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Economics impacts on Tennessee's state and regional gross product of three value added forestry development strategies : an integrated linear programming input-output approach

Jorge Alfredo Huarachi Chavez

To the Graduate Council:

I am submitting herewith a dissertation written by Jorge Alfredo Huarachi Chavez entitled "Economics impacts on Tennessee's state and regional gross product of three value added forestry development strategies : an integrated linear programming input-output approach." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

Burton C. English, Major Professor

We have read this dissertation and recommend its acceptance:

Paul Winistorfer, Daniel De La Torre Ugarte, Roland K. Roberts, Greg Pompelli

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Economics Impacts on Tennessee's State and Regional Gross Product of Three Value Added Forestry Development Strategies: An Integrated Linear Programming Input-Output Approach

A Dissertation
Presented for the Doctor of Philosophy Degree
The University of Tennessee, Knoxville

Jorge Alfredo Huarachi Chavez
May 1999

DEDICATION

The Author wishes to dedicate this study to his parents, brothers, and sisters: Armando Huarachi and Consuelo Chavez de Huarachi, Armando, Antonio, Maria Eugenia, Juana, Carmen, and Veronica. Through these years, their support, love, and encouragement provided the strength and perseverance to complete this research and my graduate studies.

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ABSTRACT

Tennessee has a sizable timber resource encompassing more than 13.3 million acres that spread across the state. Tennessee's forest products industry is one of the basic industries with $4 billion of direct contribution to the gross state product. Although Tennessee's forest resource base is comparable with neighboring states such as Mississippi and North Carolina, state wood processing industries remain behind their counterparts in neighboring states. At the same time, many rural counties have been declared as persistent low income non-metro counties characterized by low rates of growth and high levels of unemployment. The forestry sector has the potential to became an engine of growth and jobs not only in these depressed counties but also in other rural counties, bringing stability and maximizing economic contribution.

This study attempts to measure the economic impacts in terms of value added, output, and employment of three value added development strategies: import substitution of roundwood by local production; reduction in out-of state roundwood exports and increase in wood processed products; and value added driven development growth policy by identifying which industry sectors will contribute more to the regional and gross state product.

The study areas are the five economic areas developed by the Bureau of Economic Analysis Division of the Department of Commerce. Theses regions are Knoxville, Nashville, Chattanooga, Tricities, and Memphis areas. To evaluate these value added strategies, an integrated Input-Output and Linear Programming model was implemented, Tennessee Agricultural and Industrial Model (TNAIM). A non-survey

input-output model, IMPLAN, was used to create input-output regional models. These regional models were adjusted to incorporate agricultural output data to improve the overall accuracy of the I/O models. These hybrid models allowed the construction of the regional baselines for 1994. The baseline I/O models supplied I/O coefficients to the TNAIM. In addition, the Forestry Inventory Database (FIA), and Tennessee timber production and timber trade data was used to developed timber, land and trade coefficients for the TNAIM. A baseline for the TNAIM for 1994 also was developed. The alternative scenarios designated to evaluate the alternative development strategies were implemented in TNAIM. The comparison between the baseline and Scenario runs captured both the direct and indirect economic impacts. Then, the induced effects were estimated by placing the changes in industry outputs into the regional I/O IMPLAN Models. The summation of direct, indirect and induced effects constituted the total economic effects.

In the import substitution strategy Scenario I-A, a reduction in 10 percent of roundwood out-of-state imports has a positive effect on the regional economy. Total state output increases $22.03 million, value added is $7.84 and employment is 206 jobs. A reduction of one million dollars in output of imported logs brings to the state economy an increase of $2.64 million in total output, $ 0.97 million in value added and 25 additional jobs. In the import substitution strategy Scenario I-B, a reduction of 20 percent in roundwood out-of-state imports increases state gross product by $14.16 million, industry output by $38.63 and employment by 369 new jobs.

The reduction of out-of-state exports of roundwood and increase in wood processed products exports have a greater economic impact over the state economy. Total industry output increases to $182.16 million, value added in $93.90 million and employment in 2,758 new jobs. Similarly, a reduction in 20 percent of out-of-state exports of roundwood and increase in wood processed products have a positive impact in industry output of about $287.56 million, value added in $173.10 million and employment in 3,770 new jobs.

The last strategy scenario III-A, an increase of timber supply, a 5 percent in softwood and 10 percent in hardwood and increase in wood processed exports brings to the state economy about $ 305.93 million, value added in $183.54 and in employment in 3,892 new jobs. Finally, the scenario III-B, an increase of timber supply of about 10 percent for softwood and 20 percent for hardwood brings to the economy an increase in industry output of about $411.13 million, in value added $242.56 million and in employment 5,596 additional jobs.

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CHAPTER I

INTRODUCTION

Statement of the Problem

Per-capita personal income is unevenly distributed across regions in Tennessee (Center for Business and Economic Research, 1996). Moreover, in rural regions approximately 27 counties have been declared as persistent low-income non-metro counties (Ross and Green, 1985). These counties were classified as such because each reported per-capita income in the bottom quintile of all rural counties in the United States in four time periods (1950, 1959, 1969, and 1979). Low income per-capita, low rate of growth and high rate of unemployment are some of the economic indicators of well being that underlie the economic structure that foster rural poverty.

At the same time, these counties along with the rest of Tennessee's counties are endowed with abundant forest resources that encompass more than 13.3 million acres. Thus, the forestry sector could play an integral role in bringing economic growth and new jobs to these low per-capita income counties. The development and diversification of the forestry sector in Tennessee has the potential to bring additional economic growth to rural areas rich in forestry resources. Low labor cost and access to abundant raw materials are attractions to value added forest processors. Additionally, value added industries tend to

have strong backward linkages with local suppliers. According to the 1996 Economic Research Service *Rural Manufacturing Survey*, non-metro value added industries on average purchase 45 percent of their materials and inputs locally so they become more closely integrated into the local economy and have a greater economic impact.

In connection with Tennessee's abundant forest resources, a major regional change in the source of the U.S. timber supply is occurring from western states to southern states (Haynes and Adams, 1992; Stewart and Wikle, 1996). In the next fifty years, the southern states will play a big role as a major source of domestic timber supply because of their vast forest resources and the restrictions placed on western timber. The south has several comparative advantages over other regions: relatively rapid forest growth rates; large existing wood inventories containing high percentages of usable timber; good access to timber stands; and continued net reversion of agricultural lands to forest land use (Alig et al., 1996). This expansion will come particularly with the increase in timber production on privately owned lands, an important feature with implications in income distribution and regional impacts.

Tennessee's forest products industries contribute with an estimated $4 billion yearly to the state gross product (Tennessee Statistical Abstract 1996/1997). Tennessee forest resources are mainly hardwood, ranking within the top five hardwood lumber producers in the nation. Tennessee's ratio of growth to removals is the highest relative to other southern states, which reflects the potential for the development of a strong, sustainable, and value added forest products industry.

Currently, many states in the south are pursuing policies aimed at growth of value

added industries, which base their growth on abundant natural resources such as the forestry industry. The Tennessee Forest Product Center located at the University of Tennessee has among its policy objectives the enhancement of the value added manufacturing sector, processing opportunities, and the development of new technologies for the growth of Tennessee's value added forest products industries. In this context, this study attempts to measure at the aggregate level the impacts of several developmental strategies on the regional and state gross product.

Research Objective

The objective of this study was to measure the value added, output, and employment effects at the regional and state levels for the following development strategies:

1. Import substitution of roundwood by local production.
2. Reduction of roundwood exports and increase of secondary processing industry products.
3. Value added-driven development growth policy by identifying which industrial sectors will have more potential for increasing gross state product, income, and employment.

Tennessee Economic Situation: A General Overview

Tennessee's Gross State Product[1] (GSP) was $ 102.2 billion or 1.9 percent of the U.S. value added or gross domestic product (GDP) in 1994. The manufacturing sector is the leading contributor to Tennessee GSP, accounting for 24.7 percent. Other sectors such as trade, services, and finance, insurance & real state (F.I.R.E) contribute with 19, 16, and 14 percent to the GSP, respectively (Figure 1.1).

In 1994, from a total manufacturing GSP of $25.3 billion, 54 percent was distributed among the non-durable goods sectors while the remaining 46 percent was distributed among durable goods manufacturing sectors. Among the durable goods industry sectors, major contributors were industry and communication machinery, transportation equipment, electronic equipment, and fabricated metals. The lumber and wood products, and furniture and fixtures industry sectors accounted for 4.3 and 6.2 percent of total durable goods sector's GSP, respectively (Figure 1.2). Among the non-durable goods, significant industry sectors were chemicals, rubber and plastic, food, and paper, which accounted for 21, 12.2, 20.8, and 13.4 percent of the non-durable goods' gross state product.

In 1994, total state merchandise exports to the rest of the world amounted to $ 7.5 billion. From this total, 81 percent originated from the manufacturing sector while 16.3 percent originated from the agricultural and livestock industry sectors (Figure 1.3).

[1] The gross state product is the aggregation of total spending by four broad sectors of the economy, consumers, business, government, and foreigners.

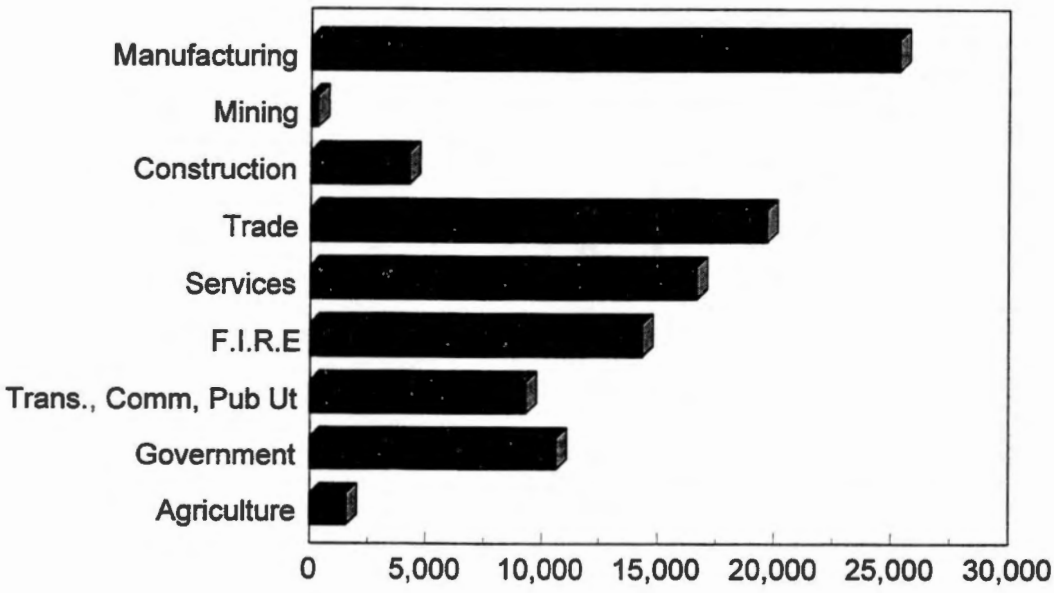

Figure 1.1 Distribution of Tennessee gross state product 1994 among major economic sectors, in $ millions

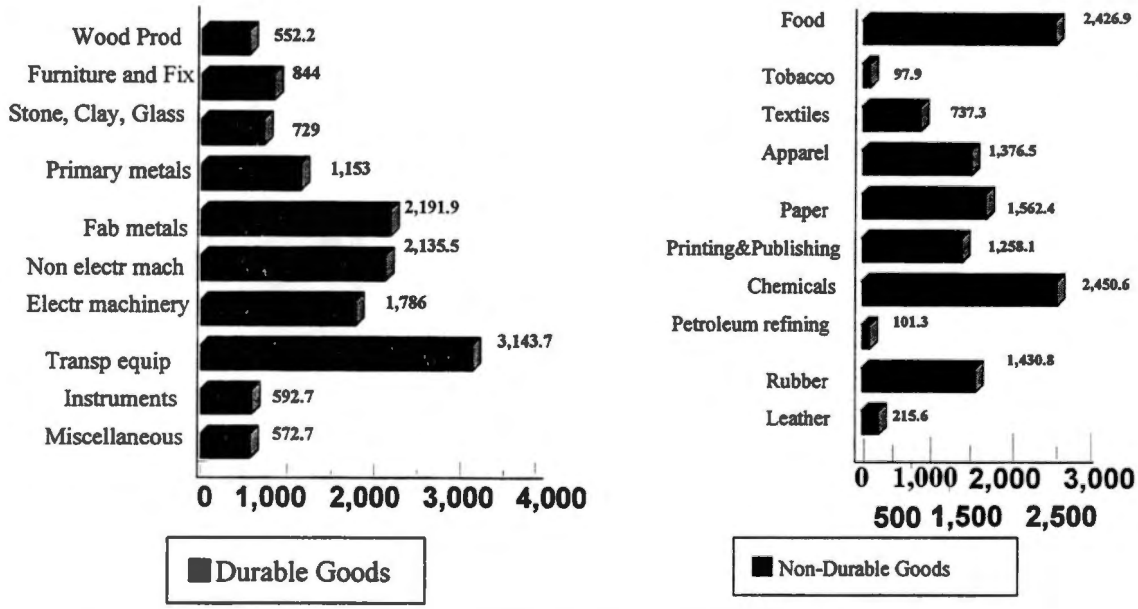

Figure 1.2 Distribution of manufacturing gross state product in millions $

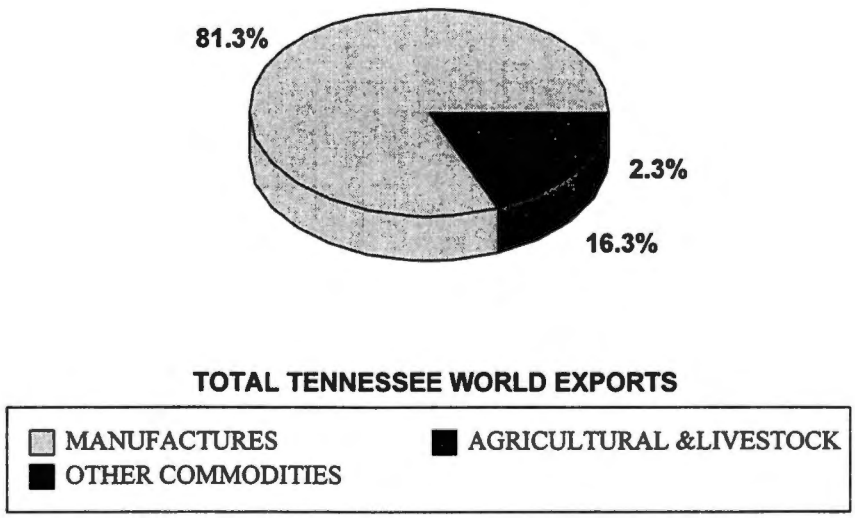

Figure 1.3 Tennessee merchandise exports to the world

The total state manufacturing exports to the rest of the world amounted to $ 6.1 billion. From this total, durable manufacturing goods accounted for 55.2 percent of the fixtures accounted for 1.4 and 1.8 percent of the total state manufacturing exports respectively (Figure 1.4).

By 1994, the Tennessee labor force was approximately 2.4 million workers. From this total, services industry sectors accounted for 24.6 percent, trade for 23.1 percent, manufacturing for 22 percent, and state and local government for 15.1 percent of the total state labor force (Figure 1.5).

During 1994, 538 thousand workers were employed in manufacturing related sectors. Among the durable goods manufacturing sectors, transportation equipment accounted for 18.6 percent, followed by fabricated metals with 16 percent, and electrical and non-electrical machinery with 14.0 and 14.6 percent, respectively (Figure 1.6). Furniture & fixtures and wood products industry sectors employed 10.5 and 7.3 percent, respectively, of the total number of jobs in the durable goods industry sectors. In the non-durable goods industry sector category, apparel, food, printing and publishing, and chemicals were the leading employers in the state. The paper and allied products industry sectors accounted for 8.8 percent of the total state jobs in the non-durable industry sectors. In summary, the forest related industries contributed directly with $ 2.9 billion in 1994 dollars to the state economy and employed 72,900 people statewide.

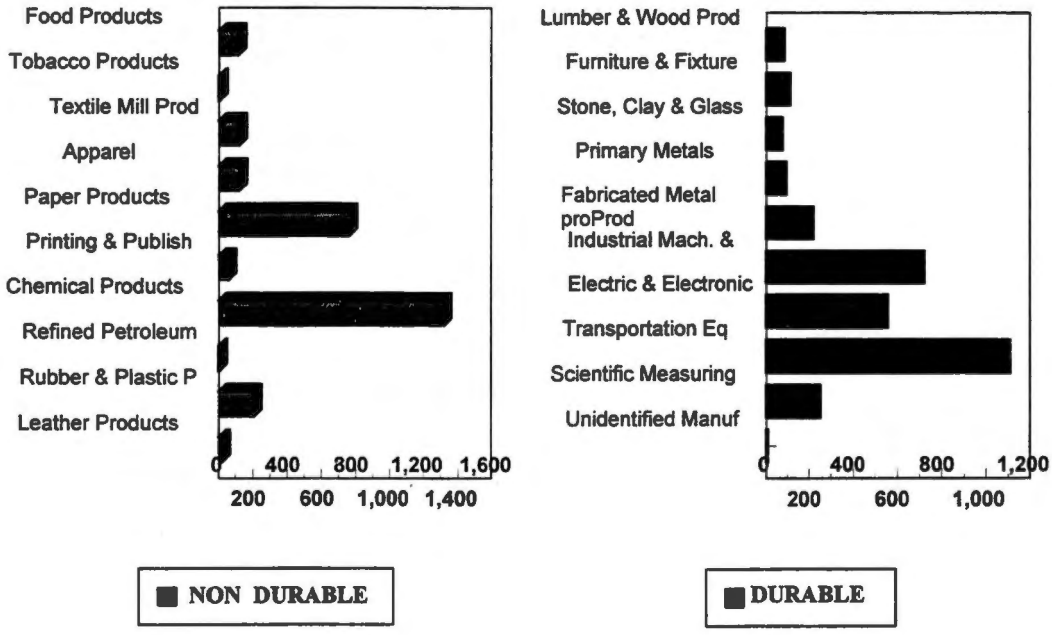

Figure 1.4 Distribution of Tennessee exports manufactures to the world 1994 among durable and non-durable producer sectors in millions

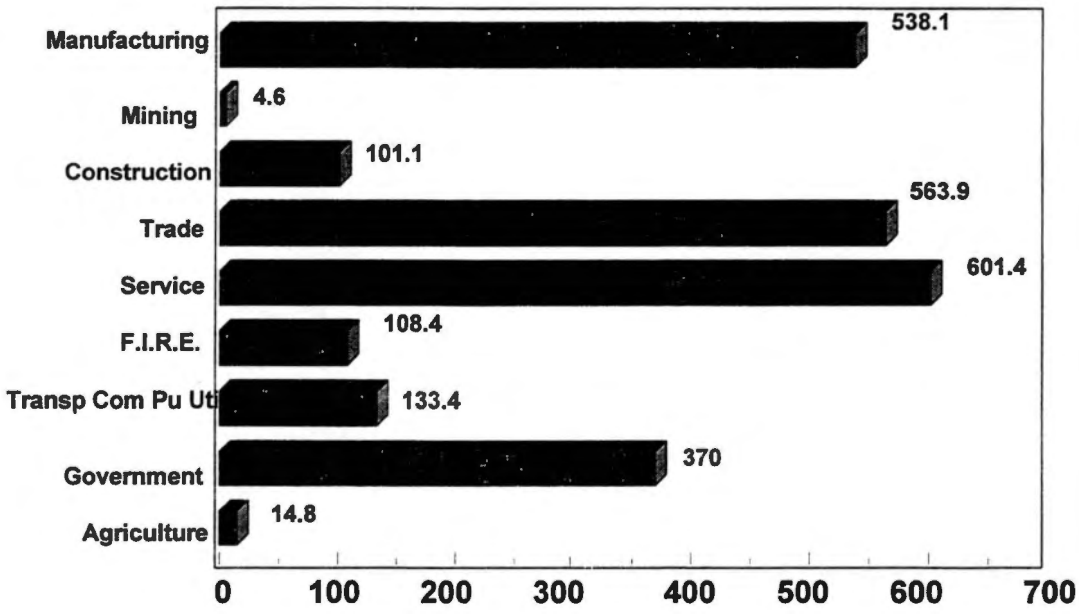

Figure 1.5 Tennessee labor force distribution among major economic in 1994 in thousand of jobs

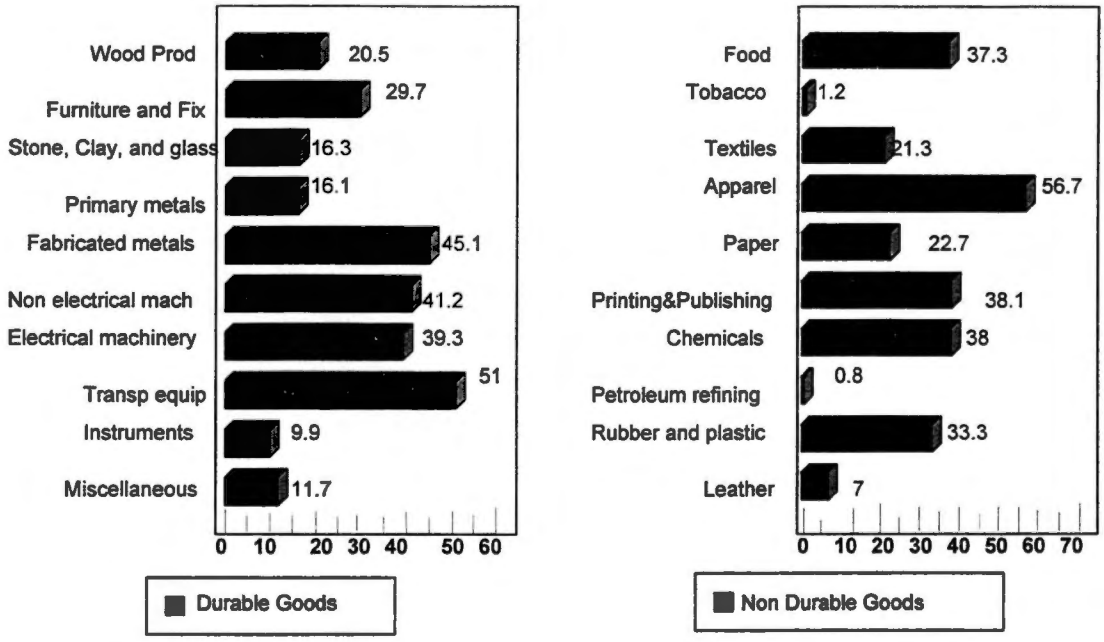

Figure 1.6 Tennessee manufacturing jobs distribution among non-durable and durable producer sectors 1994 in thousand of jobs

Forestry and Forest Activities: An Overview

The Study Regions

The study area is defined following the recent Bureau of Economic Analysis (BEA) economic areas as revised in 1995. The five B.E.A. regions encompassing the entire state of Tennessee are: Knoxville , Nashville, Chattanooga , Tricities , and Memphis. Figure 1.7 depicts the counties that comprise the five regions. The names of the regions identify the main metropolitan areas that serve as centers of economic activity and include economically related peripheral counties to that node (city) to form an economic region. The main criterion used to assign counties to a particular region is the commuting patterns. The delimitation of a particular region was made with the objective to maximize the number of people who work and reside within the boundaries of an economic area thereby reducing commuting across boundaries. The basic assumption is that personal consumption of goods and services by the economic area's residents takes place primarily within boundaries of the economic area.

