FTAA and Alabama Forest Products:
Adjustment in a Specific Factors Model

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The Free Trade Area of the Americas FTAA will increase import competition and export opportunities for forest product industries in Alabama. These industries are important in Alabama and also major sources of pollution. The present paper gauges the potential impacts of FTAA for Alabama in an applied specific factors general equilibrium model of production that includes pollution impacts. Effects of changing prices on outputs and capital returns in the forest products industries are large as are changes in pollution emissions. The wage generally rises and energy demand falls.

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Forest product industries will be affected by the Free Trade Area of the Americas FTAA, the pending free trade agreement to include all of the Americas. The Southeast accounts for about three quarters of US pulpwood production and Alabama for 11%. In the state, the Alabama pulp and paper industry accounts for 3% of output. The present paper offers some perspective on the potential economic impact of FTAA on production and income distribution in a specific factors model of production focused on forest product industries in Alabama.

Data from the International Trade Center of the US Department of Commerce indicate ratios of US exports to outputs for paper board and paper mill products are both 13%, and the ratios of imports to output 18% and 23%. Trade levels seem likely to increase in FTAA and the present simulations examine a range of forest product price changes for sensitivity.

Import competition will increase for some forest products but the growing economies in Latin American offer expanding opportunities. The USDA Economic Research Service (USDA/ERS, 1998a) predicts increased forest product trade under FTAA. Prestemon (1998b) predicts FTAA will result in a small expansion of forest product exports to the Caribbean in a partial equilibrium model while Thompson and Toledo (2001) predict the Southeast will face competition from South America.

The present general equilibrium specific factors model of production and trade examines the effects of a range of exogenous product price changes on wages, capital returns, and industrial outputs. The present model simulates the effects of FTAA price changes including pollution adjustment, exploring a range of potential impacts.

1. The theory and evidence on trade adjustment

Gains and losses with FTAA will vary across industries, similar to the effects of NAFTA. Boyd, Krutilla, and McKinney (1993) use a detailed GCE model to predict NAFTA would have noticeable effects on particular US industries and regions has been verified. Hanson (1994) predicts

NAFTA will benefit border states and the Midwest with losses in the Southeast. Marchant and Rupel (1993) and the USDA/ERS (1998a) find little pressure on average prices of agricultural products under NAFTA. Thompson (1996) predicts a slight wage increase in Alabama with a specific factors model of manufacturing. Wall (2000) shows that NAFTA has benefited manufacturing and services industries in Alabama.

Regarding trade and pollution, Batyabal and Beladi (2001) conclude that fears of unfair foreign advantage due to lax environmental regulations are exaggerated. Tobey (2001) finds no evidence that environmental policies have affected international patterns of production and trade in manufactures. Husted and Logsdon (2001) provide evidence that NAFTA has improved environmental policy raising production cost in Mexico.

Pulping involves bleach and release of a variety of stack emissions of hydrogen sulfides, nitric acids, and sulfuric acids as discussed by Smith (1997). Paper mills in Alabama use a daily average of 24 million gallons of water as reported by Ferguson (1998). The EPA Release Inventory (2003) reports the 16 paper mills in Alabama account for 65% of the water pollution and 32% of the air pollution in the state. Bailey and Newland (2000) show the racial profile of residents living close to these mills is disproportionately African American.

Pollution will remain an issue for the forest products industry and the present study examines potential adjustment in Alabama under FTAA.

2. The basic specific factors model

The present paper applies the comparative static model of competitive production and trade developed by Jones and Scheinkman (1977), Chang (1979), and Thompson (1995). Production has constant returns, competitive pricing, and cost minimization but Thompson (2003) shows relaxing these assumptions can have minimal impact. Capital is specific to each industry while labor and energy are mobile across industries.

