td>2.70</td>
<td></td>
<td></td>
<td>3.80</td>
<td></td>
<td></td>
<td>1.51</td>
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The input-output results also reveal that most of the economic consequences of the alternative scenarios are localized within the wood products industry. In the "1976 Mix" scenario, for example, 81 per cent of the increase in gross output, 74 per cent of the change in income and 69 per cent of the employment gain are contained within the wood products sector. This finding indicates that the industry's principal effect on other sectors of the state's economy come from the induced changes associated with the industry's wage and salary payments. We should note, however, that government spending effects are treated as exogenous in the model, and thus the results reported here do not capture the changes in economic activity associated with the expenditure of the tax and harvest receipts.

Output, income and employment multipliers associated with the alternative scenarios are also reported in Table 4. Because the scenarios examine net changes in economic activity among the three sectors, these multipliers reflect the composite effects of the direct, indirect and induced increases generated by sectors receiving more timber, minus the direct, indirect and induced reductions generated by sectors receiving less timber. Given differences in sectoral multipliers, differences in the value of alternative products that can be recovered from a given amount of timber and the pattern of inter-industry linkages among the three sectors, a marginal shift in timber consumption can produce scenario multipliers that differ markedly from the individual sectoral multipliers. For example, the gross output multiplier for the "1976 Mix" scenario is 3.60. The relatively large magnitude of this multiplier is attributable to several effects. First, the sectoral multiplier for plywood is greater than the multiplier for the logging and lumber sectors, and thus the increase in plywood output in the scenario has a relatively greater positive effect on total economic activity than does the reduction in logging and lumber output. Second, the value of output that can be produced from a given amount of timber is greater in the plywood sector than in the lumber and logging sectors.
In addition to the previously discussed model shortcomings regarding the definition of log export activity and the exclusion of the multiplier effects of government spending, we should note several other limitations. First, the inter-industry structure represented in IMPLAN has been calibrated on the basis of 1977 Census data, and thus does not reflect the structural changes that have occurred over the past 12 years. We do not know what effects these structural changes would have had on the scenario outcomes. Second, the labor productivity and income coefficients in the model reflect 1982 conditions, and thus do not reflect the productivity improvements in the wood products industry that have occurred since then, or the relative declines in employee compensation observed in the industry. The model's estimates of employment and income changes associated with the various scenarios are thus somewhat overstated. Despite these limitations, the IMPLAN model still provides very useful and detailed insights on the general economic consequences of structural changes in the wood products industry.

We cannot look to the input-output analysis for an explanation of the underlying causes of the changes in product mix within Oregon's wood products industry. These changes have been the result of factor mobility in the timber input markets. Timber inputs are processed into alternative products in correspondence with the relative returns that can be obtained from the product markets. Given a change in the relative returns to timber among competing products, one can expect a shift in timber allocation to those products whose relative returns are increasing. The estimated relative returns among lumber production, plywood production and log exporting activity over the past decade [1] provide support for the contention that the changes in product mix are the result of conventional market forces. Nevertheless, the consequences of these changes for employment, income and output in Oregon's timber dependent regions have not been favorable.
A Log Export Ban and the Spotted Owl Controversy

In addition to examining the effects of changes in the mix of outputs produced by the wood products industry, the input-output framework can be used in estimating the economic consequences of several other issues of current importance in Oregon, namely, a ban on the export of logs harvested from the state forests and a harvest reduction in the federally managed forests resulting from injunctions on timber sales in areas containing the spotted owl habitat. In both cases, however, the economic estimates provided by the IMPLAN model must be qualified by consideration of important exogenous market factors that are likely to have a significant bearing on the outcomes. Thus we will address the log export and harvest limitation issues by first reporting the input-output estimates of changes in economic activity. We will then discuss the effects of exogenous factors on the input-output estimates.