The Forestry Industry

The Bureau of the Census defines the wood products sector as all manufacturing activities that are classified in Standard Industrial Classification (2 Digits - S.I.C) groups: 24 (lumber and wood products), 25 (furniture and fixtures), and 26 (paper and allied products). The wood products industry transforms raw material into various semi-

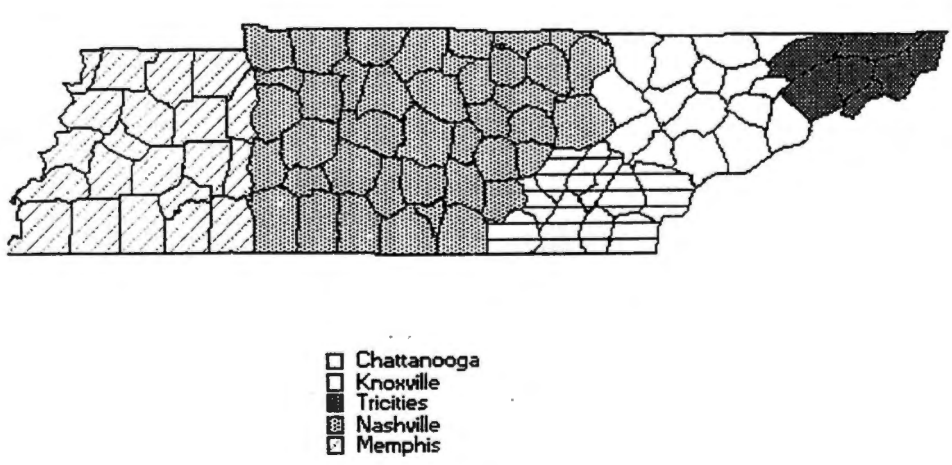

Figure 1.7 Tennessee B.E.A. regions

finished or finished products. The production process comprises three major stages: timber harvesting, primary processing, and secondary processing. The flow of raw material through the manufacturing process also produces by-products and waste materials some of which are reused and others which are disposed of. Figure 1.8 illustrates the flow of raw material and the product output from Tennessee's wood industry.

Primary forest products industries includes those establishments which are actively engaged in cutting, transporting, sawing, slicing, chipping, or other initial processing methods of raw wood. In Tennessee, these include logging camps and contractors (SIC 241); sawmills and planing mills (SIC 242); millwork, veneer, plywood and structural wood members (SIC 243); pulp mills (SIC 261); paper mills (SIC 262); and paper board mills (SIC 263) (Table A.1 in Appendix A). Table 1.1 summarizes total value added, value of shipments, payroll wages, and other important economic statistics for the primary and secondary wood processing industry segments for Tennessee in 1994. By 1994, Tennessee wood primary industry sector produced $2.88 billion worth of goods, paid $459 million in wages, and added an estimated $1.43 billion in value added through manufacturing.

The secondary wood products industry firms are those engaged in the transformation of lumber, plywood, veneer, paper and other wood products into finished goods for consumers. Secondary wood industries include wood buildings (SIC 244); wood household furniture (SIC 251); wood office furniture (SIC 252); wood portions (SIC 254); paper board containers, and fiber cans and drums (SIC 265); building paper

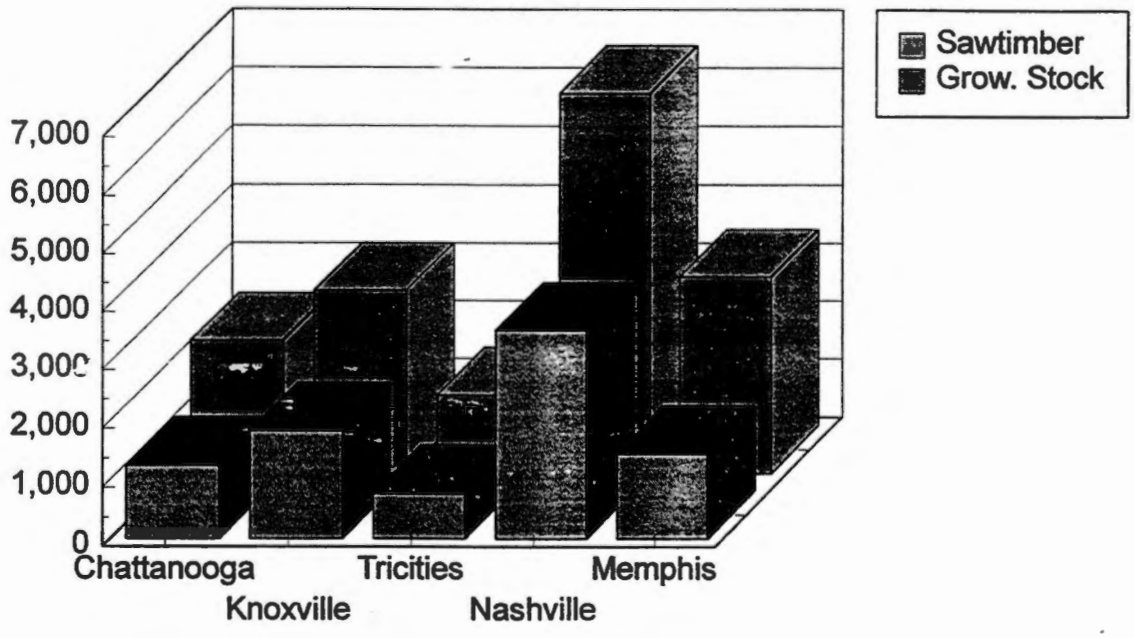

Figure 1.8 Volume of growing stock and sawtimber by Tennessee regions In millions of cubic feet

Table 1.1 Number of employees, and other selected statistics for 3D-SIC primary and secondary wood processing sectors, 1994

	Industry Name	No of Employees	Value of Shipments	Annual Payroll	Value Added	Cost of Material	Capital Invest.
Primary Industries		1,000	----------	----------	million $	----------	----------
241	Logging	1.1	112.8	14.9	40.9	72.3	2.8
242	Sawmills	8.4	900.1	149.6	382.6	526.5	19.5
243	Millwork, Veneer	3.4	300.0	60.2	134.9	165.9	4.8
263	Paper Mills	3.4	901.2	149.1	478.8	423.9	129.0
263	paper board Mills	1.7	672.1	85.7	396.2	272.5	25.1
	Sub-total	18.0	2,886.2	459.5	1,433.4	1,461.1	181.2
Secondary Industries							
244	Wood containers	1.8	85.4	18.9	47.5	39.3	3.1
245	Wood buildings	2.6	447.3	69.9	200.8	247.1	5.0
249	Misc. Wood products	2.8	359.3	41.5	101.8	259.5	4.6
251	Household furniture	19.7	1645.2	383.5	792.6	868.1	34.3
252	Office furniture	2.4	303.6	56.2	139.0	165.2	6.3
253	Public related buildings	1.9	385.7	42.1	96.3	290.7	(D)
254	Partitions, shelving,etc.	1.3	155.2	28.4	71.2	83.5	(D)
259	Miscellaneous furniture	1.5	172	29.4	94.3	79.0	2.2
265	Paperboards	6.7	1170.9	184.6	423.1	753.2	34.2
267	Converted paper	8.5	1410.7	229.8	499.3	905.4	34.1
	Sub-Total	49.2	6,135.3	1,084.3	2,465.9	3,691.0	123.8
Total		67.2	9,021.5	1,543.8	3,899.3	5,152.1	305.0

Source: 1994 Census of Manufactures, Geographic Areas Series: Tennessee. US Department of Commerce, Bureau of the Census

(SIC 266); envelopes, stationary, sanitary paper, paper coating (SIC 267); and wood chemicals (SIC 286). (See Table A.2 in Appendix A).

In 1994, the secondary wood processing sectors employed 49,200 workers, paid $1.08 billion in wages and added $2.46 billion in value added through manufacture. Table A.3 in Appendix A summarizes similar economic statistics for primary and secondary wood processing sectors for 1992.

From 1992 to 1994, the total number of establishments of wood processing sectors changed from 1,441 to 1,563 representing an increase of 8 percent for the whole period. In general, from 1992 to 1994, figures related to value added, value of shipments, and capital investment increased in real terms.

The Forest Resource Base

Tennessee has sizable timber resources with half of the state land still covered by forest. Table 1.2 shows the distribution of forestland according to land use categories across the study regions. The Nashville region has the highest percent of timberland, accounting for 44.7 percent of the total state timberland, while Tricities region accounts for only 6.8 percent of state timberland

In Tennessee private ownership is the most prevalent form of ownership. Private ownership accounted for 89 percent or 11.754 million acres of state timberland (Table 1.3). Public ownership is limited to only 11 percent or 1.509 million acres of the state timberland which is concentrated in the eastern portion of the state. This area also provides timber and non-timber amenities to the state's urban population. Within the private sector, corporate land represents 51 percent of the total timberland followed by

Table 1.2 Distribution of Tennessee forest land by land use class and B.E.A. regions, 1989

B.E.A Regions	Total Forest Land	Timberland	Reserve Timberland	Non-forest Land	All Land	Timberland's Share of Total Region Land
	thousand acres					percent
Chattanooga	1,750	1,717	33	851	2,601	66.0
Knoxville	2,467	2,214	253	1,446	3,913	56.6
Tricities	940	912	28	768	1,708	53.3
Nashville	5,950	5,930	20	5,384	11,334	52.3
Memphis	2,491	2,490	1	4,396	6,887	36.1
Total	13,598	13,263	337	12,845	26,443	50.1

Source: USDA, Forest Service 1989. Southern Forest Inventory and Analysis Database

Table 1.3 Area of timberland by B.E.A. region and ownership type, 1989

Economic Regions	All Ownership	Public Land	Forestry Industry	Farmer	Corporate Land
	---------- thousand acres ----------				
Chattanooga	1,717	354	202	244	917
Knoxville	2,214	256	37	661	1,260
Tricities	912	285	6	240	381
Nashville	5,929	391	675	1,873	2,990
Memphis	2,491	223	202	836	1,230
Total	13,263	1,509	1,122	3,854	6,778

Source: USDA, Forest Service 1989. Southern Forest Inventory and Analysis Database

farmers who own 29 percent or 3.854 million of acres of state timberland. The forestry industry only accounts for 8.4 percent or 1.122 million acres of state timberland. Of that amount, most is comprised of planted pine (USDA, Forest Service. 1989). The current distribution of Tennessee timberland according to stand size class is presented in Table A.4 in Appendix A. The stand size refers to the predominance of stocking by the size of all trees. The size refers to the diameter of the tree at breast height (d. b. h. or 4.5 feet above the ground). Almost fifty percent of the timberland area or 6.554 million acres is currently classified as sawtimber evidence of the degree of maturity of timber resources. The pole size class timber area accounts for 33 percent or 4.409 million acres of the total timberland area.

Tennessee forestland is overwhelmingly classified as the hardwood species group (Table A.5 in Appendix A). Of the total timberland, almost 87 percent or 11,861 thousand acres are in the hardwood and softwood-hardwood species group. The most important hardwood species are white oak, red oak, hickory, and yellow poplar. The softwood species group accounts for 10 percent of the total state timberland. The most important softwood species are jack pine, short-leaf pine, and Virginia pine.

Figure 1.9 illustrates the regional distribution of growing stock and sawtimber volume in million of cubic feet. Of the total volume, 52 percent correspond to sawtimber. The growing stock is defined as the volume of all live trees in the forest or stand including sawtimber, poletimber, and sapling and seedlings. Sawtimber is referred to as the portion of the tree to be sowed into timber. Growing stock and sawtimber are

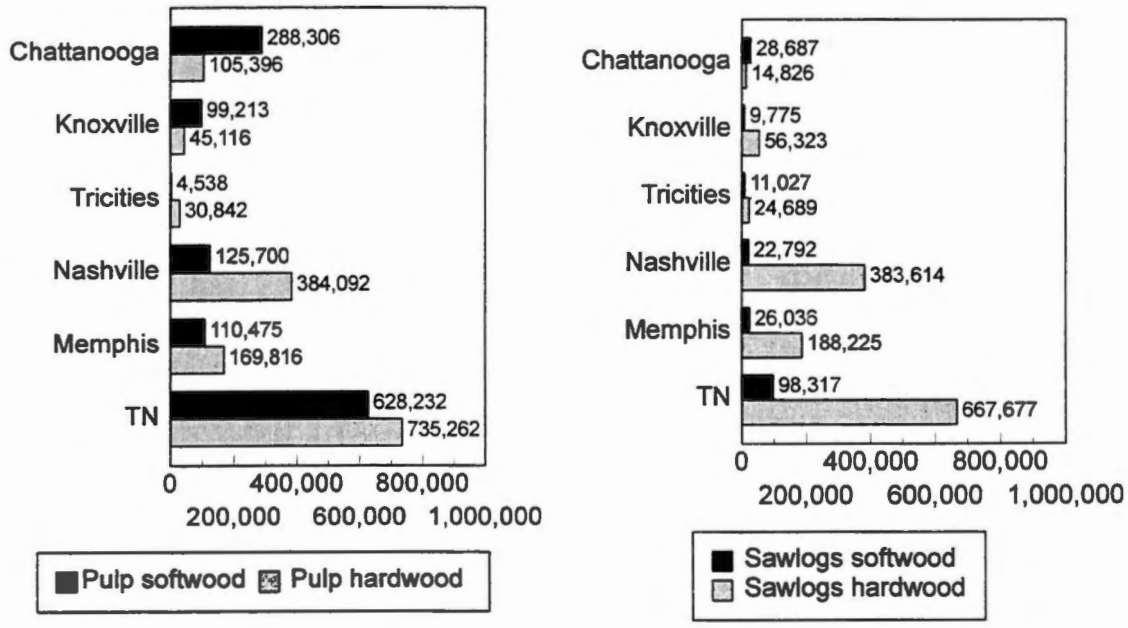

Figure 1.9 Volume of timber harvested by Tennessee regions and type of wood in standard cords for pulpwood and 1,000 board feet for sawlogs.

crude approximations of the potential availability of timber, but the total inventory is necessarily available for harvesting. Of the total volume of growing stock or 16,646 million cubic feet, 83 percent correspond to the hardwood species group while the remaining 17 percent correspond to the softwood species group.

The average net annual growth and removal of growing stock and sawtimber in 1989 by forest regions and species groups respectively are presented in Tables A.6 and A.7 in Appendix A. To estimate growth/removal ratios, the average net annual growth is divided by the average annual removal. Clearly, average annual growth exceeds annual removal making the growth/removal ratio greater than one. This means that the timber inventory is going up. Notice that growth/removals (G/R) ratios for all species are higher, specially ratios for hardwood. In Tennessee, according to the latest inventory data (1989), the ratios G/R for growing stock for softwood and hardwood are 1.8 and 2.6, respectively while the ratios G/R of sawtimber for softwood and hardwood are 2.1 and 2.4, respectively.

Table A.8 in Appendix A, shows a comparison of softwood and hardwood growth/ removal ratios among southern states. Tennessee shows the highest growth/removal ratio for hardwood among southern states. Tennessee has modest resources of softwood compared with neighboring states but nevertheless softwood resources are growing. As McDill (1997) cautions, growth/removal ratios do no tell the whole story because neither growth nor removal remain the same through time. In addition, some of these statistics are between 6 to 13 years old. However, the current trend is toward greater removal and lower growth in most of the states. By 1994, total

harvest of hardwood and softwood for sawlogs amounted to approximately 667.67 million and 98.31 million board feet (BF), respectively. The harvest of softwood and hardwood for pulpwood amounted to 628,232 and 735,262 standard cords, respectively (Figure 1.10). For these timber products, landowners received $142 million for hardwood sawlogs sales, $17.5 million for softwood sawlogs sales, $3.7 million for hardwood pulpwood sales and $18.09 million for softwood pulpwood sales.

Integration of the Forest Economy Activity with the Economy of Other Sectors

Often, in determining the economic importance of an industry sector in a given region, direct sales (total output), jobs and income associated with that activity are the method of measure. The analysis should go beyond these direct effects in two directions: backward and forward linkages. First, the economic activities that take place as a chain reaction initiated by an industrial activity such as consumer goods, that is, intermediate goods that will be used in the production process (backward linkages). For example, the main input suppliers for the secondary wood processing sectors are industries such as fabricated metals (SIC 34); textile mills (SIC 22); chemicals and allied products (SIC 28); and rubber and miscellaneous products (SIC 30). Table 1.4 shows a detail of the input requirement by industry suppliers of the secondary wood processing sectors of East Tennessee, Southwest Virginia and Western North Carolina (Tennessee Valley Authority, 1986). By 1994, the primary wood processing sectors spent $1.18 billion on purchases of materials while the secondary wood processing sectors spent $2.95 billion on purchases

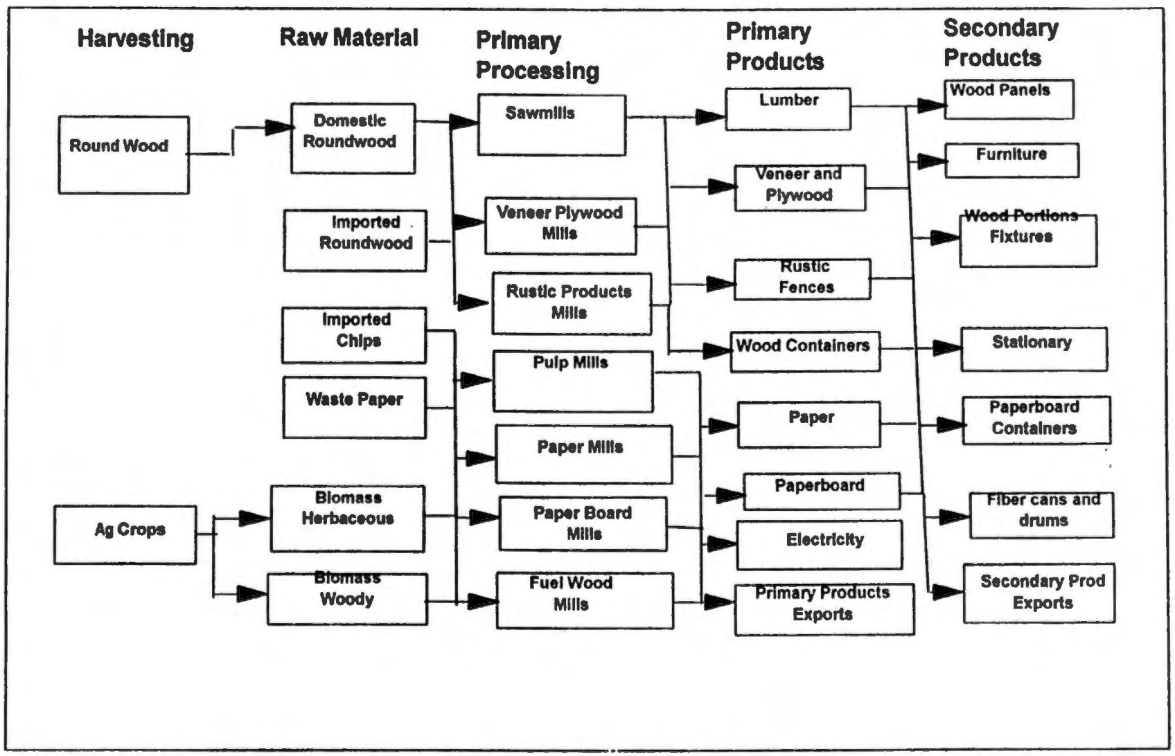

Figure 1.10 Flow of raw materials to product output for the Tennessee forest based industry

Table 1.4 Input requirement by 4D-SIC industry suppliers of forest processing firms, 1986

S.I.C.	Industry Name	Percent
2851	Paints and allied products	17.1
2221	Weaving Mills synthetic	16.3
2650	Paper board containers and boxes	15.3
3429	Furniture hardware N.E.C.	14.7
3069	Fabricated rubber products	14.2
3291	Abrasive products	6.0
3452	Bolts, Nuts, washers	3.9
2426	Hardware Dimension & Flooring	3.1
3079	Miscellaneous plastic products	2.2
3495	Wire springs	2.1
2891	Adhesives and sealant	2.1
3471	Plating and polishing	1.5
3312	Blast furnaces & Steel mills	1.8
Total		100.0

Source: TVA 1986 Survey of secondary forest processing firms in East Tennessee, Southwest Virginia and Western North Carolina

of materials.

Second, the economic activities generated for the passage of those goods and services through channels of distribution between industry to final consumers are the forward linkages. The forward linkages measure the amount of non-forestry output that results from the need to process and deliver forestry output to consumers. For the forest industry complex sector, every activity that does not by its nature cater exclusively to final demand will induce attempts to utilize its output as input in some new activities. Thus, lumber, the main product of sawmills, will be used as input by industries such as furniture, wood panels, wood portions & fixtures, home buildings, and cabinets. In addition, industries such as transportation, wholesale and retail trade, banking, and related services are included in the forward linkages because these activities are needed for the forestry output to end up in the hands of final consumers. Sectors such as transportation, wholesale, exports, and retail distribution system, banking and finance and related services are forward linkages in the economy. Input-output multipliers do not capture forward linkages.