Full employment of inputs is stated $v = Ax$ where v is the input vector, A is a matrix of cost minimizing unit inputs, and x is the output vector. Factor supplies are exogenous and perfectly inelastic. Take the differential $dv = xdA + Adx$ and introduce aggregate substitution terms $S_{ik} = \sum_j x_j(\delta a_{ij}/\delta w_k)$ summarizing input adjustments to changing factor prices to find

$$dv = Sdw + Adx. \tag{1}$$

Competitive pricing implies $p = A^T w$ where p is the vector of product prices and w the factor price vector. The Alabama economy is assumed to be a price taker in markets for finished products, including converted paper, paper mill output, and pulp & paperboard. Cost minimization implies $wdA^T = 0$ leading to

$$dp = A^T dw. \tag{2}$$

Putting (1) and (2) into elasticity and matrix form,

$$\begin{pmatrix} S & \lambda \\ \theta^T & 0 \end{pmatrix} \begin{pmatrix} w' \\ x' \end{pmatrix} = \begin{pmatrix} v' \\ p' \end{pmatrix} = \begin{pmatrix} 0 \\ p' \end{pmatrix} \tag{3}$$

Matrix S is the aggregate factor cross price elasticities. Industry shares λ are the share of factors employed in each sector, and factor shares θ the share of revenue paid to factors across sectors. Simulation involves introducing a vector of exogenous price changes and solving for endogenous adjustments in factor prices and outputs. Pollution is assumed proportional to output in the present application.

3. Forest product factor and industry shares

Data on value added, employment, factor payments, and labor in manufacturing are from the US Census of Manufacturers, energy data is from the Department of Energy, agricultural data from the USDA, and labor data for services from the Department of Labor. Value added in services is derived as the residual of gross state product. There is no energy input data for services and the smallest share of energy in manufacturing 2% is assumed. Pollution is tied to production at the 3-digit SIC industry level with data from the EPA Toxic Release Inventory (2003) as "release" for air pollution and "waste" for water pollution.

Table 1 shows total payments to labor L, capital K, and energy E with capital payment the residual of value added in agriculture A, services S, converted paper products C, paper mills P, pulp & paper board B, and the rest of manufacturing M. Summing down a column in Table 1 gives industry value added.

Table 1

Table 2 reports factor shares. For instance, value added in paper mills is $1,755 million and the labor share is 578/1,755 = 39.6%. The largest capital shares are in manufacturing M and agriculture A followed by paper board B. The forest products industries C, P, and B have smaller capital shares than the rest of manufacturing M. Labor shares are highest in services S and the three forest products industries, and the energy share is high in converted paper products C.

Table 2

Summing across rows in Table 1 gives total factor income. Assuming perfect labor and energy mobility, their prices are the same in each industry leading to the industry shares in Table 3. For instance, total labor income is $64,486 million and 578/64,486 = 0.9% of labor is employed in the paper mill industry P.

Table 3

The Latin American countries in FTAA will have abundant labor and relatively low wages. The implication is that the US would import products using labor intensively. Leamer (1984) and Bowen, Hollander, and Viane (1998) directly apply concepts of factor intensity and abundance. Table 4 reports factor intensities for pairs of inputs. For factors i and k and two products j and h, good j uses factor i intensively if

$$a_{ij}/a_{ih} > a_{kj}/a_{kh}. \tag{4}$$

The labor share in industry j is $\theta_{Lj} = wL_j/x_j$ where value added $x_j = p_j x_j$ and w is the wage and similarly for the capital factor share. The ratio of capital to labor factor shares is $\theta_{Kj}/\theta_{Lj} = ra_{Kj}/w_L a_{Lj}$ and

$$\theta_{Kj}/\theta_{Lj} = (a_{Kj}/a_{Lj})(r_j/w). \quad (5)$$

Table 4

The most labor intensive industries in manufacturing are converted paper C and paper mills P while paper board B is capital intensive relative to both labor and energy. The suggestion is that converted paper C and paper mills P will face import competition from labor cheap Latin America while paper board B would face less competition. Transport costs, however, will remain critical and paper mills P will be located close to forests. Converted paper products C and paper board B could face falling prices with import competition but there could be expanded export opportunities. Model simulations assume a range of price changes to gauge potential adjustments in Alabama.

4. Deriving cross price CES substitution elasticities

Substitution elasticities describe adjustment in the cost minimizing input of one factor due to a change in price of another as in Jones (1965) and Takayama (1982). The cross price elasticity between the input of factor i and the payment to factor k in sector j is

$$E_{ij}^{\ k} = \theta_{kj} S_{ij}^{\ k} \quad (6)$$

where S_{ij}^k is the Allen (1938) partial elasticity of substitution. With Cobb-Douglas production $S_{ij}^k = 1$ and constant elasticity of substitution CES scales the Allen partial elasticity. Linear homogeneity of the cost functions imply $\Sigma_k E_{ij}^k = 0$ and own price elasticities E_{ij}^i can be derived as the negative sum of cross price elasticities.