In 1985, timber harvested from state forests accounted for approximately seven per cent of log exports from Oregon [18]. Assuming that this percentage has remained constant in subsequent years, about 100 million board feet of timber harvested from the state forests (50 per cent of the total harvest) was exported in 1988. An export ban would shift this timber to the domestic market for processing into lumber and plywood. Using the data provided in Figure 4, we reallocated this timber from the export to the lumber and plywood sectors on the basis of the latter sectors' relative shares of timber consumption in 1985. Given the sectoral changes in timber consumption, the changes in economic activity in the state were then determined in the same fashion as in the product mix scenarios.

As of May 1989, U.S. District Court injunctions had halted sales of 758.4 million board feet of timber in the national forests and 337 million board feet in forests managed by the Bureau of Land Management [6]. These amounts represent nearly 30 per cent of the 1989 state sales targets for both the Forest Service and the BLM. As in the case of log exports, we allocated these reductions in timber consumption to the lumber and plywood sectors.
sectors using their respective 1985 shares of total timber consumption, while the harvest reduction was allocated to the logging sector.

The IMPLAN model estimates of the changes in state gross output and employment are presented in Table 5. The log export ban is projected to add $42 million to state gross output and over 400 jobs, while the harvest limitation results in a loss of 12,000 jobs and $1,150 million in gross output.

Table 5

Changes in Output and Employment Resulting From a Log Export Ban and Harvest Restrictions
(millions, 1982 dollars; person-years employment)

<table>
<thead>
<tr>
<th></th>
<th>Log Export Ban</th>
<th>Harvest Limitation</th>
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<tbody>
<tr>
<td>Change in Timber Harvested</td>
<td>0</td>
<td>-1,095.4 MMBF</td>
</tr>
<tr>
<td>Change in Timber Processed</td>
<td>98 MMBF</td>
<td>-1,095.4 MMBF</td>
</tr>
<tr>
<td>Change in Gross Output</td>
<td>41.7</td>
<td>-1,152</td>
</tr>
<tr>
<td>Change in Employment</td>
<td>438</td>
<td>-12,110</td>
</tr>
</tbody>
</table>

The estimates of increased employment and output associated with the log export ban are likely to be too high because they ignore the possible substitution of private timber for the state timber withdrawn from the export market. It has been estimated that as much as 50 per cent of the reduction in exports from the state forests would be offset by diversions of timber harvested from private forests from the domestic to the export market [4]. As a result, the net addition of timber to the domestic market would be 50 million board feet, not 100 million. This substitution effect also produces a transfer of wealth from the state to private timber owners, given the price premium obtainable in the export market.

Considering both the foregone revenues to the state and the private timber substitution effect resulting from an export ban for the state of Washington, Aust [4] estimated a net cost to the state per job created of about $110,000. Aust also noted that this figure did not account for
employment losses resulting from reduced state expenditures or increases in taxes resulting from reductions in harvest revenues. Applying the assumptions used by Aust - a $200/MBF foregone price premium for export logs and a 50 per cent volume offset due to private timber diversions to the export market - our results translate into a cost-per-job-generated estimate of $89,000.

The estimated reductions in economic activity associated with the harvest limitation are also likely to be too great for the following reasons. First, the 1982 labor productivity values in IMPLAN tend to overestimate the employment changes, given subsequent improvements in productivity. Second, the harvest reduction in the federal forests can be expected to be partially offset by increases in harvests from private lands, considering the upward pressure that a harvest limitation would place on stumpage prices. Third, Forest Service and BLM sales targets in areas unaffected by the harvest limitations could be increased.

The exogenous effects noted above do not preclude the use of inter-industry models in analyzing the repercussions of situations like those just presented, but they do make meaningful evaluation more difficult. Substitution, supply and differential timber price effects can be brought to bear, a priori, in estimating sectoral final demand changes in the inter-industry model. Because harvest revenues play an important role through local government expenditures, closure of the model with respect to the government sector would also permit the determination of the multiplier effects of harvest-induced changes in government activity.