Multiplier Analysis

The multiplier analysis is another tool to measure the economic importance or contribution of an industry in terms of valued added, output, employment, and personal income. The economic multipliers capture the total economic effects due to the initial change in final demand. Table 1.5 shows the economic multipliers such as value added, output, employment and personal income for the major 2D-SIC forest sectors such as

Table 1.5 Economic multipliers for the forest-based industries sectors for Tennessee

	Description	Direct Effects	Indirect Effects	Induced Effects	Total Effects	Type I Multiplier	Type III Multiplier
I. Value Added Multiplier							
22	Misc. Forest Products	0.240875	0.215334	0.421763	0.877972	1.893965	3.644923
133	Logging Camps	0.224096	0.097951	0.221238	0.543285	1.437095	2.424341
134	Solid Wood Products	0.414708	0.193067	0.353823	0.961598	1.465550	2.318736
148	Furniture	0.444579	0.187497	0.376131	1.008207	1.421739	2.267779
161	Pulp and paper	0.432590	0.142185	0.212681	0.787456	1.328682	1.820327
II. Output Multiplier							
22	Misc. Forest Products	1.000000	0.427583	0.710077	2.137660	1.427583	2.137660
133	Logging	1.000000	0.239739	0.372475	1.612214	1.239739	1.612214
134	Solid Wood Products	1.000000	0.417644	0.595693	2.013338	1.417644	2.013338
148	Furniture	1.000000	0.368690	0.633252	2.001943	1.368690	2.001943
161	Pulp and paper	1.000000	0.277831	0.358068	1.635899	1.277831	1.635899
III. Employment Multiplier							
22	Misc. Forest Products	8.712418	7.887880	10.382348	26.982646	1.905361	3.097033
133	Logging	5.825617	2.882169	5.446123	14.153910	1.494741	2.429598
134	Solid Wood Products	9.081783	4.844443	8.709899	22.636126	1.533424	2.492476
148	Furniture	9.993237	4.811051	9.259067	24.063355	1.481431	2.407964
161	Pulp and paper	4.885798	3.485184	5.235475	13.606456	1.713330	2.784900
IV. Personal Income Multiplier							
22	Misc. Forest Products	0.097192	0.156686	0.261722	0.515600	2.612123	5.304958
133	Logging	0.115245	0.061448	0.137288	0.313980	1.533193	2.724467
134	Solid Wood Products	0.316887	0.128652	0.219563	0.665102	1.405986	2.098859
148	Furniture	0.304332	0.125365	0.233406	0.663103	1.411937	2.178883
161	Pulp and paper	0.233606	0.093407	0.131978	0.458991	1.399850	1.964809

Source: 1994, IMPLAN Database

miscellaneous forest products, logging, solid wood products and furniture, and pulp & paper forest sectors. Type I multipliers include the direct effects and indirect effects. The direct effects consist of the value of output sales of the sector. The indirect effects are the value of inputs purchased from regional businesses to fill the order for production of the forestry sector. Thus, a value of $1.89 Type I value added multiplier for miscellaneous forest products sector means that for every dollar demanded by final consumers a total of $1.89 of value added will be generated throughout the economy in direct and indirect economic activities. Similarly, a value of $1.43 Type I output multiplier for the same sector means for every dollar sold to final demand, the original one dollar corresponds to direct effects and $ 0.43 corresponds to indirect effects.

Type III multipliers include the direct, indirect, and induced effects. These latter effects are the value of increased spending by households resulting from the increased direct and indirect business activity. The employment Type III multiplier for sector 134 solid wood products is 2.492. This value is interpreted such that for every job that the direct business activity creates, there will be 2.5 additional jobs created throughout the economy which include 1.5 jobs created by indirect and induced effects.

The forestry sector in general compares favorably in terms of economic multipliers with other agricultural sectors. Type III value added multipliers were higher in the solid wood products and miscellaneous forest products sector compared to the logging and pulp & paper sector. Type III output multipliers for solid wood products were higher in solid wood products and miscellaneous forest products than in the logging and pulp and paper sectors.

Type III employment multipliers for miscellaneous products, solid wood products and pulp & paper were larger compared to logging and furniture sectors. Type III personal income multipliers for the miscellaneous forest products sector and logging sector were higher compared to solid wood products, furniture, and pulp & paper sectors.

A note of caution in the interpretation and use of multipliers is warranted. Multiplier values are based on current industry relationships within the local economy at the time when multipliers were calculated. So, they can not be extrapolated from one region to another because inter-industry relationships can vary among regions. In addition, multiplier estimation assumes that the regional economy is completely elastic with respect to supply. This means that raw resources will be available to expand production. Finally, in estimating the economic impacts, the size of the multiplier is equally important as the absolute value of the output of the sector involved.

CHAPTER II

LITERATURE REVIEW

Introduction

Few studies have been done in Tennessee with the purpose of understanding the role and measuring the contribution of the forest-based industries to the state economy. Thus, Abt (1979) explored the possibility of incorporating into a larger model econometric aggregated model, TEN II[2], an equation for the lumber and wood products sector (SIC 24) to predict sector output, employment, and wages. Maki et al., (1987) used the excess of employment and earnings technique[3] to identify that the forest product industry is one of Tennessee's basic industries.

Other state forestry studies (Pedersen, et., al. 1989; Trenchi and Flick, 1982; and Aruna, et., al. 1997) had relied on construction of input-output state models that draw data from local surveys or secondary data. Other forestry studies have focused their attention in the regional dimension (Kaiser, 1972; and Teeter et al., 1989) responding to the fact that population, resources and economic activity distribution take place in a geographical setting and impacts between regions are significant.

In the last decades, state policy makers have focused their attention on rural regions, particularly those with abundant forest resources, to explore the opportunities that could leverage value added forest resources-based programs as a tool to increase

[2] TEN II is an state level econometric model developed and maintained by the Center for Business and Economic Research, College of Business Administration, The University of Tennessee

employment, attract new industries, and serve as engines of growth (Vlosky and Glance, 1996). It has been suggested that agricultural and forestry sectors have development potential (Neal, 1990). This is particularly important for many persistent poverty counties in Tennessee which have a relatively large agricultural sector and abundant forest resources.

Theory helps to explain why things are as they appear and to understand how things might be changed to a better way than currently exists. Rural development is still an endeavor of policy makers and agricultural economists, particularly when the nation is concerned for the economic well being of particularly depressed areas. The next section presents a brief discussion of the issues that rural development deals with, several principles that explain the economic conditions, and sector spatial distribution that will serve as a context in which this dissertation model can be understood.

Regional Economic Development

Regional economic developments come out in response to questions such as how spatial distribution of population, resources and economic activities takes place among regions. As Richardson (1982) points out, the economic well being of rural areas depends on numerous forces. Some of these forces can be understood in economic terms while others are related to the political and social structure. A brief discussion of several principles and theories related to regional economics is presented. A more complete and comprehensive discussion can be found in Bingham and Mier (1993) and Shaffer (1989).

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[3] Industries that exceed the national distribution of employment and earnings are considered to be

Location Theory

Shaffer (1989) notes that location theory assumes that business owners engage in a rational calculation of all factors that affect the cost of production and distribution, and select a location that minimizes these costs. Location theory suggests several strategies of local economic development. Thus, communities can provide incentives that somehow offset the disadvantages of location. Rural regions that depend on natural resources have location advantages such as easy access to raw materials, a less costly labor pool and location disadvantages generally referred to markets access. The main goal of rural economic development is often adding sufficient value added to raw commodities to offset transportation cost.

Agglomeration Economies

As Shaffer (1989) pointed out, agglomeration economies are an important factor for business location decisions. Agglomeration is referred to economies of scale and they can be external or internal. An example of external agglomeration is what is called urbanization of economies. Here, firms can benefit from location in urban areas due to advantages in infrastructure, labor, market access, and services. In the rural area, it is common to find internal agglomeration of economies in the presence of large firms. These firms have achieved internal economies of scale by vertically integrating production operations.

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producing for exports outside the state therefore are part of the economic state base.

Product Life-Cycle

As Bingham and Meir (1993) suggest, the product cycle theory helps to explore the criteria of location of business in the absence of external economies. This theory hypothesizes that a product passes through well defined cycles. At different stages of these cycles, the firm's strategy may be to change the location. Thus, in the innovation growth stage, it may be advantageous to locate in a metropolitan area for the availability of services. In the mature stage, the rural location may offer competitive advantages due to lower cost factors.

Central Place Theory

Central place theory shows how business activities orient themselves relative to their markets and competitors as Holland, et al., (1997) suggested. In order to gain access to markets, businesses locate in close proximity to one another giving rise to a central place. Because every product or service requires a given size market, competitors distribute themselves among central places. Smaller places have few businesses and serve smaller markets. A group of smaller places in turn serves as the market for larger places offering a wider variety of goods and services. In this way a hierarchy of places develops. Places at the top of the hierarchy include not only all of the activities found in lower order places but also most of the specialized goods and services. Central place theory is also helpful to local economic development by pointing to the relationship between business activities and the necessary market demand threshold.

Neoclassical Growth Theory

The neoclassical theory focuses on market responses to price signals. This theory assumes that in a competitive market environment, capital and labor move freely in response to price signals. Production technologies lead to differences in wages and growth rates among regions. Neoclassical theory suggests that in the absence of structural barriers labor and capital flows among regions will converge to an equilibrium point. Then, rural economic development uses strategies of marketing regions with competitive advantages such as lower labor cost and resource availability. Local development strategies address violations of the neoclassical theory assumptions and factor industry mobility.

Supply and Demand Theory

Supply side theory focuses on inputs to production assuming that demand exist for whatever is produced. Among rural development strategies suggested by this theory are: the promotion of current and structural advantages such as labor cost, labor skills, capital availability, infrastructure, services, entrepreneurial business climate and other factors that foster productive activities. Development strategies with supply side focus attempt to market amenities or improve quantity or quality of local inputs as an inducement for business location.

Demand side theories suggest that regional growth results from external demand for locally produced goods and services. The export base theory is perhaps the best known example of demand side theory. Export base theory divides a regional economy

into two types of activities: export activities and residential activities. The residential activities are those activities whose primary function is to serve export industries. As Holland, et al., (1997) pointed out, regions will specialize in those exports in which they have comparative advantages. Thus, the job of the analyst is to identity industries that make up the export base of the region and design policies that assist expansion of these export based industries. Traditionally, rural areas have focused on exploiting local natural resources and manufactured goods or attracting firms that could expand exporting activities.

Forestry Sector and Rural Development

Marcouiller (1983) stated that the forestry sector has played an integral role in regional economic growth and development throughout time. As the need for land to grow crops is balanced with regional population and regional export demand, land use patterns have evolved through time. The use of products derived from forests has also undergone an evolution from the early uses such as shelter, firewood and products for direct use in households to the current and more sophisticated products such as paper, paneling, chemicals, and other wood related products. In the last thirty years, a major shift in societal demand has increased the use of forests for recreation and aesthetic purposes.

As Alward (1980) noted, the variety of forest uses is strongly tied to the social and economic structure of rural regions. The forests, as in the past, continue to be the source for economic growth and development for rural regions.

Davis and Johnson (1987) suggested a specific criteria for a successful use of forest resources: (1) economic efficiency; (2) favorable impacts on regional and local communities; (3) equity in the distribution of cost and benefits among the members of the society; (4) economic and social stability; and finally (5) security of the environment. The same authors adapt a useful grouping of regional goals and social impact criteria for evaluating changes in forest use. These includes goals such as: (1) economic activity comprised of employment, value added, and sales; (2) individual welfare; (3) area equilibrium issues such as economic diversity, social strife and future development; and finally (4) local cost and benefits to local governments.

The use of forests as an instrument of regional economic growth is bounded by specific economic conditions of the forested areas. These conditions are general market imperfections, issues of income distribution, social acceptance of timber production, and the inclusion of social valuation of non-markets goods.

The neoclassical economic theory states that the primary objective of economic activity is the maximization of profits given a relatively short planning horizon. Whereas in the long run, forest productivity maximization could be an important goal, in the short run, its importance diminishes for those economic agents interested in short term profits. This distinction is quantified in the differences between private and social rates of returns measured by discount rates. Private investment decisions are based upon higher discount rates, which give more weight to the early periods. On the contrary, in forestry, implicitly weighted cash flows place more emphasis on longer terms of returns. Forest assets and the cost associated with their management contain primarily longer terms of returns.

Another market imperfection that occurs primarily in public lands is the inability of forestry activity to efficiently allocate open access common properties resources. Production activities such as clear cutting present potential externalities for tourism and recreational activities through aesthetic disturbances.

Another market imperfection associated especially with larger forestry ownership is the potential for exertion of market power which falls into the categories of monopoly - oligopoly and monopsony - oligopsony. As Mead (1966) notes, timber markets are particularly prone to situations of market power due to factors of production and hauling costs. Marcouiller (1983) and Leatherman (1995) had contributed to the forestry economics literature by quantifying the effects of timber production intensity on household income distribution. This issue is at the core of regional economic development. As Marcouiller (1986) states, timber production is fundamentally different from extracting depletable natural resources in that if it is properly managed, forestry is a renewable resource. Sustainable management of forests for economic growth and development provides sustainable levels of raw material into regional economies.

Clawson (1974) has identified different types of forest uses. The first one includes forestland but not necessarily for forestry production. These uses include mining of subsurface minerals, road building and residential construction or forestland grazing.

The second type of forest use is totally or partially intolerant of another use. The most common is timber harvesting, wilderness use, and intensive recreational use. Intensity of conflicts arising among these uses is related to proportional combinations and intensities of utilization and management. The third category of forest use occurs

irrespective of man's efforts but is influenced by his actions. Examples of the latter are the use of forests as a source of water or wildlife production.

In the past, conflicts have been resolved in a zero sum fashion. Lately, as Marcouiller (1996) points out, there is room for accommodation and conflicts are resolved so there are positive gains for all subjects involved.

Thomas (1992) suggested that there are several strategies for rural development of communities where forest resources are important elements of the economic structure. These strategies are the following: (1) organizing for resource-based economic development and conservation; (2) targeting value added processing; (3) targeting alternative goods and services from the forest resource; (4) enhancing productivity; (5) strengthening marketing; (6) promoting technology transfers; and finally (7) improving local human capital.

Holland, et al., (1997) suggest that there is a need for identifying developmental opportunities by using the standard tools of regional economic analysis. Regional economics suggest at least three general approaches: (1) retention and expansion of the existing economic export base activities; (2) substitution of imports for local production; and finally (3) expansion of rural-urban and inter-industry linkages.

The Static Input-Output Theory

Methods used in regional economic analysis are discussed in detail in Richardson (1995), Doeksen and Schreiner (1972) and Dervis, deMelo and Robinson (1982). Input-output analysis was originally developed by Wassily Leontief in 1930. Dervis et al.,

(1982) point out that input-output analysis provides a snapshot at a certain point in time of all economic activities in a region. Maki et al., (1994) note that input output is widely used in regional analysis because its accounting system is based on the national income and product accounting system (N.I.P.A). Anaman (1994) describes in simple terms the essence of input-output analysis. The author states that in an economy where there are hundreds of firms producing various goods, these firms require inputs for their production process for other firms in the region. Hence, if an exogenous stimulus occurs such as an increase in export demand for a particular good, these export oriented firms will increase their production in response to increased demand by acquiring more inputs from their input suppliers. In turn, these input suppliers also demand additional inputs from other firms in order to produce the extra inputs required by exports oriented firms. In this way, a chain reaction is initiated and it occurs throughout the economy in response to the initial stimulus, generating additional increases in output, income, and employment economy wide. In the I/O accounting system, there are three features to examine: the institutions, the markets, and the behavioral or technical assumptions. Excluding foreign trade, there are two markets, the factor and product markets. In the product market, there are two sets of customers: producers who deliver not only final goods to households but also intermediate goods to other producers. The inclusion of intermediate goods is a major strength of the input-output accounting system because it allows the analysis of both the structure of gross production and the inter-industry linkages. As Richardson (1995) notes, the key of the input-output analysis is the construction of three basic tables: the transaction, the direct tables and indirect coefficient tables. The transaction table shows

flow of products expressed in producer prices at current values from each sector as a producer to other sectors as a purchaser. Table 2.1 shows a transaction table for a hypothetical economy with "n" endogenous sectors (1, 2, 3, ..., n) and exogenous sectors such as consumption (C_N), investment (I_n), government (G_n), and net exports (E_n). The first column is comprised of $Z_{1,1}$, $Z_{2,1}$, ...,*and* $Z_{n,1}$ series of elements representing purchases made by sector 1 from each of the "n" sectors. The L_1, N_1, and M_1 terms are elements of the value added or payments to factors made by sector 1 such as labor, profits, taxes, and imports. The latter is considered leakage from the local economy whether it be a county, state, or region, since this flow of money paid does not enter to the local economy. Reading across, the first row $Z_{1,1}$, $Z_{1,2}$, $Z_{1,3}$,..., $Z_{1,m}$, C_1, I_1, G_1 and E_1 represent sales by sector 1 to each of the sectors and each of the final demand categories, consumption of households (C_1), investment (I_1), government (G_1) and exports (E_1). The row terms values $Z_{1,1}$, $Z_{1,2}$, $Z_{1,3}$,..., $Z_{1,m}$ are known as intermediate demands and the four last terms are known as final demand or exogenous sectors because changes in those occur autonomously due to political decisions and changes in consumer preferences (Miller and Blair, 1985).

As Leontief (1986) notes the input output transactions table must be balanced in that the total output of each producer sector (total of row) must be equal to its total outlay (total of column). This is a fundamental accounting requirement so that no economic activity is lost or gained and all income and outlay is accounted for. The transaction

Table 2.1 Input-output transaction table

to / from	1	2	3	...	n	Final Demand (Y)				T.I.O (X)
1	Z_{11}	Z_{12}	Z_{13}		Z_{1n}	C_1	I_1	G_1	E_1	X_1
2	Z_{21}	Z_{22}	Z_{23}		Z_{2n}	C_2	I_2	G_2	E_2	X_2
3	Z_{31}	Z_{32}	Z_{33}		Z_{3n}	C_3	I_3	G_3	E_3	X_3
:	:	:	:		:	:	:	:	:	:
n	Z_{n1}	Z_{n2}	Z_{n3}		Z_{nn}	C_n	I_n	G_n	E_n	X_n
Value	L_1	L_2	L_3		L_n					L
Added	N_1	N_2	N_3		N_n					N
	M_1	M_2	M_3		M_n					M
	:	:	:		:					
Total Outlay	X_1	X_2	X_3		X_n	C	L	G	E	X

tables may be written as a set of simultaneous equation as follows:

$$\begin{aligned} &Z_{11} + Z_{12} + \ldots\ldots\ldots\ldots + Z_{1n} + Y_1 = X_1 \\ &Z_{21} + Z_{22} + \ldots\ldots\ldots\ldots + Z_{2n} + Y_2 = X_2 \\ &\vdots \\ &Z_{n1} + Z_{n2} + \ldots\ldots\ldots\ldots + Z_{nn} + Y_n = X_n \end{aligned} \tag{2.1}$$

where Z_{ij} are sales from industry sector "i" or row to industry sector "j" or column.

Y_i is sales from industry sector "i" to final demand.

X_i is total industry output (TIO) of industry sector "i".

The use of the transaction table is very limited since it is only a description of the current situation (Chenery and Clark, 1959). The direct requirement coefficient table answers the question of changes in output in response to change in the demand for final products. This direct coefficient table is constructed by dividing the sector values of inputs purchased from other sectors of the economy Z_{ij} by the total value of the sector output X_j

$$a_{ij} = Z_{ij} / X_j \tag{2.2}$$

where the quotient (a_{ij}) obtained is an entry of the direct requirement table. The set of a_{ij} coefficients is also known as matrix of technical coefficients. These coefficients indicate the fraction of the total expenditure by industry sector at the top of a column "j" that were

spent buying from the sector listed on the left or row in table 2.1. Each column of the direct requirement table is the production formula or production recipe for the production of the output of industry sector "j" (Hasting and Brucker, 1993). The elements of each column are assumed to be constant and an average for all firms within an industry sector regardless of input prices or how much is being produced. If a sector represents an aggregate of many different products, the inputs needed for each product is represented by average requirement column. Richardson (1972) notes that if the product or services needed is not available in the region, and must be imported, the direct requirements are not identical with the production function. By knowing this production recipe, local production is known as well as how the industries in it interact to each other.

O'Connor and Henry (1975) point out that the following assumptions are imbedded in the definition of the technical coefficients:

a) each sector produces only one homogeneous commodity.

b) each sector has a fixed input-output ratio.

c) each sector output is produced with a unique input structure and therefore substitution between inputs is not allowed. The underlying production function of I/O theory is known as the Leontief production function.

d) each sector operates under conditions of constant return to scale. When inputs are increased by "n" times, output is also increased by "n" times. In addition, economies of scale in production do not exist.

If we substitute Z_{ij} for $a_{ij}X_i$, Equation (2.1) can be rewritten as:

$$\begin{aligned} &a_{21}X_{11} + a_{12}X_{12} + \ldots\ldots\ldots\ldots + a_{1n}X_{in} + Y_1 = X_1 \\ &a_{21}X_{21} + a_{22}X_{22} + \ldots\ldots\ldots\ldots + a_{2n}X_{2n} + Y_2 = X_2 \\ &\vdots \\ &a_{n1}X_{n1} + a_{22}X_{n2} + \ldots\ldots\ldots\ldots + a_{2n}X_{nn} + Y_n = X_n \end{aligned} \tag{2.3}$$

This set of equations reveals the interdependence of each sector with all other sectors because it indicates that the level of output of any sector "i" is dependent upon the level of output in any sector "j", the input requirement on each sector and the level of its final demand.