Substitution elasticities are the weighted average of cross price elasticities across industries,

$$\sigma_{ik} = \Sigma_j \lambda_{ij} E_{ij}^{\ k} = \Sigma_j \lambda_{ij} \theta_{kj} S_{ij}^{\ k}. \quad (7)$$

Cobb-Douglas elasticities are reported in Table 5, and as an example CES = 0.5 would imply elasticities half as large.

Table 5

The largest own substitution elasticity is labor and the smallest manufacturing capital. Own capital substitution elasticities in the paper industries C, P, and B are relatively high. Every 1% increase in its capital input price causes a 0.61% input decline in the paper board industry B but only 0.30% decline in manufacturing M. Own capital elasticities are smaller than own labor and energy elasticities except in services S, paper board B, and converted paper products C. Changes in wages induce more of adjustment in capital input than vice versa. Changes in energy prices generate less substitution than wages.

5. Comparative static properties of the forest products model

Solving the comparative static system (3) elasticities of factor prices with respect to product prices in Table 6 indicate some factors benefit while others lose with any price change, and benefits are uneven. A higher price raises the return to industrial capital but lowers other capital returns due to departing labor and energy. Price changes affect the returns to specific capital much more than the wage or the price of energy.

Table 6

A 1% increase in the price of pulp & paperboard p_B would have minor effects on the wage w and the price of energy e but increase the its capital return r_B by 3.89%. The higher price draws labor from other sectors but the effect is small because the relatively small industry uses labor the least intensively.

Price changes for converted paper products p_C and paper mills p_P have similar but somewhat larger effects. A 1% increase in the price of services p_S would raise the wage 1.81% and its capital return 3.62%, the large effect on the wage due to the large size of the sector. A 1% increase in the price of other manufactures p_M has an elastic 1.25% effect on the price of energy e due to its energy intensity and large size.

Price in the large service sector S has the strongest effects. Among the forest products industries, the paper mills price p_P has slightly larger impacts. These comparative static effects of prices on factor prices are the same for any degree of CES substitution.

Table 7 shows price elasticities of outputs along the production frontier. A higher price raises industry output attracting labor and energy inputs and lowering other outputs. All output effects are inelastic with the largest own effect 3.78% for paper mills P. The C-P-B paper industries have larger own output effects than manufacturing M. The service sector S own output elasticity is small due to the large size of the sector making it difficult to attract inputs from the rest of the economy.

Table 7

6. Potential factor price adjustments to FTAA

The method of projecting factor price adjustments is to multiply the matrix of factor price elasticities in Table 6 by an exogenous vector of price changes. The present simulated price changes range from 5% to -10% with increases for services p_S and decreases for manufacturing p_M and a variety of forest product prices changes in Tables 8, 9, and 10.

The price increases in the first column of Table 8 raise the wage w 12.8% and lower the price of energy e -7.53%. The higher wage is due mainly to the higher price of the large labor intensive service sector. The literature is unanimous that FTAA will promote US services. The return to capital in manufacturing r_M falls by 17.3%, and all capital return effects are magnified from price changes. The higher prices have large positive effects on capital returns in paper mills r_P, converted paper products r_C, and paper board r_B.

*Table 8 *

The second column in Table 8 assumes symmetric price declines for forest products B-C-P, resulting in lager increases in the wage and energy price. Falling prices of forest products is slightly better for aggregate labor since these industries are not labor intensive. Declining prices have large negative effects on forest product capital returns. The large expanding service sector attracts a good deal of labor and energy from forest products as well as manufacturing.

The price of capital intensive paperboard p_B is assumed to rise in Tables 9 and the increase in the price of services is smaller at 3%. The wage is tied closely to the price of services, increasing only 7.84% in the first column, and the energy price effect is dampened by the smaller price decreases. Larger adjustments occur in the second column with an increase in the price of agriculture and a larger increase in the price of paperboard p_B.