Conclusions

The late 1970's were a boom period for Oregon's wood products industry. For timber, the major impact of the increase in wood products demand during this period was a rapid increase in its price. With relatively expensive timber, other inputs were used more intensively to recover more output per unit of timber input. The shift from the high demand
and high price conditions of the 1970's to the recession of the early 1980's resulted in a large drop in output and employment in the industry. The aftermath of this recession was then primarily characterized by a much more rapid recovery of industry output than employment, which motivated the concerns about the apparent rapid increases in labor productivity.

In most industries, a downturn in the business cycle leads to a reduction in nominal labor productivity because firms slow to pare their workforce. During an upturn firms are also slow to hire additional workers, so output per worker tends to increase. But this pattern does not fully characterize the experience of the wood products industry during the period from 1979 onward. The conventional cyclical effects on labor productivity during this period were augmented by structural changes in the industry and price-induced changes in the intensity of factor utilization.

The evaluation of labor productivity changes in the wood products industry is clouded by the apparent decline in the quality of the timber processed. Smaller diameter logs are being harvested, and their more uniform size makes automated processing more feasible. The shift to new automated processing technologies should reduce labor requirements per unit of output. But interviews with the managers of 23 lumber and plywood mills in the state indicated that productivity improvements following the adoption of automated processing technologies have not been readily apparent [10].

The consequences of labor productivity improvements for the economic vitality of Oregon's timber dependent communities have been a concern of researchers in this region for some time [12, 13, 21]. In evaluating this issue 20 years ago, Schallau et al [12] concluded:

Peripheral communities having weak ties with area and regional centers are likely to become increasingly isolated as total employment declines in response to rising productivity per worker in the timber-dependent industries and relocation of high-order services to larger places (p. 104).
Thus the rapid increase in the industry's labor productivity in the 1980's has brought renewed attention to the question of community stability in resource dependent areas, and has provided additional incentive to the search for alternative development possibilities. A ban on log exports can appear to be very attractive in such a context, because it promises to increase labor intensity in the processing of the state's timber resources. The opportunity costs associated with such endeavors are more easily forgotten in the conditions that have characterized the recent employment decline in the industry. Potentially more constructive are the planning efforts throughout the state resulting from legislation enacted in 1987 [9], which appropriated $25 million to finance the implementation of a comprehensive set of "regional strategies" for economic development.

Projections of timber supply constraints in the state, coupled with the potential for further limitations following the resolution of the spotted owl conflict, could dwarf the concerns about labor productivity-induced employment declines. We are now witnessing an intense debate over forest management policies. Ten years ago Stevens [13] offered a prediction of the nature of this debate, and it is becoming apparent that he was on the mark:

Timber-dependent communities will resist further encroachments on their timber base, owners of fixed capital will press for an expanded public harvest, and environmentalists will do battle with both. (p. 717)

Even a "best case" scenario regarding the resolution of the present timber harvest debate in Oregon indicates that the amount of timber that will be processed in the 1990's will be less than what was processed in the 1980's. Further employment declines in the state's timber-dependent regions can thus be expected as the result of cuts in output and continuing improvements in labor productivity.

Policy initiatives can play both a direct and indirect role in mitigating the effects of the employment decline. More general economic development initiatives, such as the regional strategies program mentioned earlier, can produce new employment opportunities for those who will be entering the labor force in these areas in the coming years. For those
workers now employed in the wood products industry, programs for retraining the relatively unskilled group of "core" occupations [13] may be needed.

Unlike many other industries, general conditions affecting output and employment in the wood products sector can be more readily foreseen, given the very long term growth cycle of the timber resource base on which this industry depends. It would be to the advantage of the state and its timber-dependent communities to capitalize on the advantages that such foresight provides by initiating efforts to address the economic adjustments accompanying the anticipated declines in wood products output and employment.
References