If final demand variable (Y_i) is treated as exogenous, the set equation (2.3) can be rewritten as:

$$\begin{aligned} &X_1 - a_{11}X_{11} - a_{12}X_{12} - \ldots\ldots\ldots\ldots - a_{1n}X_{1n} = Y_1 \\ &X_2 - a_{21}X_{21} - a_{22}X_{22} - \ldots\ldots\ldots\ldots - a_{2n}X_{2n} = Y_2 \\ &\\ &X_n - a_{n1}X_{n1} - a_{n2}X_{n2} - \ldots\ldots\ldots\ldots - a_{nn}X_{nn} = Y_n \end{aligned} \tag{2.4}$$

which in matrix notation is expressed as:

$$\begin{bmatrix} (1-a_{11}) & -a_{12}\ldots\ldots & \ldots\ldots\ldots & -a_{1n} \\ -a_{21}\ldots\ldots & (1-a_{22}). & \ldots\ldots\ldots & -a_{2n} \\ -a_{n1}\ldots\ldots & -a_{n2}\ldots\ldots & \ldots\ldots\ldots & (1-a_{nn}) \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix} = \begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix} \tag{2.5}$$

or

$$A^* X = Y \tag{2.6}$$

where A^* is the result of the difference between two matrices, an identity matrix (I) and technical coefficients (A) matrix. Thus, equation (2.6) can be written as :

$$(I - A)X = Y \tag{2.7}$$

where A^* is equal to *(I-A)* and the sector output is a function of final demand Y. Finally, equation (2.8) is the solution of the algebraic manipulation of the static input-output model and is found by pre-multiplying each side of equation 2.7 by $(I-A)^{-1}$ to yield:

$$X = (I - A)^{-1} Y \tag{2.8}$$

By using equation (2.8), levels of output can be estimated from all sectors required to support specified levels of final demand. The $(I-A)^{-1}$ matrix is also known as Leontief inverse matrix. Each element of this matrix indicates the amount of direct and indirect production effects from sector "i" necessary to sustain a final demand of one unit of sector "j". The Leontief matrix has special properties such as the diagonal elements are positive and the off-diagonal elements are negative or zero.

An example for an economy of only three sectors is presented to illustrate the interpretation of the inverse Leontief matrix interdependence coefficients.

$$(I-A)^{-1}=\begin{bmatrix} \overset{*}{A}_{11} & \overset{*}{A}_{12} & \overset{*}{A}_{13} \\ \overset{*}{A}_{21} & \overset{*}{A}_{22} & \overset{*}{A}_{23} \\ \overset{*}{A}_{31} & \overset{*}{A}_{32} & \overset{*}{A}_{33} \end{bmatrix} \tag{2.9}$$

Column 1 contains coefficients for industry sector 1, column 2 contains those for sector 2 and column 3 those for sector 3. In column two the coefficients indicate that for each dollar of sales to final demand by sector 2, total input requirement is A_{12} from sector 1, A_{22} from sector 2, A_{32} from sector 3. The input required from sector 2, A_{22} includes its \$1 dollar of sales going to final demand , and additional indirect output which is brought about by the fact that they must increase output to satisfy the increase in final demand experienced by industry sector 2. Thus, coefficients A_{ij} are positive and greater than one and contains both the direct effects and indirect effects.

If the matrix of direct and indirect coefficients is multiplied by one unit change in final demand which takes places in a particular sector for example sector 2, then the total input requirement needed to satisfy final demand must be calculated as follows:

$$\begin{bmatrix} \overset{*}{A}_{11} & \overset{*}{A}_{12} & \overset{*}{A}_{13} \\ \overset{*}{A}_{21} & \overset{*}{A}_{22} & \overset{*}{A}_{23} \\ \overset{*}{A}_{31} & \overset{*}{A}_{32} & \overset{*}{A}_{33} \end{bmatrix}\begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = A_{12}+A_{22}+A_{32}=\sum_{1=1}^{3} A_{i2} \tag{2.10}$$

Equation (2.10) indicates that a unit change in final demand in sector 2 will cause

a total change in all sectors equal to $\sum_{i=1}^{3} A_{i2}$ which is the output multiplier. In addition to the direct and indirect effects, there are induced effects. The induced effects are those effects resulting from owners, employees, and their families spending their income in the region of the study. The addition of all effects (direct, indirect, induced) is referred to as the total effect (Doeksen and Schreiner, 1974). There are basically two types of input-output models: open and closed models. In the open model, the household sector is considered to be an exogenous sector. In this model, only direct and indirect effects are calculated. In the closed model, household is considered to be an endogenous sector. In addition to direct and indirect effects, induced effects can be estimated. The theoretical differences between these models are discussed in detail by Miller and Blair (1985).

Output multipliers in an open model are known as Type I multipliers. The output multipliers that are estimated from closed models are known as Type II multipliers. The underlying assumption in the estimation of induced effects is that an increase in income results in an increase of household expenditures on goods and services. This increase in expenditures occurs linearly. The Type III multipliers also contain direct, indirect and induced effects as Type II. The difference with respect to Type II is that additional purchases of household goods and services (induced effects) comes from new households added as a result of change in population in the region. This assumption is not always true since there are occasions when a change in the economy does not always result in an increase in population. Instead, it may be the result of a decrease in unemployment or increase in labor productivity.

Once output multipliers are determined, employment, income, value added and other endogenous variables are estimated from the set of input-output equations so equation (2.8) can be generalized to express changes in all endogenous variables due to changes in the exogenous variables. As Hewings (1982) notes, the magnitude of the multipliers varies from model to model. The variation of the magnitude is influenced by the aggregation scheme and method of regionalization. As long as input requirements among sectors remain the same, the $(I-A)^{-1}$ coefficients will not change. Therefore, only one matrix inversion is required. So equation (2.8) may be written in terms of impact evaluation as follows:

$$\Delta X = (I - A)^{-1} \Delta Y \tag{2.11}$$

where ΔX is the change in the vector of total output and ΔY is the change in the vector of final demand. This equation is used for forecasting purposes of total industry output when changes in final demand are known. The inverse matrix or Leontief matrix can be written in the form of a convergence expansion series yielding equation (2.12).

$$I + A_i + A_2 + \ldots\ldots + A_n \approx \left(I - A\right)^{-1} \tag{2.12}$$

where the approximation becomes very close to $(I-A)^{-1}$ as "n" gets larger. Starting from a vector of final demand, one computes the successive rounds of input requirements that

arise into attempt to satisfy the exogenous Y vector. When the process converges, it is said that the process has reached a general equilibrium solution in the productive area of the economy.

The I/O Static Model with Trade

The standard approach assumes that imported goods and domestic goods are the same, and they are perfect substitutes in all uses. The balance equation may be re-written as:

$$Xi + Mi = AXi + Yi + Ei \tag{2.13}$$

where :

Xi is the gross output of sector "i";

AXi is the intermediate demand for the output of sector 'i".

Yi is the final demand for the sector "i";

Ei is the export demand for the output of sector "i";

Mi is the total imports of products classified in sector 'i";

Solving for X_i , the equation is transformed to:

$$Xi = (I - A)^{-1}(Yi + Ei - Mi) \tag{2.14}$$

Equation (2.14) is the analogous of equation (2.8) except that the term ($Y_i + E_i - M_i$) is net demand for domestic goods. The problem with this formulation is that for some sectors net final demand might be negative. A negative final demand means running the production process in reverse, taking from the product and delivering its components to the rest of the system, which is not a reasonable assumption.

Chenery and Clark (1959) solved this problem by making a crucial behavioral assumption that the ratio of imports to domestic production is fixed by sectors. This procedure will solve the possible negative final demands, but exports and imports are still treated as perfect substitutes.

A different approach is to treat imports completely differently from domestically produced goods. The intermediate flows matrix must also be redefined to exclude imports because conceptually non-competitive imports do not have the same units as domestic production.

In order to construct an economic model for the domestic economy under the assumption that imports are not perfect substitutes for domestically produced goods, it is necessary to take away the imported component from intermediate demand (ID_i) and final demand (Y_i).

The intermediate demand of a sector X_i can be written as a function of its outputs:

$$ID_i = \sum_{j=1}^{m} X_{ij} = \sum a_{ij} X_j \qquad (2.15)$$

where X_{ij} is the intermediate use of commodity "i" by industry sector "j". The a_{ij} are the corresponding input-output coefficients. Then, imports M_i are decomposed in imports of commodity ""i" demanded for intermediate use or M^{id} and imports of commodity "i" for final use or M^f. Total imports are then expressed as:

$$M_i = M^{id} + M^f \tag{2.16}$$

The u^{id} and u^f ratios are defined as domestic supply ratios or proportions of intermediate and final demand supplied by domestic industries respectively. Equation (2.17) is obtained by substituting these ratios into equation (2.13) to get :

$$X_i = u^{id} \sum_j a_{ij} X_j + u^f Y_i + E_i \tag{2.17}$$

Similarly, imports can be stated as:

$$M_i = m_i^{id} ID_i + m_i^f Y_i \tag{2.18}$$

where $m_I = (1-u_i)$ is defined as import coefficients for intermediate and final goods.

Equation (2.17) and (2.18) can be restated in matrix notation as:

$$X = \hat{u}^{id} AX + \hat{u}^{f} Yi + Ei \tag{2.19}$$

and

$$M = \hat{m}^{id} AX + \hat{m}^{f} Y_i \tag{2.20}$$

where "^" over a variable denotes a diagonal matrix and A is the matrix of input-output or technical coefficients which includes a domestic A^d and imported A^m components. In addition, they represent the technology inter-industry relationship with domestic components known as regional absorption coefficients defined by the following relationship:

$$A = A^d + A^m \tag{2.21}$$

where : $A^d = \hat{u}^{id} A$ is the domestic input-output matrix and $A^m = \hat{m}^{id} A$ is the import matrix of intermediate use. Equations (2.19) and (2.20) can be solved to yield the domestic production needed to satisfy a specified level of domestic and exports demand given the structure of production represented by the coefficients matrix A, imports, $\hat{u}^{id}$ and $\hat{u}^{f}$.

$$X_i = (I - A^d)^{-1} (\hat{u}^{f} Y_i + E_i) \tag{2.22}$$

This equation is known as the fundamental impact analysis equation. Note that the imports do not appear in equation (2.22) and that each vector has its units in the domestic sector production. The I/O matrix A^d has units of domestically produced inputs per unit of domestic production. Exports indirectly embody imports through intermediate goods required for their production, but indirect effects work only through the I/O matrix and exports are measured in units of domestic output.

The Regions as a Theoretical Framework

As Richardson (1978) pointed out, all definitions of regions fall within three main categories: (1) uniform or homogeneous regions; (2) nodal or core-periphery regions; and (3) programming or planning regions. The idea of the homogeneous region is based on the fact that regions may exhibit certain uniform characteristics such as similar production structure, homogeneous consumption patterns, similar occupations, distribution of labor, location of a dominant natural resource, similar topography and similar climate. This criterion also includes non-economic variables such as social attitudes, demographics, and political outlook. However, in many economic phenomena, interregional differences may override features of uniformity.

The nodal or polarized criterion emphasizes the interdependence of different components within a region rather than inter-regional relationships between homogenous regions. As indicated by Hughes and Litz (1996) components within a region can be ordered hierarchically based on the effective demand for goods and services. This ordering ranges from small towns to urban areas or cities. In small towns only lower-

ordered economic activities are prevalent while in cities high order economic activities are prevalent. Robison et al., (1993) extended the nodal concept to core-periphery theory. The core or urban center is defined as an area within the region that determines the structure of the economy in the surrounding areas or periphery. The latter is largely dependent on the central place for its supply of higher order goods and services. As suggested by location theory, many periphery regions specialize in the production of goods in which they have competitive advantages. These advantages may come from abundant local natural resources or from inexpensive labor used in the economic activities. As Hughes and Holland (1994) noted, periphery growth tended to spill over into the core at a greater level than the converse. Holland (1997) pointed out that identification of rural economic development may lie in identification of economic linkages between rural communities and higher order central places in the functional economic regions. This region category is the one adopted by the present study.

The third category of the regional definition is planning or programming regions. These regions are defined in terms of coherence and unity of the economic decision making process. Thus, planning regions could be defined as political jurisdictions that respond to specific policy formulation.

Regional, Interregional and Multiregional I/O models

As Kaiser (1972) notes there are three methods available for developing a I/O model that will supply area estimates: regional, interregional and multiregional models.

Under the regional analysis, each region is treated as a quasi-autonomous unit

with all inflows and outflows to other regions consolidated in a import-export sector. The main advantage of the regional approach is that it allows the analyst to construct cash flows which reflect only the structure of local economies. The main disadvantage is that it does not account for linkages that local industries have with other regional markets (Midmore, 1996). Regional models only describe the transactions among local industries and it may be used to estimate demand placed on neighboring regions for input and output.

The interregional approach treat identical sectors located in different regions as separate industries (Blair and Miller, 1985). In this approach, the total output X_i for a particular industry sector "i" in a given region "r" can be represented by the following expression:

$$X_i^r = \sum_{j=1}^{n} \sum_{s=1}^{z} X_{ij}^{rs} + \sum_{s=1}^{z} Y_i^{rs} \qquad (2.23)$$

$j = 1.....,n.$

$s = 1,....,z.$

where X_{ij}^{rs} represents the output of industry "i" produced in region "r" and sold to industry "j" in region "s". The Y_i^{rs} term represents sales of product of industry sector "i" produced in region "r" for final consumers in region "s". In each region, the output of an industry is equal to the sum of its sales to all industries and final consumers in all regions. Table 2.2 shows a transaction matrix for a hypothetical two region interregional model. In region "r" there are three producing sectors and in region "s" there are two producing

Table 2.2 Interindustry interregional transaction table

	Selling sector	Purchasing Sector	Region R			Region S	
			1	2	3	1	2
Region R	1		Z_{11}^{rr}	Z_{12}^{rr}	Z_{13}^{rr}	Z_{11}^{rs}	Z_{12}^{rs}
	2		Z_{21}^{rr}	Z_{22}^{rr}	Z_{33}^{rr}	Z_{21}^{rs}	Z_{22}^{rs}
	3		Z_{31}^{rr}	Z_{33}^{rr}	Z_{11}^{rr}	Z_{31}^{rs}	Z_{32}^{rs}
Region S	1		Z_{11}^{sr}	Z_{12}^{sr}	Z_{13}^{sr}	Z_{11}^{ss}	Z_{12}^{ss}
	2		Z_{21}^{sr}	Z_{22}^{sr}	Z_{23}^{sr}	Z_{21}^{ss}	Z_{22}^{ss}

sectors. The intra-regional trade flows matrices are represented by $Z_{ij}^{rr}, Z_{ji}^{rr}, Z_{ij}^{ss}, and\ Z_{ji}^{ss}$. Off-diagonal matrices $Z^{rs}, and\ Z^{sr}$ are the inter-regional linkages and represent exports from region "r" and simultaneously imports of region "s" and vice versa.

As in equation (2.1) for the regional case, the basic equation for the interregional I/O case can be represented by:

$$X_1^r = Z_{11}^{rr} + Z_{12}^{rr} + Z_{13}^{rr} + Z_{11}^{rs} + Z_{12}^{rs} + Y_1^r \tag{2.24}$$

The first three terms on the right hand side represent sales from industry sector 1 in region "r" to three sectors (1, 2, and 3) within the region. The next two terms are the interregional trade flows from industry sector "i" in region "r" to two sectors that are in region "s". The last term Y_1^r represents sales to final demand of output of industry sector 1 in region "r". Additionally, there will be similar equations for X_2^r, X_3^r, X_1^s and X_2^s.

Using the regional input technical coefficients represented by:

$$a_{ij}^{rr} = Z_{ij}^{rr} / X_j^r \tag{2.25}$$

and the interregional trade coefficients represented by:

$$a_{ij}^{rs} = Z_{ij}^{rs} / X_j^s \tag{2.26}$$

and replacing into equation (2.24) the following expression is found:

$$X_1^r = a_{11}^{rr} X_1^r + a_{12}^{rr} X_2^r + a_{13}^{rr} X_1^r + a_{11}^{rs} X_1^s + a_{12}^{rs} X_2^s + Y_1^r \tag{2.27}$$

By following the same procedure as in equation (2.4) moving the Y_1^r term to the right hand side yields:

$$(1 - a_{11}^{rr}) X_1^r - a_{12}^{rr} X_2^r - a_{13}^{rr} X_3^r - a_{11}^{rs} X_1^s + - a_{12}^{rs} X_2^s = Y_1^r \tag{2.28}$$

Similarly, there will be expressions for $Y_2^r, Y_3^r, Y_1^s, Y_2^s$ terms on the right hand side. These five equations can be represented compactly as:

$$\begin{aligned} (I - A^{rr}) X^r - A^{rs} X^s &= Y^r \\ - A^{sr} X^r + (I - A^{ss}) X^s &= Y^s \end{aligned} \tag{2.29}$$

where Y^r is the three-element vector of final demand for region "r" goods and Y^s is the two elements vector of final demand for region "s" goods. Thus, equation (2.8) in the regional model can be transformed in two-interregional input-output model as:

$$\left\{\begin{bmatrix} I & 0 \\ 0 & I \end{bmatrix} - \begin{bmatrix} A^{rr} & A^{rs} \\ A^{sr} & A^{ss} \end{bmatrix}\right\}\begin{bmatrix} X^{r} \\ X^{s} \end{bmatrix} = \begin{bmatrix} Y^{r} \\ Y^{s} \end{bmatrix} \tag{2.30}$$

The main advantage of the inter-regional I/O model is that it captures the magnitude effects on each sector in each region. The accompanying disadvantages are that data needs are increased greatly.

The multiregional approach uses the regional technical coefficients matrix A^{r} in place of regional input coefficients matrix A^{rr}. The basic assumption is that the input requirement per unit of output is constant from region to region. As Teeter et. al.(1989) stated the multiregional I/O model is basically a supply-demand pool technique which uses a simultaneous linear equation system under the restrictions that the true sum of shipments from each regional industry to other regions equals the known shipments from that industry to those regions. The same authors developed a four multiregional I/O model of forest based economic activities for the USA. This multiregional I/O model was used to examine the inter-regional output, employment, and income effects of final demand changes for forest products in particular regions. The model revealed that forest based industries were regionally interdependent with differences in the degree of spillover effects among regions.

The Linear Programming Model

According to the neoclassical theory, the objective of the development project or firm is to maximize profits. Thus, the problem facing the firm is to decide how much to produce so as to maximize profits given the production function, resources availability, and current prices. Linear programming in its simplest form, is stated as a programming problem (1) if it can be represented by the concept of activity analysis; (2) if the objective of the policy maker can be described as a function of the activities levels; and (3) if the various functional relationships satisfy the linearity assumptions (Chenery and Clark, 1959).

In algebraic terms, the primal linear programming formulation can be written as follows:

$$MaxZ = \sum_{j=1}^{n} c_j X_j \tag{2.31}$$

such that:

$$\sum_{j=1}^{n} aij Xj \leq bi \tag{2.32}$$

$$Xj \geq 0, \quad \text{for all } i = 1,...,m \quad \text{for all } j = 1,...,n \tag{2.33}$$

where the problem is to find the set of activity levels X_j that yield the largest possible

value of the objective function Z defined in terms of X_j but which does not violate any of the resource constraints equation (2.32) or involved any negative activity level equation (2.33). As Hazell and Norton (1986) note, the linear programming assumptions such as additivity and proportionality both define the linearity of the activities. Most important, both assumptions relate the value of the objective function and the fixed resources with the underlying production function which exhibit constant returns to scale. A second important feature of linear programming is the duality problem. The original or primal LP formulation deals with the problem of selecting the economic activities and the level of them in order to maximize profits. Further increases in profits are only possible if the firm purchases additional units of fixed resources. The dual problem answers the question of how much the firm should be willing to pay to rent additional units of each resource. The dual problem is dealing with finding the inputted or shadow prices of the fixed resources that yield the lowest possible value for the total endowment. The minimization in the dual avoids the problem of overvaluing resources and it requires that the total value of resources used by one unit of each activity Xj is not less than the gross margin Cj earned by that activity.

The I/O-LP Model Empirical Applications

Input-output analysis has been used extensively to evaluate the impacts or effects caused by autonomous changes in the economy in terms of individual sectors' output and resource requirements. Despite the criticism and limitations of underlying assumptions,

this technique provides the most complete information about the economic relationships among industry sectors that comprise the economic structure of an economic region.

On the other hand, the underlying I/O assumptions may constitute only a special case in linear programming analysis: fixed input factors, no substitution among inputs and unlimited availability of resources. By blending both models, the linear programming and I/O models, it is possible to model regional economies since some features of linear programming are used to overcome the I/O model limitations such as unlimited resource supply, and fix input usage.

In 1953, Moses blended I/O and Linear Programming techniques in order to achieve substitution and optimization within a general equilibrium framework. The author linked an inter-regional I/O with an LP transportation problem for the US economy that had as an objective to find a network of trade which would satisfy the requirements with a minimum total expenditure on transportation. The purpose of the transportation model was to show the optimal trade allocations or quantities of a specified good that were available at different regions and the quantities of the good that are required at a number of destinations. English (1975) used an I/O-LP model to the measure the economic impacts on local residents in North-Central New Mexico in four potential U.S. Forest Service management practices. The model used a forest input-output model and added a little more information on the management activities labor and capital resource constraint.

Penn et al., (1976) applied I/O-LP approach to measure the short economics effects on the U.S. economy of alternative scenarios involving reduced energy

availability due to trade embargo. The addition of LP overcomes the two major underlying I/O limitations : primary resources are available to support any level of production and no inputs are fixed. Data from an I/O model of the U.S. economy was incorporated into the linear model with primary inputs restrictions directly imposed. The I/O model was closed with respect to households making this industry sector part of the Leontief matrix. Energy constraints were developed for five basic types of energy from the following resources: coal, crude petroleum, refined petroleum, electricity, and natural gas. The scenarios of energy availability involved reduction in quantities of domestic coal, crude petroleum, and natural gas supply. The objective function was set to maximize gross output by production sectors subject to the following constraints: gross output equals to demand, household gross output equals to employee compensation by producing sectors. The authors were able to predict the effects of these alternative energy situations on US's output level, employment and GNP.