* Table 9 *

Table 10 represents a radical price scenario with prices changing by 10%. The price of capital intensive paperboard p_B rises while prices in other forest products and manufacturing fall. The wage and energy price changes are quite large. Industrial capital return changes are larger than their price changes due to the magnification effect.

* Table 10 *

7. Potential output and pollution adjustments to FTAA

Output adjustments are found by multiplying the output elasticities in Table 7 by projected price changes. With the price increases in the first column of Table 8, manufacturing output x_M falls -6.56% while agricultural output x_A increases 4.54% and service output x_S 10.5%. The increased output of paper mills x_P is about three times that of converted paper products x_C and paper board x_B.

The downside output effects with price decreases are much larger for paper industries B-C-P. Forest product industries are small and unable to attract much labor or energy from the rest of the economy. If the B-C-P prices fall, labor and energy are readily absorbed by the rest of the economy and output falls considerably. Output adjustments in Tables 9 and 10 are also quite large suggesting a lot will be at stake as the forest product industry adjusts to FTAA.

Associated changes in pollution for the forest products industries follow outputs, and net effects depend the size and direction of output adjustments. The 5% price increases in Table 8 generate increases of 1,544 tons of air and 11,838 tons of water pollution. For paper mills P, increases are 565 and 4,793 tons of release and waste from initial levels of 3,643 and 30,885 tons. For paper board production B the changes are 750 and 4,807 tons for release and waste from initial pollution levels of 13,394 and 85,830 tons. There are also increases of 229 and 2,238 tons from converted paper products C in release and waste from initial levels of 3,930 and 38,388 tons.

With falling outputs in the second column of Table 8, the associated reductions in pollution are 4,161 and 31,666 tons total release and waste, almost three times the size of the increases. For paper mills P there are decreases of -798 and -6,768 tons of release and waste for paper mills. For paper board B there are reductions of -2,388 and -15,301 tons, and for converted paper products C reductions of -981 and -9,352 tons.

Adjustment magnitudes depend on price changes and substitution. All adjustments vary directly with uniform price changes. Constant elasticity of substitution CES production scales output and pollution adjustments. For instance, CES = 0.5 implies half the reported adjustments in outputs and pollution levels.

8. Conclusion

The present specific factors model projects potential income redistribution, output adjustments, and changes in pollution due to FTAA focusing on Alabama forest product industries. The wide range of simulated adjustments in outputs and capital returns for forest products suggests substantial economic adjustment. The present model generally projects higher wages, lower energy prices, and increased capital returns in agriculture and services but lower returns in manufacturing. Pollution in Alabama will be affected depending on output adjustments in the forest products industries.

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Table 1. Factor Payments, $mil

	A Agriculture	S Services	C Conv Paper	P Paper mill	B Paper board	M Mfg	Total
L	126	43,019	119	578	269	20,375	64,486
K	447	29,815	126	978	1,046	24,886	57,298
E	103	1,486	57	206	174	14,366	16,392
Total	676	74,320	302	1,755	1,489	59,627	138,176

Table 2. Factor Shares θ_{ij}

	A	S	C	P	B	M
L	.186	.579	.351	.396	.329	.180
K	.661	.401	.392	.416	.553	.702
E	.153	.020	.257	.188	.117	.117

Table 3. Industry Shares λ_{ij}

	A	S	C	P	B	M
L	.002	.667	.002	.009	.004	.316
K	.008	.520	.002	.017	.018	.434
E	.006	.091	.003	.013	.011	.876

Table 4. Factor Intensities

	K/E	K/L	E/L
A	4.34	3.55	0.82
S	20.1	0.69	0.04
C	2.21	1.06	0.48
P	4.75	1.69	0.36
B	6.01	3.89	0.65
M	1.73	1.22	0.71

Table 5. Substitution Elasticities σ_{ik}

	w	e	r_A	r_S	r_B	r_C	r_P	r_M
$\hat{a}_L$	-.951	.449	.001	.400	.001	.005	.002	.094
$\hat{a}_E$	.221	-.552	.002	.054	.002	.007	.005	.260
$\hat{a}_A$	.186	.153	-.339	.000	.000	.000	.000	.000
$\hat{a}_S$	.579	.020	.000	-.599	.000	.000	.000	.000
$\hat{a}_B$	.351	.257	.000	.000	-.608	.000	.000	.000
$\hat{a}_C$	.396	.188	.000	.000	.000	-.584	.000	.000
$\hat{a}_P$	.329	.117	.000	.000	.000	.000	-.446	.000
$\hat{a}_M$	.180	.117	.000	.000	.000	.000	.000	-.297