Petkovich and Ching (1978) proposed a modification of a regional I/O model in a linear programming framework to show the effects of reduction in sector capacity constraints or sector destruction on a regional economy. These authors presented six cases based on the degree of destruction and the level of imports of the affected sectors to meet the original final demands. The authors suggested that by modeling I/O in an LP framework two problems can be overcome: the existence of bottlenecks and substitution of imports. If the assumption is that no structural changes have occurred in the regional economy, this approach is suitable for the short run analysis. Basically, the whole row of the I/O constraint of the affected sector is scaled down by an scalar "r" whose values

range between zero and one. The output of the destroyed sector X_d should be less or equal to the same previously specified function of the original level of output X_d. In addition, the upper limit of import restriction should be the destroyed sector output.

Alward (1980) applied an I/O -LP to evaluate and assess the regional economic policies of the forest service. The author examined what allocations of national forest service system resources produced an output vector that most effectively accomplished regional economic policies. The author pointed out that in evaluating policies one should take into consideration their cost and how their benefits are distributed among producers. In addition, the author was able to make several formulations of I/O-LP: (1) production objectives subject to structural constraints representing the allocative efficiency problem in land management; (2) production objective subject to economic effect constraints. By using this formulation the objective function remains the same but the constraint set includes considerations for economic impact variables. Distributed economic impacts could be attained by incorporating constraints such as minimum level of income and employment; (3) economic impact objective subject to structural constraints. The objective function would reflect the purpose of maximizing some economic parameters such as value added, income or employment subject to fixed resources and output constraints; and finally (4) vertical efficiency subject to economic policy constraints. Constraints upon economic characteristics are established to carry out a distribution policy regarding to a specific target group with the objective of accomplishing the policy in the most vertically efficient manner.

Penson and Fulton (1980) used an I/O-LP model to examine the effects of a cut back in production by Texas agricultural producers on Texas' state economy. The authors suggest that a quadratic I/O-LP model is more consistent with the assumption that consumers determine how much of the goods and services they want to purchase based on their relative prices. In the traditional programming approach, the level of final demand for the product of each production sector is determined exogenously. In the quadratic I/O-LP model final demand is determined endogenously. The authors estimated empirically that agricultural producers in Texas would be worse off than before only if the producer of raw agricultural products imported the inputs needed from outside the state.

I/O-LP has been extensively applied in analyzing policies related to energy and water availability. (Lofting, 1968, and Rhea, 1970). Henry and Bowen (1981) applied an I/O-LP approach to evaluate the impacts of growth on regional water resources into the Central South Carolina region. This I/O-LP model provided a method for estimating water marginal values or shadow prices to alternative uses. Each industry sector's water demands is viewed in relation to total available surplus. A shortage of water in a particular sector indirectly restricts delivery to final demand by several sectors.

Bowker and Richarson (1989) applied an I/O-LP model for evaluating economic impacts of alternative farm policies on rural communities in Texas. The policies evaluated were continuation of the 1985 farm bill, lower target prices and the Harkin Bill. These polices reduced production but increased net returns and caused losses for non-crop industries such as agricultural services (banking and credit). The beneficiaries were

the group of industries related to households such as retail trade and services.

Jones and Huang (1983) linked a 38 I/O sectors model of the state of Iowa with an agricultural LP program. The model was applied in estimating the effects on the Iowa economy of four cases: restriction of water resource, substitution of inputs, change in final demand and estimation of a new industry.

The Integrated I/O and LP Model

The out input-output approach is a special case of linear programming in which the objective function has only one solution (Richardson, 1972). Table 2.3 illustrates an input-output (I/O) problem with a linear programming (LP) structure as presented by Jones and Huang (1983). The first quadrant in this table shows the intermediate demand flows of goods and services which both produced and consumed in the process of current production. The second quadrant shows the final demands for the goods and services which includes consumer purchases from producing sectors. The last column in the second quadrant shows the summation of intermediate and final demand.

That is:

$$(X_{i1} + X_{i2} + ... + X_{in}) + (C_i + G_i + I_i + E_i) = X_i \qquad (2.37)$$

or

Intermediate Demand + Final Demand = Gross Output

where:

X_{ij} is the sales by industry sector "i" to industry sector "j".

Table 2.3 An input-output table with linear programming structure

	Purchasing sectors								
	Quadrant I Intermediate production					Quadrant II Final outputs of producing sectors			
from	1	2	3	...	n	Final Demand (Y)			Total Gross Output (X)
to									
1	x_{11}	x_{12}	x_{13}		x_{1n}	C_1	I_1	G_1	E_1	$= X_1$
2	x_{21}	x_{22}	x_{23}		x_{2n}	C_2	I_2	G_2	E_2	$= X_2$
3	x_{31}	x_{32}	x_{33}		x_{3n}	C_3	I_3	G_3	E_3	$= X_3$
:	:	:	:		:	:	:	:	:	:=
n	x_{n1}	x_{n2}	x_{n3}		x_{nn}	C_n	I_n	G_n	E_n	$= X_n$
	Quadrant III Resources inputs to production					Quadrant IV Resources inputs to final demand				Resource Avail.
Land	Y_{11}	Y_{12}	Y_{13}		Y_{1n}	H_1	T_1	D_1	N_1	$\leq B_1$
Labor	Y_{21}	Y_{22}	Y_{23}		Y_{2n}	H_2	T_2	D_2	N_2	$\leq B_2$
Water	Y_{31}	Y_{23}	Y_{33}		Y_{3n}	H_3	T_3	D_3	N_3	$\leq B_3$
Timber	:	:	:		:	H_4	T_4	D_4	N_4	$\leq B_4$

C_i is household consumption for goods and services produced by industry sector 'i".

G_i is government expenditures for goods and services produced by sector 'i".

I_i is gross domestic capital formation of goods produced by sector "i".

E_i is exports of goods and services produced by sector "i".

The inputs to each sector per dollar of output expressed as a_{ij} are a constant function of output X_j, that is:

$$X_{ij} = a_{ij}X_j \text{....for all } i \text{ and } j \tag{2.38}$$

By substituting Equation (2.38) into Equation (2.37) yields:

$$a_{i1}X_1 + a_{i2}X_2 + \text{.....} + a_{in}X_n + C_i + G_i + I_i + E_i = X_i \tag{2.39}$$

The third and fourth quadrant shows the flows of inputs for the intermediate and final demand respectively. The final column in the fourth quadrant indicates resources availability for each category of the input resources. This relationship can be expressed as:

$$(Y_{k1} + Y_{k2} + \text{.....} + Y_{kn}) + (H_k + T_k + D_k + N_k) \leq B_k \tag{2.40}$$

inputs to intermediate demand + inputs to final demand ≤ input resource availability

By defining:

$$Y_{kj} = b_{kj}X_j \tag{2.41}$$

and by substituting Y_{kj} to equation (2.40) the following expression is obtained:

$$(b_{k1}X_1 + b_{k2}X_2 + \ldots\ldots + b_{km}X_{km}) + (H_k + T_k + D_k + N_k) \leq B_k \tag{2.42}$$

where b_{kj} is the amount of resource "k" required to produce a unit of goods and services in industry sector "j".

Chenery and Clark (1959) and Everett and McCarl (1986) compare assumptions of linear programming with those of input-output analysis. Both require knowledge of resource usage per unit of input. The second assumption is that total input usage, and output respectively equals the sum of the individual input usage and output for each activity or sector in the model. Another assumption is the certainty required by non-stochastic coefficients. However, I/O analysis assumes fixed price ratios with unlimited resources availability to meet any demand while linear programming assumes a perfectly competitive input market with a single price up to the limit of resources supplies. The next assumption of I/O approach is that each commodity is supplied by a single sector. In linear programming this assumption is different, since commodities may be produced by any number of activities and each activity may have several outputs. Finally, the I/O

model spans an arbitrary period of time, usually short-run, to minimize consideration of technological change while LP can handle any time period. In conclusion, the two models appear to be compatible and in some instances complementary to each other in their assumptions.

As Brink and McCarl (1971) pointed out, the mathematical integration of I/O and LP is accomplished simply by the following specification:

$$Maximize \quad (1,1,.....,1,1)\,X \tag{2.43}$$

subject to:

$$(I - A)X \leq Y \tag{2.44}$$

$$b_{ij}\, X_j \leq B_i \tag{2.45}$$

$$X_j \geq 0 \tag{2.46}$$

where the *(I-A)* matrix is the technical coefficients matrix of the I/O model subtracted from an identity matrix. The purpose of the *(I-A)* matrix is to account for the processing sectors' output requirements given the base levels of final demand for each sector and the per unit intermediate demand of each activity. The I/O-LP problem seeks to maximize the value of the sum of the outputs from all industries under the constraint that the output for each industry does not exceed the use of that output in final demand and in inputs to other industries. Equation 2.45 is called the resources constraint. The optimum output levels will only be reached if there is available sufficient amount of some basic resources such as water, labor, and land. The b_{ij} are known as the technical resources coefficients and are

derived from a single observation of the resources requirement for sector "j". Expanding equation 2.45, the demand for resources, i = 1 to m yields:

$$\begin{aligned} B_1 &= b_{11}X + b_{12}X_2 + \ldots\ldots + b_{1n}X_n \\ B_2 &= b_{21}X + b_{22}X_2 + \ldots\ldots + b_{2n}X_n \\ &\vdots \\ B_n &= b_{m1}X + b_{m2}X_2 + \ldots\ldots + b_{mn}X_n \end{aligned} \tag{2.47}$$

where B_n are the resource available.

When inequality is strict the interpretation of the constraint is that final demand can not be satisfied. In this case, the Leontief inverse does not exist. When slack activities (s) are added to equation (2.44) the constraint is expressed as:

$$(I - A)\ X + IS = Y \tag{2.48}$$

The problem is to determine which activities out of X and S will be basic. Only activities X will be basic, and all the elements of the A matrix are between zero and one. This means, that only the diagonal elements of the $(I - A)$ are positive and off diagonals are negative. In the solution where all activities X are basic, these activities must appear in the constraint pre-multiplied by the inverse matrix. In order to obtain the

IX expressed in the constraint equation 2.47, this equation is pre-multiplied by the basic inverse $(I-A)^{-1}$.

Then, the constraint is transformed to:

$$IX+(I-A)^{-1}S=(I-A)^{-1}Y. \tag{2.49}$$

Since slack activities must be zero in the solution, the equation 2.48 is transformed to:

$$IX=X=(I-A)^{-1}Y \tag{2.50}$$

which is the same solution as the I/O fundamental equation (2.8).

CHAPTER III

Development of an Analytical I/O-LP Tennessee Model

Introduction

The Tennessee Agricultural industry model has both input-output and linear programming components. To evaluate the importance of the forest industrial complex on the Tennessee economy two models are required: a linear programming model is needed to estimate the forward and backwards impacts of possible changes on log exports or imports or in percent of growing stock harvested. The I/O structure relates the forestry complex industry sectors to other industrial sectors and the LP structure facilitates the linkages of land and timber resources uses and output of forestry sectors and other industrial sectors. The baseline I/O structure for this study is developed using the 1994 IMPLAN regional database. The original IMPLAN tables are adjusted by incorporating more accurate secondary data gathered from state and federal agencies. This process is known as hybridization of the I/O tables, which improves the analytical and predicted capabilities of the I/O models.

The purpose of this chapter is to first provide information on Tennessee's economic regions and focus on the forest industry complex. In addition, the software

tools used in this study are described along with an algebraic representation of the Tennessee Agricultural Industry Model (TN-AIM). Finally, the scenario development to address the objectives of this study are described.

Description of Tennessee Economic Regions

As indicated in chapter II, economic activity locus around a centroid city. In Tennessee, there are five major cities around which economic activity takes place: Chattanooga, Knoxville, Memphis, Nashville, and the Tricities. Counties surrounding the five cities are aggregated together to five economic activity regions. These regions are the same as the Business Economic Areas developed by the U.S. Department of Commerce (Johnson, 1995). The Bureau of Economic Analysis has divided the whole country into 172 economic regions. Each economic region consists of one or more major metropolitan areas (nodes) and surrounding counties economically linked with these nodes. The main factor in determining the boundaries of each region is the commuting patterns of the labor force. By definition, the labor force of an economic area should work and reside in each area so commuting across boundaries regions is limited. The five regions are: West (Memphis), Central (Nashville), East-north (Tricities), East-Central (Knoxville) and East-South (Chattanooga) regions. Table 3.1 shows the demographics and economic indicators of the five economic regions.

West Region (Memphis)

The West (Memphis) was the second largest region with an area of approximately

Table 3.1 Demographics and major economic indicators of the Tennessee regions

Region	Area	Population	Households	Income Households	T.I.O	Value Added
	Sq. miles	----------number ----------		$ dollars	---million of dollars----	
Knoxville	6,150	926,700	350,822	48,358	35,500	19,839
Nashville	17,691	1,860,400	677,276	55,059	90,002	46,333
Memphis	10,651	1,411,400	522,452	54,645	68,899	37,889
Tricities	2,673	434,900	167,269	44,051	16,353	8,477
Chattanooga	4,054	541,900	208,837	50,193	27,306	13,948
Total	41,215	5,175,300	1,926,656	52,243	238,060	126,486

Source: IMPLAN 1994

10,651 squares miles. The households' per-capita annual income in 1994 amounted to 54,645 dollars which was slightly higher than the state average. The total industry output of the region amounted to $ 68.8 billion.

The leading sector of the Memphis economic base was the manufacturing sector that represented almost 30 percent of the total regional output. Trade, services, transportation, communication and utilities sectors were also important economic sectors. In the manufacturing industry sector, industrial machinery and transportation equipment industries were the most important industrial sectors responsible for 9.2, 7.2, and 5.1 percent, respectively of the regional industry manufacturing output. In the trade and services sectors, wholesale and health services were the leading industries sectors accounting for 55.6 and 29.4 percent of the total regional output of trade and services respectively. In the transportation and communication and utility sector, air and motor freight transportation industry sectors were the leading economic sectors.

The total value added generated in Memphis economic region was approximately $37.8 billion. Among the main value added sector contributors were manufacturing, trade, services and banking & finance with contributions of about 22, 19, and 17.9 percent of the regional total value added, respectively.

Regarding employment, trade, services, manufacturing, and state and local government were the largest employers, accounting for 24.9, 23.5, and 10.6 percent of the total regional jobs, respectively.

From the 26.5 billion exported in 1994, manufacturing, transportation, communication and utilities, and trade accounted for 51.1, 15.5, and 12.5 percent of the

total regional exports, respectively.

The Forestry complex industry total output amounted to $3.5 billion distributed among the paper & allied products industry sector group (70 percent) , wood products (18.8 percent) and furniture and fixtures (13.8 percent). Among the leading industries sectors in the paper & allied products industry sector group were paper mills, sanitary paper and paper board containers with shares of 18.2, 18.5, and 8.4 percent of the total regional forestry complex output, respectively. In the wood products industry group, sawmills and planning mills, hardwood dimension and flooring mills accounted for 3.5 and 3.4 percent of the total regional forestry output.

Middle Region (Nashville)

The Nashville economic region is the largest region with 17,691 squares miles of area. In 1994, the Nashville economic region had the largest annual per-capita income in the state, approximately 55,059 dollars. The total industry output of this economic region amounted to $ 90 billion which represented approximately 37.8 percent of the total state industry output.

The manufacturing and services sectors were the leading economic sectors and accounted for 30.4 and 33.4 percent of the total regional industry output, respectively. Among the manufacturing sectors, transportation and industrial equipment produced 33 and 8.5 percent of the total regional manufacturing output, respectively. In the service sector, health, business and professional industry sectors accounted for 13, 5.5 and 5.7 percent of the total regional industries services output, respectively.

The total regional value added amounted to $59.7 billion from which services,

manufacturing, and trade contributed with approximately 38.9, 20, and 12.3 percent of the total regional value added, respectively.

The Nashville economic region employed in 1994 almost 1.11 million workers with more than 27 percent of this total concentrated in the services economic sector, followed by trade with 20.6 percent, manufacturing with 18.2 percent and state and local government with 9.7 percent of the regional jobs.

The regional exports amounted to approximately $ 41.1 billion distributed among manufacturing (60.1 percent) and services (21.3 percent).

The total industry of the forestry complex for the Nashville economic region was $3.5 billion that represented 23.3 percent of the state forestry industry output. Wood products and furniture and fixtures accounted for 40.4 and 32.2 percent of the regional forestry industry output, respectively. Among the wood sectors, sawmills and planning mills, hardwood dimension and flooring mills, and mobile homes were the leading sectors and accounted for 13.9, 6.7, and 4.8 percent of the regional forestry complex output, respectively.

Central Region (Chattanooga)

The Chattanooga economic region has an area of approximately 4,054 square miles. The Chattanooga region's household annual per-capita income is slightly lower than the state's household annual per-capita income. The regional total industry output amounted to $ 27 billion from which 32 and 28 percent correspond to manufacturing and services economic sectors, respectively.

Among manufacturing, the leading sectors were food processing, electric equipment, textiles, chemicals, and paper products. In the services industry group, the health services industry sector accounted for 15 percent of the regional total industry output. The federal-non-military sector was another important sector that contributed with 10.1 percent of the total regional industry output.

In 1994, the total value added generated in the Chattanooga economic region was $12.56 billion dollars. Among the leading contributing sectors were manufacturing (29.5 percent), services (19.7 percent), trade (15.31 percent) and federal government (9.55 percent).

Regarding employment, of the 322,023 jobs in the region, 22 percent were offered by the manufacturing sector, 25 percent by the services sector, and 21 percent by the trade sector.

In Chattanooga, $ 11.7 billion of goods and services were exported in 1994. Of this total, the manufacturing sector and federal government sector contributed with 5.7 and 27.27 percent, respectively.

The total industry output of the forest complex industry was $1.46 billion distributed among paper and allied products (56.7 percent), furniture and fixtures (34.7 percent), and wood products (8.4 percent). Among paper and allied group, paper mills, paperboard containers and boxes, and paperboard mills accounted for 23.0, 14.6, and 10.6 percent of the regional forestry industry output. In the furniture and fixture group, upholstered furniture and public building furniture accounted for 19.5 and 10.9 percent of the total regional industry output respectively.

East-Central Economic Region (Knoxville)

The Knoxville economic region has approximately 6,150 squares miles of area. In 1994, the household per-capita income was about $ 48,358. The total regional industry output amounted to $ 35 billion of which manufacturing, services, trade and banking and finance accounted for 31, 19.9, 13.5, and 11.7 percent, respectively. In the manufacturing group, wood and furniture fixtures industry sectors accounted for 13.8 percent of the total regional manufacturing industry output. Transportation equipment, fabricated metal and food processing followed, accounting for 10.6, 11.4, and 9.9 percent of the total regional industry output respectively. In 1994, the total value added generated in the Knoxville region was about $ 19.83 billion from which 23.9 percent corresponded to services sector, 23.3 percent to banking and finance and 23.05 percent to manufacturing industry sector.

Of the 510,044 jobs in the region, 27.1 percent were in the service sector, 21.3 percent in the trade sector, and 17.1 percent in the manufacturing sector.

In 1994, $12.8 billion of goods and services were exported, of which 61.3 percent corresponded to the manufacturing sector, 13.4 percent to the services sector, and 60.2 percent to trade.

In the forestry complex industry sectors, the $ 1.6 billion of regional industry output in 1994 was distributed among furniture and fixtures (59.8 percent), wood products (32.3 percent) and paper and allied products (7.8 percent).

Among the furniture and fixtures, upholstered household furniture (sector 149) and wood household furniture (sector 148) accounted for 18.6 and 11.6 percent of the total industry regional output respectively. In the wood products group, mobile homes

(sector 143) is the leading industry sector and accounted for 10.8 percent of the total regional total industrial output. Finally, in the paper and allied products group, converted paper products Non- Elsewhere Classified (N.E.C), sector 173, accounted for 4.3 percent of the total regional industry output.

East-North Economic Region (Tricities)

The Tricities economic region is the smallest Tennessee economic region with approximately 2,673 squares miles of area. In 1994, the household per-capita income was the lowest in the state, approximately $ 48,358. The total regional industry output amounted to $ 16.35 billion of which manufacturing, services, and trade in that order accounted for 42, 15, and 11 percent of the total industry output, respectively.

Regarding employment, of the 238,327 jobs in the region in 1994, 24.46 percent were in the manufacturing sector, followed by the services sector with 23.44 percent and the trade sector with 19.79 percent.

In the exports sector, of the $ 6.4 billion of goods and services exported to the rest of the world in 1994, the manufacturing and trade sectors accounted for 74.3 and 10.2 percent of the total regional industry output exported, respectively.

In the Tricities economic region of the $ 684 million of regional industry output, 54 percent was accounted for by the paper & allied products group, 28.6 percent by the wood products group, and 17.3 percent by the furniture and fixtures group. Among the paper and allied products group, converted paper products (sector 173) and paperboard containers and boxes (sector 164) accounted for 24.3 and 17.6 percent of the total regional industry output, respectively.

Among the wood products group, the sawmill and planning mills (sector 134) and wood preserving (sector 145) accounted for 8.5 and 7.8 percent of the total regional industry output, respectively.

The Methodological Approach

The Tennessee Agricultural Industrial Model (TNAIM) is designed to provide a relatively detailed representation of the forest-based production sector and aggregate production of industries.

The Objective Function

The objective function of TNAIM seeks to maximize the value added of all industry sectors across regions that comprise the economy of Tennessee.

$$Max..Z = \sum_{r} \sum_{j=1,...,132,134..525} C_{r,j} X_{r,j} + \sum_{r} C_{r,133} X_{r,133} - \sum_{rs} e_{rs,133} E_{rs,133} \qquad (3.1)$$

r = 1,.....,5 for the Tennessee B.E.A. regions in sequence: Knoxville, Nashville, Chattanooga, Tricities and Memphis.

rs =12,...,54 for domestic exports of sector 133 from region "r" to region "s' and r≠s where
s = 1,.., 5 the same regions as in "r".

j = 1,....., 525 for the industry sectors

where:

$C_{r,j}$ are the ratios of value added per $ million of total industry output (TIO) for industry sector "j" in region "r";

$X_{r,j}$ are the TIO's for industry sector 'j" in region 'r' in $ million;

$C_{r,133}$ are the ratios of value added for industry sector 133 (logging camps and logging contractors) in region "r";

$X_{r,133}$ are the TIO's for sector 133 (logging) in region "r";

$e_{rs,133}$ are the cost ratios of cost of transportation from region "r" to region "s" of industry sector 133. These coefficients have a negative sign since they are transportation cost; and

$E_{rs,133}$ are the TIO's for industry sector 133 exported from region "r" to region "s".

The I/O Constraints

Three types of I/O constraints are specified in this model: The first I/O constraint is for all industry sectors except 133 (logging camps and logging contractors) and 525 (households) industry sectors.

$$\sum_{j} Br,i,j\,X\,r,i,j - SXr,i,j \leq Yr,i \qquad (3.2)$$

r = 1,.....,5 regions

i = 1,....,132,134,...,524; all industries except 133 and 525

j = 1,.....,132,134.....,524

where:

$X_{r,i,j}$ is previously defined;

B_{rij} are the coefficients that result by subtracting the regional coefficient matrix *(A)* from the identity *(I)* matrix. The coefficients have a positive sign when i=j and a negative sign when i≠j. In addition, the $B_{r,i,j}$ coefficients are netted from imports; and

$SX_{r,i,j}$ is a final demand flexibility variable for region "r", industry "i" and sector "j".

The flexibility variable is only applied to forest based industry sectors, 134 to 173 industry sectors, respectively.

Y_{ri} is the final demand of industry sector "i" in region "r".

Equation (3.2) states that the total value of industry output for sector "i" $(X_{r,i,j})$ after subtracting the intermediate demand (AX_{rj}) should be less than or equal to the final demand of industry "i" in region "r". The regional technical coefficients and final demand components are netted from imports and households final demand respectively.

The second set of I/O constraints is for the 133 (logging camps and logging contractors) industry sector for each region. This constraint is specified by the basic I/O balance equation:

$$\sum_{j} Br,133,jXr,133,j + Mr,133 - Ers,133 - SFEr,133 \leq Yr,133 \qquad (3.3)$$

where:

$X_{r,133,j}$, $B_{r,133,j}$, $E_{rs,133}$ and $Y_{r,133}$ has been previously defined;

$M_{r,133}$ is the total value of imports in millions of dollars of industry sector 133 in region r".

$SFE_{r,133}$ is the slack variable of foreign exports.

The third set of economic activity constraints is for the households sector that is stated as follows:

$$-\sum_{j=1}^{524} Wr,525,jXr,525,j + (1 - Cr,525,525)Xr525,525 \leq Yr,525 \qquad (3.4)$$

where:

$X_{r,\,525,\,j,}$ and $Y_{r,525}$ has been previously defined; and

$W_{r,525,j}$ is the employee compensation ratio per $ million of industry output sector "j" in region "r".

$C_{r,525,525}$ is the employee compensation ratios of workers employed directly by the households sector per million of dollars of the same industry by region "r".

$X_{r,\,525,\,525}$ is the TIO's for households industry sector.

Household personal consumption expenditures is a linear function of household gross output $(X_{r,525,525})$ and is distributed among production sectors according to employee compensation coefficients $(W_{r,525,\,j}\ and\ C_{r,525,525})$.

Land Constraint

Forestland is limited by the forestland available in each Tennessee region. The forest land constraint is stated as follows:

$$\sum_{k=13301}^{13344} b_{r,\,lozwp,\,k}\, X_{r,\,lozwp,\,k} - \sum_{k=13345}^{n} f_{r,\,lozwp,\,k}\, X_{r,\,lozwp,\,k} \le L_{r,\,lozw} \qquad (3.5)$$

$r = 1,...,5$ for the Tennessee regions.

$l = 1,...,5$ for the following sequence of land use class: timberland, forestland, non-forest land and other land.

$o = 1,...,4$ for the following sequence of ownership type: public, forest industry, farmer and other private land.

$z = 1,...,4$ for the following types of stand size: sawtimber, poletimber, seedling & sapling and non-stocked.

$w = 1,2$ for the following types of wood: softwood and hardwood.

$p = 1,2$ for the following types of wood products: sawlogs and pulpwood.

$k = 13301,....,n$ is the industry output for sector 133 distributed among the combination of land use class "l", ownership type "o", stand size "z", type of wood "w" and type of wood products "p".

TIO's industry sector 133 activities (j):

Knoxville: k = 13301,...,13348
Nashville: k = 13301,...,13346
Chattanooga: k = 13301,....,13344
Tricities: k = 13301,...., 13332
Memphis: k = 13301,...., 13342

Slack TIO's industry sector 133 activities (j)

Knoxville: k = 13349,...,13396
Nashville: k = 13347,...,13392
Chattanooga: k = 13345,....,13388
Tricities: k = 13333,...., 13364
Memphis: k = 13343,...., 13384

where:

$b_{r,lozwp,\,k}$ is the amount of land in acres required for producing one million dollars of total industry output for 133 logging camps and logging contractors industry sector by region "r", land class "l", ownership type "o", stand size "z", type of wood "w" and type of wood product "p".

$X_{r,\,lozwp,k}$ is the total industry output of 133 industry sector in million dollars by region "r", land class use "l", ownership type "o", stand size "z", and type of wood "w".

$f_{r,lozwp,\,k}$ is the amount of slack land in acres for producing one million dollars of TIO's industry sector 133 Logging Camps & Logging Contractors by region, land class "l", ownership type "o", stand size "z", type of wood "w" and type of wood product "p".

$X_{r,\,lozwp,k}$ is the slack of total industry output for 133 industry sector in million dollars by region "r", land class use "l", ownership type "o", stand size "z", type of wood

"w" and type of wood product "p".

$L_{r,lozw}$ are the right hand sides values in acres of timberland reported by the forest inventory database by region "r", land use class "l", ownership type "o", stand size "z", and type of wood "w".

Timber Constraint

This constraint states that the volume of wood required per million of industry 133 logging camps & logging contractors should be less than or equal to the total amount of timber available in cubic feet by region "r", land class "l", ownership type "o", stand size "z", and type of wood "w". The timber constraint can be written as follows:

$$\sum_{k} d_{r,loswp,k} X_{r,loswp,k} - \sum_{k} g_{r,loswp,k} X_{r,loswp,k} \leq T_{r,wp} \qquad (3.6)$$

where:

$d_{r,lozwp,133}$ is the amount of type of wood in million of cubic feet required to produce one million dollars of TIO's 133 industry sector logging camps & logging contractors distributed by land use class "l", type of ownership "o", stand size "z", type of wood "w", and wood product "p" in region "r".

$T_{rwp,133}$ is the volume of harvested timber in millions of cubic feet by region "r", type of wood "w" and type of wood products "p".

The set of constraints is used to link harvesting activities $(X_{r,lozwp,k})$ by region "r", land class "l", type of ownership "o", and stand size "z" and wood type "w" with the logging industry. The linkage constraint can be written as follows:

$$-X_{r,133,133} + X_{r,lozwp,k} \equiv 0 \qquad (3.7)$$

The total value of industry output for the logging sector in each region 'r" should be equal to the sum of all industry harvesting activities ($X_{r,lzowp}$) by land use class "l", type of ownership "o", stand size "z", type of wood "w" and type of wood products "p".

Domestic Interregional Exports Constraint

The domestic state exports constraint refers to the total interregional domestic exports in million of dollars among logging (sector 133) from region "r" to region "s" that occurs between regions in the state of Tennessee. This constraint can be written as follows:

$$\sum_{r} Ers,133 \leq SE \tag{3.8}$$

where:

$E_{rs,133}$ is the amount of domestic exports in millions of dollars of industry sector 133 logging camps and logging contracts from region "r" to region "s" in Tennessee.

SE is the total value of domestic interregional exports of industry sector 133 logging camps and logging contracts in millions of dollars for the whole state.

Out-of-State Imports Constraint

The out-of-state import constraint is referred to as the domestic imports of the logging sector from other states. The import constraint can be formulated as follows:

$$I\,r,133 \leq Mr,133 \tag{3.9}$$

where :

$I_{r,133}$ is the amount of imports of timber by industry sector 133 logging by region "r" from neighboring states.

$M_{r,133}$ is the right hand side value of the total regional imports of logging sector in millions of dollars.

Slack for Land and Timber Constraint

The slack land and timber constraint allows increasing the supply of timber over the level of harvesting by the amount of the reduction on roundwood imports of sector industry 133 by region "r". This constraint is stated as:

$$\sum_{k=13345}^{n} X_{r,\,lozwp,\,k} \leq RM \tag{3.10}$$

where:

RM is the RHS value of timber expressed in millions of dollars that will allow an increase to the timber supply.

Forestry Industry Sector's Output Growth Constraint

This constraint is constructed with the purpose of limiting the TIO's industry output for the forest-based industry complex. The constraint is stated as follows:

$$X_{r133,\ldots,137} \leq O_{r,133,\ldots,173} \tag{3.11}$$

r = 1,....,5 Tennessee regions

j = 133, ...,173 forest based industry sectors

Labor Constraint

The labor constraint can be expressed as follows:

$$\sum_{j} h_{r,j} X_{r,j} \leq LB_{r,i} \tag{3.12}$$

r = 1,....,5 Tennessee regions

j = 133,...., 173 forest based industry sectors.

i = 1, 2, 3 where 1, is wood products, 2, is furniture, and 3 is pulp and paper. The furniture industry group includes metal furniture

where:

$h_{r,j}$ is the number of jobs per million of total industry output of sector "j" of the forest industry complex.

$LB_{r,i}$ is RHS's value in number of jobs in each region for the entire forest industry complex.

Flexibility Final Demand Forestry Industries Constraint

The final demand forestry constraint was introduced to allow the estimation of the forward economic impacts of an increase in the processing of raw material (logs) by primary and secondary wood industry sectors. This constraint is stated as follows:

$$SX_{r,j} \leq SR_j \tag{3.13}$$

j = 133

where:

$Sx_{r,133}$ has been previously defined.

SR is the amount of increase in final demand of forestry sector "j" equivalent to the availability of raw material (logs).

Foreign Exports Slack Constraint

This constraint was developed to allow the increase in the supply of raw material (logs) without affecting the final demand and consequently the total industry output. This constraint is used in the scenario which measures the economic effects of reducing foreign exports of raw material and increasing the processing activities by the same amount. This constraint is stated as follows:

$$SFX_{r,133} \leq SFR_r \qquad (3.14)$$

where:

$SFX_{r,133}$ has been previously defined.

SFR is the right hand side value of the foreign exports that will be disposable for regional processing by the primary and secondary forestry sectors by each region "r".

Additional constraints for value added and total industry output were constructed to record the changes in those variables for the three aggregated forestry sectors: wood products, furniture and pulp and paper group sectors.

Methodological Tools

There are four models used in this analysis (Figure 3.1). The first model is IMPLAN, an Input-Output model. It is used to supply coefficients to the second model TNAIM, and provides impact information once solution data from the second model are impacted. The second major component is TNAIM, a linear programming model that contains information on timber resources as well as representing the state economy. Other data sources include Forestry Service Inventory Data and Tennessee Agricultural Statistics.

System solution occurs in the following manner: A baseline solution for 1994 is established both in IMPLAN and TNAIM. Then the alternative scenarios designated to address the question of the study are implemented in TNAIM. The TNAIM's solution of the alternative scenarios is then inputted into IMPLAN. From the TNAIM solution, both direct and indirect effects are reported and induced effects are taken from IMPLAN. Note that the direct plus indirect effects include forward and backward linked impacts. These impacts are then placed into the IMPLAN model when the induced effects include change in total industry output as reported in the TNAIM model.

IMPLAN

This study relies on the use of the 1994 IMPLAN Pro software currently available. The IMPLAN (IMpact analysis for PLANing) is a computer software package developed by the Forest Service in the early 1980s and falls into the category of non-

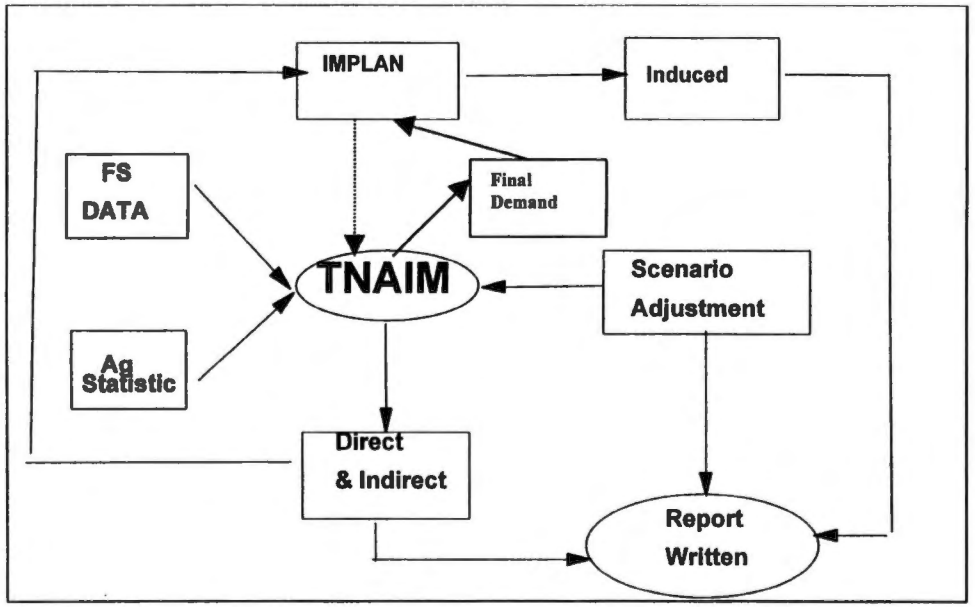

Figure 3.1 Schematic of the analysis using Tennessee agricultural and industrial model and IMPLAN

survey input-output models. The IMPLAN system includes descriptive accounts of inter-industry and inter-sector transactions among producing and purchasing economics units-business, households, and government- in a county, group of counties, state or group of states. The availability of regional data make the non-survey approach not only reliable but also cost effective when compared with other survey input-output models. The IMPLAN regional data is highly disaggregated into 528 industry sectors at 3-digit Standard Industrial Classification (SIC). Industries can be aggregated to meet the needs of the study. Aggregation speeds up the model development and processing and reduces the size of the reports but it should be cautioned that highly aggregated data also introduces biases due to loss of data detail. Biases are introduced from averaging production functions, output per workers, and other value added ratios.

Sector Aggregation Criterion

Sector aggregation criterion is one of the initial steps for generating regional accounts using IMPLAN-Pro software and requires special careful consideration. Basically, sector aggregation depends on the objectives of the study, computational expense, and the availability of data (Miller and Blair, 1985). For conventional input-output analysis, the latter two issues are relatively unimportant because data are already available through IMPLAN and the process of matrix inversion and reporting do not represent significant costs. Consideration should be given to aggregation of sectors that have similar production functions. This should reduce aggregation bias associated with input factors, value added and employment. Siverts and Palmer (1983) suggest the following guidelines to construct an aggregation scheme:

1. Leave disaggregated sectors that are going to be the target of the study.

2. Leave disaggregated sectors with large and distinctive total industry output.

3. It is appropriate to aggregate sectors which do not have changes in final demand to avoid complicated models difficult to handle. Sectors should be aggregated based on similarities of production processes and demand minimizing the aggregation bias associated with input demand, income generation, and output demand.

4. If an area is specialized in production of particular goods, these sectors should be left disaggregated.

This study aggregates the 528 IMPLAN industry regional sectors into a range that fluctuates from 97 to 114 industry aggregation sectors. The agricultural, livestock and forestry industry sectors are left unaggregated. The rest of industry sector were aggregated following the 2-digit SIC group definition. This criterion seems reasonable since the commodities are similar in terms of production processes. The aggregation scheme is provided in Appendix C. Exceptions were made for Federal Government sectors which were aggregated into one sector regardless of the 2-digit SIC classification.

IMPLAN uses regional data and applies it to the national matrices to create a set of regional accounts. The national absorption matrix table shows the industries production functions and it is derived from the national use matrix. IMPLAN's basic assumption is that regional industry production functions follow the same structure as the national production functions represented by the national absorption table. The regional data consist of value added, total industry output, and final demand components by the industry sector. Once the study region is defined, IMPLAN computes the regional

absorption coefficients by multiplying the national absorption coefficients with an absorption factor. The latter is defined as a ratio of the inverse of regional value added to national value added. These regional absorption coefficients, although adjusted, still represent the average national production technology. These coefficients are gross which means they include imports from outside the region. In order to reflect regional impacts, imports should be removed from the regional coefficients and regional final demand. IMPLAN accomplishes this objective by using the regional purchase coefficients (RPC) previously estimated by using econometric equations with variable values filled from regional data. An RPC coefficient represents the portion of the total local demand that is met by local production and attempts to account for cross hauling -the regional importation and exportation of commodities from the same sector.

Data Needs and Model Modification

Employment, all components of value added, and total industry output for each agricultural sector in the model should be modified as appropriate. The IMPLAN regional models must accurately reflect the local economies. In this way, the supply side of the regional model can be made as accurate as possible. The Census of Agriculture (1992) and the National Agricultural Statistics Service NASS (1994) data were used to adjust IMPLAN's regional total industry output (TIO) data. Table 3.2 shows the bridge between census and NASS categories agricultural and livestock sectors. This study follows the recommendations suggested by Lindall (1998). The 1994 NASS crop county data was used to obtain total production for wheat, corn, sorghum, cotton and soybeans. Prices for the same crops were obtained from *Tennessee Agricultural Statistics 1997.* Combining

Table 3.2 Census 1992/NASS 1994 to IMPLAN agricultural and livestock sectors bridges

Agricultural Sectors	IMPLAN Industry Sectors	IMPLAN sector number
From Census 1992		
Dairy	Dairy Farm Products	1
Poultry & Products	Poultry & Eggs	2
Cattle & Calves	Ranch Fed Cattle	3
	Range Fed Cattle	4
	Cattle Feedlots	5
Sheep, Lambs, and Wool	Sheep, Lambs, and Goats	6
Hogs & Pigs	Hogs, Pigs, and Swine	7
Other Livestock	Miscellaneous Livestock	9
Hay and Field Seeds	Hay and Pasture	13
	Grass Seeds	14
Tobacco	Tobacco	15
Fruits, Nuts and Berries	Fruits	16
	Tree Nuts	17
Vegetables, Sweet Corn, and Melons	Vegetables	18
Other Crops	Miscellaneous Crops	20
Nursery and Greenhouse Crops	Greenhouse and Nursery Products	23
From NASS:		
Cotton and Cotton seed	Cotton	10
Wheat	Food Grains	11
Corn	Feed Grains	12
Sorghum		
Soybeans	Soybeans	21

Source: National Agricultural Statistics Service- USDA

these two information sources, the value of production for the mentioned crops were estimated.

For the remaining crops and livestock categories, the following procedure was implemented. First, the total market value of agricultural products sold in each region was obtained from the *Agricultural Census 1992* database. The same information by crop was obtained for the state. Next, output value market share for each region in the total output value product of the state was estimated. Then, the output value product market share of each region was applied to the 1994's state output value for each product. The latter information was obtained from the *Tennessee Agricultural Statistics 1997* and *Tennessee Abstracts 1996-1997.* The underlying assumption for this procedure was that regional output values product shares 1994 was exactly the same as that of 1992 which seems reasonable since no major changes in the regional market product shares are expected in such a short period of time.

The census value for cattle & calves needed to be distributed among ranch feed cattle, range feed cattle and cattle feedlot. In Tennessee, ranch feed cattle makes up most of the livestock operation, so the value of range feed cattle and cattle feedlots were left unchanged. The value for ranch feed cattle was estimated by subtracting from the cattle and calves, range feed cattle and cattle feedlots. Similar criterion was applied to the estimation of hay and pasture and grass seeds. The Census value needed to be distributed among the above IMPLAN categories. The IMPLAN grass seeds values were left unchanged. This value was subtracted from the estimated hay and fields seeds to get the estimated value for hay and pasture. In the same way, fruits, nuts and berries needed to be

distributed between fruits and tree nuts. Since the production of tree nuts is lesser than the production of fruits, IMPLAN total industry output value for sector tree nuts was left unchanged and subtracted from the estimated value of fruits, nuts and berries in order to estimate the value of fruits. Due to the lack of regional secondary information, IMPLAN total industry output value for sector 9 (miscellaneous livestock) and sector 22 (forest products) were left unchanged. Table 3.3 shows the comparison between IMPLAN total industry output figures for agricultural and livestock sectors and those after the adjustment process.

The analytical capabilities of the IMPLAN system can be classified into two broad categories; (1) the description of the economic structure of the region, and (2) the estimation of impacts from changes in final demand of industry sectors. These two analytical capabilities are accomplished in two IMPLAN modules. The first module allows the user to generate a set of balanced regional input-output and social accounts and a set of multipliers. In this module two models are constructed for each region: The descriptive model and the predictive model. The descriptive model describes the transfer of money between all industries and institutions. It contains the input-output accounts and social accounts. The predictive model is the set of input-output multipliers which predicts total regional activity change based on changes in consumption. The descriptive model has to be generated before the predictive model. In the first model the user can change regional data by using an editor. In addition, it also contains an aggregation option to aggregate industry sectors in accordance with the user's aggregation scheme.