Table 6. Factor Prices and Prices

	p_A	p_S	p_B	p_C	p_P	p_M
w	-.005	1.81	-.003	-.012	-.014	-.780
e_E	.008	-.304	.004	.021	.023	1.25
r_A	6.51	-.889	-.016	-.075	-.081	-4.45
r_S	-.014	3.62	-.012	-.075	-.048	-2.47
r_B	-.005	-2.01	3.89	-.015	-.015	-.841
r_C	-.007	-3.15	-.004	5.30	-.021	-1.12
r_P	-.023	-3.66	-.014	-.065	8.48	-3.71
r_M	-.040	-.963	-.023	-.106	-.114	2.25

Table 7. Output and Prices

	p_A	p_S	p_B	p_C	p_P	p_M
x_A	2.21	-.592	-.006	-.026	-.028	-1.56
x_S	-.006	1.12	-.006	-.038	-.021	-1.05
x_B	-.003	-1.78	2.36	-.011	-.010	-.559
x_C	-.004	-2.50	-.002	3.10	-.011	-.581
x_P	-.010	-2.19	-.006	-.027	3.78	-1.55
x_M	-.012	-.577	-.007	-.032	-.034	.662

Table 8. Adjustment to FTAA with ±5% Price Changes

% Price			% Factor Price			% Output			Release (Tons)	Waste (Tons)	Release (Tons)	Waste (Tons)
			w	12.8	13.1							
			e	-7.53	-8.01							
A	0	0	r_A	16.9	18.7	x_A	4.54	5.14				
S	5	5	r_S	29.8	31.1	x_S	10.5	11.2				
B	5	-5	r_B	13.5	-25.1	x_B	5.59	-17.8	750	4,807	-2,388	-15,307
C	5	-5	r_C	16.2	-36.5	x_C	5.84	-25.0	229	2,238	-981	-9,592
P	5	-5	r_P	42.3	-41.8	x_P	15.5	-21.9	565	4,793	-798	-6,768
M	-5	-5	r_M	-17.3	-14.9	x_M	-6.56	-5.83				
								total	1,544	11,838	-4,167	-31,666

Table 9. Adjustment to FTAA with 3% and 5% Price Changes

% Price			% Factor Price			% Output			Release (Tons)	Waste (Tons)	Release (Tons)	Waste (Tons)
			w	7.84	9.43							
			e	-4.78	-7.34							
A	0	3	r_A	11.1	39.8	x_A	3.05	12.9				
S	3	3	r_S	18.6	23.7	x_S	6.67	8.86				
B	3	5	r_B	8.25	17.8	x_B	3.48	9.35	467	2,993	1,255	8,041
C	-3	-5	r_C	-21.9	-30.3	x_C	-15.0	-20.1	-589	-5,760	-787	-7,688
P	-3	-5	r_P	-25.1	-34.6	x_P	-13.2	-17.6	-480	-4,072	-642	-5,444
M	-3	-5	r_M	-9.05	-13.3	x_M	-3.54	-4.78				
								total	-602	-6,839	-174	-5,091

Table 10. Adjustment to FTAA with 10% Price Changes

% Price			% Factor Price			% Output			Release (Tons)	Waste (Tons)	Release (Tons)	Waste (Tons)
			w	13.4	17.1							
			e	-13.8	-14.4							
A	3	5	r_A	62.8	74.0	x_A	20.9	24.2				
S	3	5	r_S	36.6	43.8	x_S	14.4	16.6				
B	10	10	r_B	41.6	37.5	x_B	24.1	20.5	3,227	20,682	2,748	17,616
C	-10	-10	r_C	-51.1	-57.4	x_C	-32.6	-37.6	-1,279	-12,498	-1,475	-14,417
P	-10	-10	r_P	-58.2	-65.6	x_P	-28.7	-33.1	-1,043	-8,852	-1,203	-10,209
M	-10	-10	r_M	-23.5	-25.5	x_M	-7.80	-8.98				
							total		905	-667	70	-7,010