In the impact analysis module, the user assigns a specified series of changes in

Table 3.3 Adjustment of IMPLAN agricultural and livestock industry output

Industry name	Adjusted Output	IMPLAN Output	Adjusted Output	IMPLAN Output	Adjusted Output	IMPLAN Output
	Tricities		Nashville		Memphis	
	Million of dollars					
Dairy Farm Products	36.40	33.20	121.13	110.69	17.12	16.48
Poultry and Eggs	3.00	4.05	101.43	89.45	17.00	6.99
Ranch Fed Cattle	40.90	33.10	222.33	173.52	66.28	47.48
Range Fed Cattle	1.20	1.19	7.03	7.03	1.85	1.85
Cattle Feedlots	1.50	1.48	12.41	12.41	8.50	8.5
Sheep, Lambs and Goats	0.03	0.08	0.23	0.69	0.04	0.15
Hogs, Pigs, and Swine	0.03	0.55	30.65	29.82	42.69	41.54
Other Meat Animal Products	1.65	0.02	15.42	0.27	5.08	0.04
Miscellaneous Livestock	0.00	0.00	0.00	0.00	0.0 0	0.00
Cotton	0.00	0.00	8.31	4.94	286.63	191.59
Food Grains	0.11	0.17	12.30	11.70	32.99	26.36
Feed Grains	1.65	2.46	48.65	46.49	94.20	84.67
Hay and Pasture	19.54	27.21	101.67	129.52	30.70	30.38
Grass Seeds	0.00	0.00	0.59	0.59	0.03	0.03
Tobacco	57.62	65.93	123.57	143.22	3.76	3.66
Fruits	0.33	3.46	2.07	9.57	3.25	5.22
Tree Nuts	0.001	0.001	0.01	0.01	0.14	0.14
Vegetables	1.09	3.87	22.00	25.96	18.89	20.64
Sugar Crops	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous Crops	4.08	0.00	22.56	4.35	2.57	1.33
Oil Bearing Crops	0.15	0.38	37.06	35.42	170.11	146.51
Forest Products	0.47	0.47	4.75	4.75	1.89	1.89
Greenhouse and Nursery Products	7.94	13.39	113.79	85.27	16.68	14.09

Source: IMPLAN 1994 and Tennessee Statistical Abstracts 1994

Table 3.3. (Continued)

Industry name	Adjusted Output	IMPLAN Output	Adjusted Output	IMPLAN Output	Adjusted Output	IMPLAN Output
	Knoxville		Chattanooga		Total State	
	----------Million of dollars----------					
Dairy Farm Products	29.67	27.31	42.98	39.21	247.30	226.89
Poultry and Eggs	13.75	15.59	78.20	62.18	213.39	178.26
Ranch Fed Cattle	56.30	44.61	34.59	27.88	420.46	326.59
Range Fed Cattle	1.63	1.63	1.03	1.03	12.73	12.73
Cattle Feedlots	2.61	2.61	1.05	1.05	26.05	26.05
Sheep, Lambs and Goats	0.05	0.17	0.01	0.06	0.36	1.15
Hogs, Pigs, and Swine	2.38	2.64	1.48	2.32	77.23	76.87
Other Meat Animal Products	3.26	0.03	3.03	0.007	28.44	0.367
Miscellaneous Livestock	0.00	0.00	0.00	0.00	0.00	0.00
Cotton	0.00	0.00	0.00	0.00	294.94	196.53
Food Grains	0.48	0.70	1.01	1.05	46.89	39.98
Feed Grains	2.96	3.91	3.79	3.89	151.25	141.42
Hay and Pasture	27.96	40.44	14.39	18.31	194.26	245.86
Grass Seeds	0.00	0.00	0.00	0.00	0.62	0.62
Tobacco	55.72	62.40	7.27	8.87	247.94	284.08
Fruits	0.95	3.72	0.76	2.86	7.36	24.83
Tree Nuts	0.003	0.003	0.003	0.003	0.157	0.157
Vegetables	7.29	7.26	15.7	7.14	64.97	64.87
Sugar Crops	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous Crops	2.85	0.00	0.75	0.00	32.81	5.68
Oil Bearing Crops	1.09	1.41	3.44	3.039	211.85	186.76
Forest Products	1.18	1.18	0.46	0.46	8.75	8.75
Greenhouse and Nursery Products	15.14	19.01	4.23	5.05	157.78	136.81

Source: IMPLAN 1994 and Tennessee Statistical Abstracts 1994

final demand to sectors experiencing the impacts or shocks to estimate the corresponding changes in total sector industry output, employment, personal income, wages, value added and taxes. IMPLAN modeling applications have been used extensively in issues ranging from assessing regional impacts of agricultural conservation programs, trade, drought, energy and water management resources limitation to the economic importance of the agricultural, forestry and other specific sectors in the regional economy.

Tennessee Agricultural Industrial Model (TNAIM)

This study uses a General Algebraic Modeling Systems (GAMS) algorithm to solve the Tennessee Agricultural Industrial Model, a regional I/O and linear programming model. GAMS is mathematical programming software designed to solve both linear and non-linear optimization problems.

There are four sections within regional TNAIM:

1. The regional industry to industry interaction matrix;

2. The timber resource availability matrix;

3. The interregional transportation and trade sectors; and

4. The levels of production demand, trade, and resource availability vector.

The model maximizes regional value added, allows transportation of logs between regions, contains the ability to import logs, and has information that converts growth of sawtimber, and pulpwood into harvested material.

TNAIM Development

The Regional Industry to Industry Interaction

In order to provide the I/O structure needed in the Tennessee model a five regional I/O models were developed using IMPLAN consisting of a flow table of interindustry transactions, a direct requirement or technical coefficients matrix, a Leontief (I-A) matrix and total requirement matrix. The transaction table used was the industry by industry Social Accounting Matrix (SAM) to generate the needed coefficients. There were seven steps in developing TNAIM. These steps were:

1. The five Tennessee regions were defined according to the Bureau of Economic Analysis.

2. The regional accounts of the regional I/O IMPLAN models were edited by adjusting the total industry output values for the agriculture and livestock sectors. After editing, the remaining industry sectors were aggregated according to the aggregation scheme explained earlier.

3. The SAM industry by industry transaction table was generated using Microsoft Access.

4. The regional household sectors were incorporated into the Leontief matrix. The personal consumption expenditures (PCE) columns for high, medium and low-income households and employee compensation row were used to make the household sector endogenous. This requires the row and column total to be equal.

However, in 1994 total personal consumption expenditures (columns)

exceeds total employee compensation (rows). The difference was entered as a maximum final demand, allowing up to these additional amounts to be spent on consumption items.

5. The technical coefficients were estimated by dividing the value of all purchases made by each sector industry from other industries by the gross total output sector of that industry.

6. The row of regional coefficients for sector 133, logging camps and logging contractors were replaced by the absorption coefficients, which include imports. This estimation was accomplished by dividing the regional coefficients by sector 133's RPC.

7. The Leontief matrix coefficients *(I-A)* were estimated. These coefficients are computed by subtracting the matrix of the technical coefficient *(A)* from the identity matrix *(I)*.

The Timber Resource Availability Matrix

In this research, commercial forestland in Tennessee is estimated from the 1989 Forest Inventory and Analysis database (FIA), of forest service and Tennessee Forestry Division. The FIA data represent over 13,265 million of acres of forestland contained in 95 counties in Tennessee. The 1989 Forestry Inventory Data is the latest form of disaggregated forestry data available for Tennessee. The forest measurement data were taken from 4,698 individual sample plots. Each sample plot is treated identically in the model and they are considered as a single analysis area.

In each small plot there are sample points which are used to select the sample

trees to be measured. The FIA database consists of two types of files: The plot level files in which units are expressed in acres and the tree level files which contain tree attributes and other measures. The following is a description of the key attributes of this database selected in this research:

Plot Records:

- Plot identification number: A unique identification number plot which may be repeated within a state or survey unit.

- County: Name of the county where the analysis area is located.

- Ownership Class: Type of land ownership such as public, forestry industry, farmer, corporation, and other private ownership class.

- Land use class: A classification that indicates the basic biological potential of the land and its current use. Categories of land class are timberland, reserve forest land, non-forest land and water.

-Stand size class: A classification of forestland based on the predominant stocking by the size of all live trees present on the plot. This classification is based on the diameter measurement of a tree taken at breast-height (d. b. h) or 4.5 feet above ground. The stocking classes are: sawtimber, poletimber, seedling-sapling and non-stocked.

- Volume expansion factor (EXPVOL): The number of acres that the plot represents for estimating the current volume and number of trees.

- Area expansion factor (EXPACR): The number of acres that the plot represents for estimating variables such as ownership and land use class.

- Removal expansion factor (EXPREM): The number of acres that the plot represents for estimating removals adjusted by variables such as ownership class and land use.

Tree Records:

- Species group: A two-digit species group number that can be reduced to hardwood and softwood species.

- Volume expansion factor(VOLFAC) : The number of trees per acre that the tree record represents per acre for calculating volumes.

-Removal expansion factor (REMFAC): The number of trees per acre per year that represents the volume of removals.

- Net cubic foot volume (NETCFVL): The net volume of growing stock per tree expressed in cubic feet.

- Net cubic foot volume in sawlogs (NETCFSL): The net volume of wood for sawlogs per tree expressed in cubic feet.

The growing stock refers to all live trees except rough and rotten, in a forest or stand including sawtimber, poletimber, saplings, and seedlings. Sawlogs are defined as logs large enough to be carved into lumber, usually at least 10 to 12 inches in diameter. The removals of hardwood and softwood sawlogs and pulpwood in cubic feet per acre were estimated[5] as follows:

$$\text{Growing Stock Volume (GS)} = \text{EXPVOL} \times \text{VOLFAC} \times \text{NETCFVL}$$

$$\text{Sawlogs Volume (SL)} = \text{EXPVOL} \times \text{VOLFAC} \times \text{NETCGSL}$$

[5] Formulas taken from Forest Inventory and Data base 1989.

Pulpwood Volume = Growing stock volume - Sawlogs volume

The removals of growing stock for softwood and hardwood in cubic feet per acre were estimated by dividing the total volume of growing stock over the total number of acres of each combination of ownership class, stand size, land class, and species group respectively. Similar calculation was done for estimating removals of sawlogs for softwood and hardwood in cubic feet per acre. The pulpwood removals per acre were the difference between growing stock removals and sawlog removals. The average removals in cubic feet per acre of hardwood and softwood pulpwood and sawlogs adjusted by ownership type, land use class, and stand size are provided in Tables D.1 to D.5 in Appendix D.

To estimate land coefficients per million of industry output sector 133, (logging camps and logging contractors), removal volume ratios were transformed to a number of acres per million of dollars of industry output for sector 133. This transformation was accomplished by dividing one million dollars of total industry output value by the total amount of value of each removal per acre. These coefficients describe the number of acres needed to produce one million dollars of industry value for sector 133.

The timber coefficients per million of total industry output for sector 133 were estimated by multiplying the cubic feet/acre removals times acres per million of 133's TIO previously estimated. Tables D.6 to D.10 in Appendix D provide the timber coefficients adjusted by land use, type of ownership, stand size, and species group respectively.

Interregional Transport and Trade Sector Coefficients

The domestic interregional export coefficients are assumed to be negative because they represent the differential in cost of transportation ratios between the average regional cost of transportation and the ratio of cost of transportation from one region to another. By assuming a negative value, the transportation cost from one region to another is accounted. The following procedure was followed to estimate domestic exports coefficients. First, distance between main regional cities was measured using the Automap software. Second, it was assumed that the regional cross hauling would not exceed one hundred miles (one-way trip) or two hundred miles (two-way trip). Third, the estimates of an average regional cost of transportation per million dollars of industry output of sector 133 were taken from the IMPLAN database. Then, the transportation costs of logs between the regional cities were calculated according to the distance. The difference between the average regional transportation cost and the transportation between cities were considered to be domestic export transportation coefficients. Table 3.4 shows the domestic exports coefficients for the exports activities from one region to another.

The Level of Production Demand, Trade and Resource Availability Vector

Estimation procedures for final demand, land, timber, out-of-state imports and domestic interregional exports are described in this section.

Levels of Production Required

In addition to producing for other industries within a region, an industry must pay salaries (households), taxes, and export commodities. The final demand components for

Table 3.4 Distance, regional and interregional transportation costs, and domestic export coefficients

Export Activity	from	to	One way Distance	Two way Distance	Transp. cost /$ million TIO 133	Inter regional Transp. cost	Domestic export coefficients
			----------miles----------		----------dollars----------		ratio
E12	Knoxville	Nashville	179	358	7,474	13,378	-0.005904
E13	Knoxville	Chattanooga	110.5	221	7,474	8,258	-0.007840
E14	Knoxville	Tricities	113	226	7,474	8,445	-0.000971
E15	Knoxville	Memphis	386	772	7,434	28,849	-0.021375
E21	Nashville	Knoxville	179	358	7,111	12,728	-0.005617
E23	Nashville	Chattanooga	134	263	7,111	9,528	-0.002410
E24	Nashville	Tricities	292	584	7,111	20,764	-0.013653
E25	Nashville	Memphis	223	447	7,111	15,893	-0.008782
E51	Memphis	Knoxville	386	772	7,303	28,184	-0.020886
E52	Memphis	Nashville	223	447	7,303	16,322	-0.009019
E53	Memphis	Chattanooga	338	676	7,303	24,684	-0.017381
E54	Memphis	Tricities	499	998	7,303	36,441	-0.029100

TNAIM are: foreign exports, capital formation and state & local government and federal government purchases. Personal consumption expenditures (PCE) were excluded from the vector of final demand because they were treated as endogenous variables.

Land Right Hand Sides Values

The land RHS values for land were estimated from the Forestry Inventory database using Paradox Software. These RHS values are presented in Tables D.11 to D.15 in Appendix D.

Timber Right Hand Side Values

The timber right hand side values for sawlogs hardwood and softwood and pulpwood softwood and hardwood in thousands of cubic feet are presented in Table 3.5. Table 3.6 shows the regional value of production of softwood and hardwood pulp and sawlogs respectively. The table E.16 in Appendix E shows the volume of harvesting in standard cords and thousand board feet (MBF) for pulp and sawlogs, respectively for each county in Tennessee.

Domestic Out of State Imports and Out of State Exports Right Hand Side Values

The right hand side for interregional domestic exports and out-of-state domestic imports were taken from the results of the survey of wood primary processing plants in Tennessee and in neighboring states known to be processing roundwood from Tennessee conducted by Stratton and Wright in 1995. These authors found that Tennessee had 495 sawmills dedicated to the processing of sawlogs and 5 pulp mill facilities that receive roundwood for pulpwood. In 1995, the total volume of roundwood sawlogs harvested and processed in these sawmills (retained production), plus all imported from

Table 3.5. Total volume of softwood and hardwood for pulpwood and sawlogs in thousand of Cubic Ft. by region .

Region	Pulp softwood	Pulp hardwood	Sawlogs softwood	Sawlogs hardwood
	----------thousand of Cu Ft ----------			
Chattanooga	21,157	7,672	5,914	3,815
Knoxville	6,411	6,224	2,796	12,303
Tricities	27	2,006	900	3,001
Nashville	10,214	32,783	305	82,132
Memphis	7,029	15,755	1,707	47,130
Total	44,838	64,440	11,622	148,381

Source: Tennessee State Forestry Division, 1994.

Table 3.6. Value of production of softwood and hardwood pulp and softwood and hardwood sawtimber

Region	Pulp softwood	Pulp hardwood	Sawlogs softwood	Sawlogs hardwood
	---------- million of dollars ----------			
Nashville	6.23	17.60	6.45	104.25
Chattanooga	14.28	4.83	8.12	4.03
Knoxville	4.92	2.07	2.77	15.30
Tricities	0.22	1.41	3.12	6.71
Memphis	5.47	7.78	7.37	51.15

Source: Tennessee State Forestry Division, 1994.

neighboring states reached the amount of 169 million cubic feet. From this total, approximately 155 million cubic feet were hardwood roundwood while the remaining 14 million cubic feet were softwood sawlogs. Thus, Tennessee roundwood harvested and processed as sawlogs within the state (retained) reached 90 percent of its total sawlogs production. Tennessee imports approximately 18 million cubic feet of roundwood for sawlogs, exceeding the exports by 2 million cubic feet (Table 3.7).

Table 3.7. Tennessee sawlogs volume of production, domestic exports, retained within state, domestic imports and receipts

Type of Wood	Production	Domestic Exports	Retained Production within State	Domestic Imports	Sawmills Receipts
	----------thousand of Cubic Feet ----------				
Softwood	15,187	3,750	11,437	3,209	14,646
Hardwood	152,369	12,860	139,509	15,324	154,833
Total	167,556	16,610	150,946	18,533	169,479

Source: Tennessee Timber Industry an Assessment of Timber Product Output and Use (Stratton, and Wright, 1998)

Regarding pulpwood, according to the same survey Tennessee pulpwood production reached the amount of 109 million cubic feet which represents approximately 39 percent of the state total roundwood production. From this total, 45 million cubic feet were softwood roundwood, whereas the remaining 64 million cubic feet were hardwood roundwood.

From the total state roundwood production for pulpwood, nearly 43 percent was

harvested and processed at state pulp mills. The roundwood pulpwood exports amounted to 62 million cubic feet or 76 percent of the total exported roundwood. The roundwood pulpwood imports amounted to 42 million cubic feet or 20 million more than what was exported (Table 3.8).

Table 3.8 Tennessee pulpwood volume of production, domestic exports, retained within state, domestic imports and receipts

Type of Wood	State Production	Domestic Exports	Retained Production within State	Domestic Imports	Sawmills Receipts
	----------thousand of Cubic Feet----------				
Softwood	44,838	9,654	35,184	28,396	63,580
Hardwood	64,440	52,825	11,615	14,127	25,742
Total	109,278	62,479	46,799	42,523	89,322

Source: Tennessee Timber Industry an Assessment of Timber Product Output and Use (Stratton, and Wright, 1998)

The dollar value of the sawlogs and pulpwood produced, exported, and used within the state (retained), and imported from other states and total processed regardless of origin (receipts) are presented in Tables 3.9 and 3.10. The conversion factors used to convert cubic feet to board feet were 0.18018 for softwood sawlogs and 0.16556 for hardwood sawlogs. For pulpwood, cubic feet were converted to standard cords by using the relation of 72.5 cubic feet per cord in the case of softwood and 76.6 cubic feet per cord factor in the case of hardwood. The prices for sawlogs and pulpwood used were those reported by the Stumpage Price Mart Tennessee, 1994. These prices were the

Table 3.9 Tennessee dollar value of sawlogs production, domestic exports, retained within the state, domestic imports and total receipts

Type of Wood	State Production	Domestic Exports	Retained Production within State	Domestic Imports	Sawmills Receipts
	----------million of dollars----------				
Softwood	22.46	5.55	16.92	4.75	21.66
Hardwood	230.08	19.42	210.66	23.14	233.80
Total	252.54	24.97	227.58	27.89	255.46

Source: Tennessee Timber Industry an Assessment of Timber Product Output and Use (Stratton, and Wright, 1998)

Table 3.10 Tennessee dollar value of pulpwood production, domestic exports, retained within state, domestic imports and total receipts

Type of Wood	State Production	Domestic Exports	Retained Production within State	Domestic Imports	Sawmills Receipts
	----------millions of dollars----------				
Softwood	41.33	8.90	32.43	26.17	58.60
Hardwood	69.39	56.88	12.51	15.21	27.72
Total	110.71	65.78	44.93	41.38	86.32

Source: Tennessee Timber Industry an Assessment of Timber Product Output and Use (Stratton, and Wright, 1998)

average delivered prices for softwood and hardwood sawlogs and pulpwood.

Table 3.11 shows the sum of the total value of state roundwood production. In 1995, the total value of the state roundwood production amounted to approximately 363 million dollars of which 82 percent was hardwood roundwood while the remaining 18 percent was softwood roundwood. Tennessee domestic exports amounted to 90 million dollars of which 76 million dollars were hardwood exports and 14 million dollars were softwood exports. Domestic out-of-state imports amounted to 69 million dollars or 21 million dollars less than exports. Total sawmills receipts amounted to 641 million dollars of which 80 million dollars were softwood roundwood and 261 million dollars were hardwood roundwood respectively.

The imports roundwood right hand side values were distributed across regions by using industry 133's RPC provided for IMPLAN database. The RPC of sector 133 for Knoxville, Nashville, Chattanooga, Tricites and Memphis economic regions were 64, 70, 45, 78, and 58 percent respectively.

The Baseline Run

The baseline run is conducted to simulate total industry output for the forestry complex industry sectors and other industry sectors that comprise each of the five economic regions in the state of Tennessee for year 1994. This process is accomplished through maximization of gross state product for all industrial sectors in the state of Tennessee.

Table 3.11 Tennessee total dollar value of sawlogs and pulpwood production, domestic exports, retained within state, domestic imports and receipts

Type of Wood	State Production	Domestic Exports	Retained Production within State	Domestic Imports	Sawmills Receipts
	----------millions of dollars----------				
Softwood	63.79	14.44	49.34	30.92	80.26
Hardwood	299.47	76.30	223.17	38.35	261.52
Total	363.26	90.74	272.51	69.27	341.78

Source: Tennessee Timber Industry an Assessment of Timber Product Output and Use (Stratton, and Wright, 1998)

Preparation work for running the base run includes estimation of regional I/O technical coefficients, land, timber, value added and interregional domestic exports coefficients. Additional work was dedicated for the estimation of the right hand side values for final demand, land availability, timber constraints, interregional domestic exports and out-of-state imports. Data sources and procedures used in estimating these coefficients as well as right hand side values have already been described earlier in this chapter. The model for the base run consists of equation (3.1) through (3.9), which have been described in detail earlier.

Maximization of Gross State Product (GSP) for all industry sectors in the five regions of Tennessee is used in determining total production output for all industries for the whole state. After the sector aggregation process, there were 529 industrial sectors distributed into the five economic regions as follows: 104 industry sectors each in Knoxville and Chattanooga, 97 industry sector in Tricities, 111 industry sectors in Memphis and 113 industry sectors in Nashville, respectively. In addition, 212 activities were related to sector 133 (logging camps & contracts) which reflects regional structure of the logging sector based on land use class (l), ownership types (o), stand size (z) and type of wood (w).

The base line contains the vectors of final demand (FD), total industry output (T.I.O), land and timber resource usage levels. Table 3.12 shows the T.I.O., value added and employment of the wood, furniture and paper & allied products industry sector grouped by economic region. Table 3.13 shows the regional optimal levels of total

3.12 Base run forestry complex economic indicators by Tennessee regions

Economic Region	Forestry Groups	T.I.O	Value Added	Number of Jobs
		-----million of dollars----		
Knoxville				
	Wood Products	545.78	225.68	6,662
	Furniture	810.20	384.42	11,339
	Pulp & Paper	241.07	91.04	1,459
Sub-Total		1,597.05	659.18	18,460
Nashville				
	Wood Products	1,011.39	380.79	10,564
	Furniture	380.81	158.30	4,252
	Pulp & Paper	616.60	221.29	3,984
Sub-Total		2,208.80	760.38	18,799
Chattanooga				
	Wood Products	143.33	52.14	1,506
	Furniture	505.97	217.62	6,250
	Pulp & Paper	830.47	317.70	3,914
Sub-Total		1,479.77	587.46	11,671
Memphis				
	Wood Products	633.37	245.59	7,308
	Furniture	217.64	91.05	2,856
	Pulp & Paper	2,506.39	1,076.39	10,486
Sub-Total		3,356.80	1,413.03	20,651
Tricities				
	Wood Products	198.56	58.11	2,330
	Furniture	52.23	21.25	844
	Pulp & Paper	370.11	151.51	2,380
Sub-Total		620.90	230.88	5,554
Total state		9,063.32	3,650.94	75,136

Table 3.13 Base run results of logging sector for T.I.O, out-of-state imports, interregional domestic exports and out-of-state imports and final demand.

Economic Region	T.I.O	Imports	Domestic Exports	Domestic Imports	Final Demand
	----------millions of dollars----------				
Knoxville	25.70	10.7	0.00	5.14	3.74
Nashville	168.67	29.13	10.50	5.51	13.72
Chattanooga	34.37	7.56	-	6.79	2.80
Tricities	13.19	3.63	0.00	1.43	1.97
Memphis	81.79	30.8	5.51	0.00	9.90
Total	327.96	81.82	17.74	17.74	32.13

industry output, out-of-state imports, and intra-state domestic exports for sector 133 logging camps & contracts by different regions. Table 3.14 shows the total industry output, final demand levels and shadow prices for the sectors that comprised the forestry industry complex. Tables 3.15 through 3.19 show the results of timber usage and their shadow prices for sector 133 logging by different Tennessee regions. Finally, Table 3.20 shows timber usage level and their shadow prices for sector logging by regions and types of wood.

Development of Impact Scenarios

This study considers three main impact scenarios: the import substitution of roundwood; the export reduction of roundwood and increase in exports of wood processing products; and secondary industry wood output growth. The runs of these three scenarios are intended to be contrasted with the result of the base run.

The Import Substitution Scenario

The import substitution is an important scenario because imports are considered leakage of regional economies. Commodities produced in regions often use goods and imported services from other states. Some of the receipts from product sales must be used to pay for imported inputs. By replacing theses imported goods with ones locally produced, the drainage to the local economy is stopped and the economic linkages among local firms are strengthened. The assumption is that Tennessee regions enjoy comparative advantages for their quality and abundance of forest resources, labor pool

Table 3.14 Base run final demand levels of the forest based industry sectors

Region / No sector	Industry name	T.I.O	Final Demand	Shadow Prices
		-------million of dollars-------		
Knoxville				
22	Forest Products	1.17	1.07	1.100
24	Forestry Products	7.80	7.75	0.363
133	Logging Contractors	25.70	3.74	0.331
134	Sawmills planing Mills, General	35.34	3.08	0.696
135	Hardwood D and Flooring Mills	111.35	59.55	0.784
136	Special Product Sawmills, N.E.C	0.98	0.05	0.842
137	Millwork	29.55	1.56	0.671
138	Wood Kitchen Cabinets	42.81	20.34	0.807
140	Structural Wood Members, N.E.C	29.58	16.56	0.604
142	Wood Pallets and Skids	10.71	4.71	0.723
143	Mobile Homes	183.43	182.84	0.648
144	Prefabricated Wood Buildings	48.59	47.20	0.607
146	Reconstituted Wood Products	4.60	0.28	0.478
147	Wood Products, N.E.C	14.13	4.51	0.800
148	Wood Household Furniture	197.04	168.83	0.661
149	Upholstered Household Furniture	314.28	290.97	0.648
152	Wood TV and Radio Cabinets	56.52	53.95	0.636
153	Household Furniture, N.E.C	2.79	2.06	0.775
154	Wood Office Furniture	0.09	0.09	0.767
156	Public Building Furniture	123.22	112.05	0.593
157	Wood Partitions and Fixtures	1.48	0.63	0.653
160	Furniture and Fixtures, N.E.C	114.74	112.30	0.440
162	Paper Mills, Except Building Paper	12.86	12.82	0.658
163	Paperboard Mills	14.89	14.83	0.598
164	Paperboard Containers and Boxes	127.79	29.46	0.443
165	Paper Coated & Laminated Packaging	0.96	0.96	0.621
166	Paper Coated & Laminated N.E.C.	3.63	3.58	0.574
167	Other plastic paper	5.81	5.81	0.550
169	Die-cut Paper and Board	1.91	1.91	0.563
173	Converted Paper Products, N.E.C	73.19	71.57	0.599

Table 3.14 (Continued)

Region / No sector	Industry Name	T.I.O	Final Demand	Shadow Prices
		-------Million of dollars-------		
Nashville				
22	Forest Products	4.76	4.31	2.45
24	Forestry Products	44.01	43.36	0.694
133	Logging Camps and Logging Contractors	168.67	13.72	0.340
134	Sawmills and Planing Mills, General	314.61	109.91	1.107
135	Hardwood Dimension and Flooring Mills	151.81	116.94	1.598
136	Special Product Sawmills, N.E.C	0.55	0.02	1.546
137	Millwork	31.66	1.55	1.349
138	Wood Kitchen Cabinets	47.97	10.67	1.453
140	Structural Wood Members, N.E.C	11.80	0.79	1.255
141	Wood Containers	9.43	5.99	1.512
142	Wood Pallets and Skids	37.55	20.22	1.413
143	Mobile Homes	110.24	110.17	1.270
144	Prefabricated Wood Buildings	4.82	4.64	1.227
145	Wood Preserving	2.62	0.06	1.097
146	Reconstituted Wood Products	4.50	0.25	0.999
147	Wood Products, N.E.C	66.35	39.85	1.549
148	Wood Household Furniture	92.52	40.38	1.465
149	Upholstered Household Furniture	51.69	15.25	1.412
152	Wood TV and Radio Cabinets	3.06	0.33	1.252
153	Household Furniture, N.E.C	0.08	0.02	1.588
154	Wood Office Furniture	0.74	0.74	1.547
156	Public Building Furniture	172.93	73.12	1.189
157	Wood Partitions and Fixtures	25.95	19.58	1.600
160	Furniture and Fixtures, N.E.C	33.81	32.20	0.805
161	Pulp Mills	0.36	0.36	1.166
162	Paper Mills, Except Building Paper	8.58	8.55	1.335
164	Paperboard Containers and Boxes	262.96	19.98	0.933
165	Paper Coated & Laminated Packaging	97.19	93.59	1.159
166	Paper Coated & Laminated N.E.C.	17.63	17.16	1.143
167	Other plastic paper	87.12	85.99	1.119
168	Bags, Paper	63.40	63.02	1.202
169	Die-cut Paper and Board	2.07	2.07	0.970
170	Sanitary Paper Products	3.41	3.41	0.870
171	Envelopes	46.82	46.75	1.180
173	Converted Paper Products, N.E.C	27.03	26.58	1.078

Table 3.14 (Continued)

Region / No sector	Industry name	T.I.O	Final Demand	Shadow Prices
		--------Million of dollars-------		
Chattanooga				
22	Forest Products	0.44	0.41	2.345
24	Forestry Products	11.70	11.67	1.049
133	Logging Camps and Logging Contractors	34.37	2.80	0.337
134	Sawmills and Planing Mills, General	20.86	2.02	0.835
135	Hardwood Dimension and Flooring Mill	5.01	0.16	1.272
137	Millwork	7.13	0.31	1.206
138	Wood Kitchen Cabinets	1026	1.52	1.355
140	Structural Wood Members, N.E.C	11.77	5.10	1.039
141	Wood Containers	1.52	0.74	1.144
142	Wood Pallets and Skids	9.47	5.58	1.151
144	Prefabricated Wood Buildings	0.71	0.70	0.888
145	Wood Preserving	8.57	2.74	0.785
146	Reconstituted Wood Products	4.33	0.28	0.877
147	Wood Products, N.E.C	17.16	10.51	1.292
148	Wood Household Furniture	42.96	30.11	1.278
149	Upholstered Household Furniture	285.48	265.77	1.321
152	Wood TV and Radio Cabinets	0.49	0.05	1.191
154	Wood Office Furniture	7.37	7.19	1.638
156	Public Building Furniture	160.40	153.22	1.200
157	Wood Partitions and Fixtures	9.25	7.30	1.514
161	Pulp Mills	40.54	40.12	1.057
162	Paper Mills, Except Building Paper	338.30	336.54	1.278
163	Paperboard Mills	155.14	154.05	0.886
164	Paperboard Containers and Boxes	213.82	123.12	0.934
166	Paper Coated & Laminated N.E.C.	1.19	1.19	0.952
167	Other plastic paper	80.18	79.14	1.001
169	Die-cut Paper and Board	0.32	0.32	0.954
171	Envelopes	0.28	0.28	1.048
173	Converted Paper Products, N.E.C	0.66	0.66	1.039

Table 3.14 (Continued)

Region / No sector	Industry name	T.I.O	Final Demand	Shadow Prices
		-------Million of dollars-------		
Memphis				
22	Forest Products	1.87	1.70	2.499
24	Forestry Products	25.34	25.12	0.711
133	Logging Camps and Logging Contractors	81.79	9.90	0.349
134	Sawmills and Planing Mills, General	128.05	13.07	0.967
135	Hardwood Dimension and Flooring Mills	121.79	95.86	1.528
136	Special Product Sawmills, N.E.C	2.70	0.64	1.497
137	Millwork	82.54	34.37	1.336
138	Wood Kitchen Cabinets	17.51	0.37	1.440
139	Veneer and Plywood	20.55	1.79	1.016
140	Structural Wood Members, N.E.C	1.32	0.06	1.172
141	Wood Containers	18.05	13.34	1.418
142	Wood Pallets and Skids	24.10	3.064	1.297
143	Mobile Homes	85.67	85.63	1.304
146	Reconstituted Wood Products	5.22	0.33	0.963
147	Wood Products, N.E.C	16.80	3.35	1.611
148	Wood Household Furniture	31.02	5.37	1.573
149	Upholstered Household Furniture	99.59	67.48	1.438
152	Wood TV and Radio Cabinets	20.64	16.79	1.339
153	Household Furniture, N.E.C	0.01	0.003	1.714
154	Wood Office Furniture	0.69	0.69	1.723
156	Public Building Furniture	47.71	37.11	1.096
157	Wood Partitions and Fixtures	11.81	8.16	1.652
160	Furniture and Fixtures, N.E.C	5.53	4.80	0.800
161	Pulp Mills	222.23	219.81	1.173
162	Paper Mills, Except Building Paper	652.77	648.65	1.315
163	Paperboard Mills	197.27	196.09	1.129
164	Paperboard Containers and Boxes	300.42	26.82	1.030
165	Paper Coated & Laminated Packaging	144.37	139.45	1.252
168	Bags, Paper	36.08	35.84	1.279
169	Die-cut Paper and Board	1.18	1.18	1.097
170	Sanitary Paper Products	662.54	650.55	0.908
171	Envelopes	18.25	18.23	1.238
173	Converted Paper Products, N.E.C	271.24	264.39	1.196

Table 3.14 (Continued)

Region / No sector	Industry name	T.I.O	Final Demand	Shadow Prices
			--------Million of dollars-------	
Tricities				
22	Forest Products	0.46	0.42	2.396
24	Forestry Products	12.75	12.73	0.700
133	Logging Camps and Logging Contractors	13.19	1.97	0.332
134	Sawmills and Planing Mills, General	58.32	6.39	0.941
135	Hardwood Dimension and Flooring mills	10.38	4.57	1.523
137	Millwork	12.55	0.66	1.253
138	Wood Kitchen Cabinets	6.94	0.06	1.459
140	Structural Wood Members, N.E.C	11.18	5.57	1.235
142	Wood Pallets and Skids	5.01	2.43	1.309
144	Prefabricated Wood Buildings	0.42	0.41	1.058
145	Wood Preserving	53.72	46.63	0.987
146	Reconstituted Wood Products	9.53	2.26	1.002
147	Wood Products, N.E.C	4.05	0.91	1.428
148	Wood Household Furniture	36.81	26.08	1.364
149	Upholstered Household Furniture	0.25	0.023	1.401
153	Household Furniture, N.E.C	4.88	4.09	1.800
154	Wood Office Furniture	3.68	3.58	1.628
156	Public Building Furniture	6.58	1.79	1.021
162	Paper Mills, Except Building Paper	77.55	77.17	1.347
164	Paperboard Containers and Boxes	121.12	59.72	1.012
166	Paper Coated & Laminated N.E.C.	2.26	2.23	1.172
168	Bags, Paper	0.47	0.47	1.240
171	Envelopes	2.21	2.21	1.115
173	Converted Paper Products, N.E.C	166.47	162.88	1.075

Table 3.15. Land usage by ownership type, stand size, land class, specie groups, in acres for Memphis region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Land
				Million Acres
1	1	20	2	0.164
1	2	20	2	0.530
1	3	20	2	0.006
2	1	20	1	0.021
2	1	20	2	0.061
2	2	20	1	0.028
2	3	20	1	0.026
3	2	20	2	0.067
3	3	20	1	0.039
4	1	20	1	0.011
4	3	20	1	0.023
4	3	20	2	0.082

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

Table 3.16. Land usage by ownership type, stand size, land class, specie groups, in acres for Chattanooga region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Land
				Million acres
1	1	20	1	0.110
1	1	20	2	0.093
1	2	20	1	0.024
1	2	20	2	0.023
1	3	20	1	0.033
1	4	25	1	0.017
1	4	25	2	0.017
2	1	20	2	0.068
3	2	20	2	0.063
3	3	20	1	0.020
4	2	20	1	0.109
4	3	20	2	0.009

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

3.17. Land usage by ownership type, stand size, land class, specie groups for Knoxville region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Land
				Million acres
1	1	20	1	0.542
1	1	20	2	0.102
1	2	20	1	0.048
1	2	20	2	0.035
1	3	20	2	0.008
1	4	25	2	0.006
2	1	20	2	0.008
2	2	20	1	0.007
2	2	20	2	0.013
2	3	20	1	0.004
2	3	20	2	0.001
3	2	20	2	0.050
3	3	20	1	0.047
3	3	20	2	0.047
4	1	20	1	0.392
4	1	20	2	0.345
4	2	20	2	0.202

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

3.18. Land usage by ownership type, stand size, land class, specie groups for Nashville region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Land
				Million acres
1	1	20	2	0.190
1	3	20	2	0.054
2	1	20	1	0.023
2	1	20	2	0.047
2	3	20	1	0.073
2	3	20	2	0.084
2	4	20	1	0.003
2	4	20	2	0.003
3	2	20	1	0.054
4	1	20	1	0.090
4	2	20	2	0.941

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

Table 3.19. Land usage by ownership type, stand size, land class for Tri-Cities region.

Ownership Type(a)	Stand Size(b)	Land Class(c)	Type of Wood(d)	Land
				Million acres
1	1	20	1	0.038
1	1	20	2	0.092
1	3	20	1	0.008
2	3	20	2	0.003
3	2	20	2	0.079

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

Table 3.20 Timber usage levels and their shadow prices for sector logging sectors by regions.

Regions	Wood Product Constraints	Volume of wood	Shadow Price
		million Cu. Ft.	$ million/ million Cu Ft
Knoxville	Pulp hardwood	6.41	0.150
	Pulp softwood	6.22	0.190
	Sawlogs hardwood	2.79	0.424
	Sawlogs softwood	12.25	0.401
Nashville	Pulp hardwood	10.21	0.278
	Pulp softwood	32.78	0.343
	Sawlogs hardwood	0.31	0.533
	Sawlogs softwood	82.13	0.459
Chattanooga	Pulp hardwood	21.15	0.098
	Pulp softwood	7.67	0.121
	Sawlogs hardwood	5.91	0.375
	Sawlogs softwood	3.82	0.323
Memphis	Pulp hardwood	7.03	0.106
	Pulp softwood	15.76	0.131
	Sawlogs hardwood	1.71	0.489
	Sawlogs softwood	47.13	0.465
Tricities	Pulp hardwood	0.03	0.081
	Pulp softwood	2.00	0.100
	Sawlogs hardwood	0.90	0.299
	Sawlogs softwood	3.00	0.283

and infra-structure access. The import substitution strategy of competitive imports may offer opportunities for growth to local businesses and job opportunities for rural residents.

Two sub-scenarios of import substitution are implemented: Scenario I-A, a reduction of 10 percent , and Scenario I-B a 20 percent reduction of the amount of roundwood imported across all five regions in Tennessee. These figures were chosen because they are attainable and reflect conservative estimates of experts.

The changes in regional roundwood import volumes implies changes in the Regional Purchases Coefficients (RPC). By replacing the regional coefficients by the absorption coefficients for the whole raw industry sector 133 in the Leontief matrix, imports can be adjusted automatically, since these coefficients include imports. In the design of the TNAIM model, import levels of roundwood for industry sector 133 are given by each region, taken from the Industry Summary Report of IMPLAN regional models . Table 3.21 shows the values of the roundwood imports by each region for the baseline, sub-scenario 10 percent and sub-scenario 20 percent reduction in imports. The following adjustments need to be done to the original base run model:

The right hand side values of imported roundwood (equation 3.9) are changed for those of the sub-scenario scenarios. In addition, the right hand side values of the foreign exports (equation 3.14) are set to the same level of import reduction to allow the increase in total industry output of sector 133 logging.

Table 3.21. Import reduction scenarios

B.E.A Regions	Import levels baseline (1994)	Scenario I-A Import Reduction 10 percent	Scenario I-B Import Reduction 20 percent
	----------$ million----------		
Knoxville	10.70	10.16	9.63
Nashville	29.14	25.95	22.83
Chattanooga	7.56	6.74	5.92
Tricities	3.63	3.17	2.79
Memphis	30.80	27.48	24.17
Total	81.82	73.50	65.45

Timber constraint right hand side values (equation 3.10) need to be adjusted reflecting the change in the level of harvesting to make up for the import reduction. The new production of logs will have ripple effects throughout the economy since the logging sector will increase its local input purchases.

The changes in industry output that result by comparing the import substitution levels scenarios are attributed to the import substitution strategy. However, these output differences do not capture the total economic effects of import substitution strategy on the economy. These output (ΔX) changes are used to find the final demand vector following

the Bhat (1995) and Siegel (1989) recommended procedure stated in the following equation:

$$\Delta Y = \Delta X (I - A)^{-1} \tag{3.13}$$

These final demand changes are used to shock the I/O IMPLAN regional models to capture indirect and induced impacts. The results of these impacts are reported in terms of industry output, value added, and employment for each region as well as the total for the state.

Reduction of Exports of Roundwood and Increase in Exports of Processed Wood Products Scenario

The second scenario deals with the problem of measuring the total economic impacts of further processing logs (roundwood) into lumber and other processed wood products. The expansion of dollars worth of processed exports as a substitute for dollars worth of raw material exports will affect forward linked sectors, and reduce the demand for raw wood products. However, this additional availability of raw material will be used as inputs for wood processing sectors whose output expansion will have ripple effects throughout the economy.

Two sub-scenarios are considered: Scenario II-A, a 10, and Scenario II-B, a 20 percent reduction in out-of-state roundwood exports by industry sector 133 (logging camps & contracts). To accomplish these scenarios, the following adjustments need to be

implemented into the TNAIM model: First, the right hand side values of final demand for logs in sector 133 (Equation 3.3) are changed with the values that reflect the reduction in exported roundwood (Table 3.22).

Table 3.22. Out of state exports reduction of roundwood scenarios.

B.E.A Regions	Export levels baseline (1994)	Scenario II-A Export Reduction 10 percent	Scenario II-B Export Reduction 20 percent
	----------	$ million	----------
Knoxville	3.74	3.66	2.99
Nashville	13.72	12.34	10.97
Chattanooga	2.89	2.52	2.24
Tricities	1.97	1.77	1.57
Memphis	9.90	8.91	7.92
Total	32.13	29.20	25.69

To maintain the baseline levels of logs production, the right hand side values of the foreign exports slack constraint (Equation 3.14) will be set to levels of export reduction in each region. These wood raw materials will be used as inputs by forward linked sectors. To reflect these forward linkages, the right hand side values of the final demand, s forestry complex sector slack constraint (Equation 3.13) will be changed proportionally to reflect the new availability of logs. The comparison between the base run and the results from these two scenarios in terms of employment, value added and industry output will yield the direct and indirect effects. To estimate the induced effects these changes in total industry output for the forestry complex sectors are impacted into

the IMPLAN I/O regional models. The summation of the direct, indirect, plus induced effects are the total economic effects of this strategy.

Forestry Industry Complex's Output Sector Growth Scenario

Finally, the last scenario is developed with the goal to identify potential forest based sectors among all sectors that comprise the forestry complex group that maximizes regional and state gross product. In recent years, states with abundant forest resources are developing programs which targeted the wood processing industry segment with the goal not only to stabilize rural economies but maximize their economic contribution. As Winistorfer (1998) notes Tennessee has the opportunity to tap the timber market shift supply from northern to southern states to develop its manufacturing wood industry. Although Tennessee's forest resource base is comparable with its neighboring states such as Mississippi and North Carolina, the state's wood processing industry segment lags behind its counterparts in neighboring states. An important objective would be to identify potential wood secondary industries among the three 2D-SIC industry groups: wood products, furniture & fixtures, and paper & allied products wood that contribute the most to maximize the total regional and state gross product when harvesting levels are increased to levels that are sustainable. These harvesting percentage increases were obtained by asking the experts of the Tennessee Forestry Division a conservative guess. Table 3.23 shows the scenarios III-A, and III-B of harvesting increased levels which basically are 5 and 10 percent increases from the baseline harvesting levels for softwood and 10 and 20 percent increases in harvesting levels for hardwood. This scenario can be tested by implementing the I/O-LP model with the following changes:

Table 3.23. Total volume of new harvesting levels of softwood and hardwood pulp and softwood and hardwood sawlogs by region.

Region	Baseline	Scenario III-A	Scenario III-B
	----------million Cu Ft.----------		
Knoxville			
Pulp softwood	6.41	6.73	7.85
Pulp hardwood	6.22	6.84	7.15
Sawlogs softwood	2.79	2.93	3.07
Sawlogs hardwood	12.30	12.91	14.14
Nashville			
Pulp softwood	10.21	10.72	11.23
Pulp hardwood	32.78	36.05	37.69
Sawlogs softwood	0.31	0.32	0.33
Sawlogs hardwood	82.13	90.34	94.45
Chattanooga			
Pulp softwood	21.15	22.2	23.26
Pulp hardwood	7.67	8.43	8.82
Sawlogs softwood	5.91	6.20	6.50
Sawlogs hardwood	3.81	4.19	4.38
Tricities			
Pulp softwood	0.021	0.022	0.023
Pulp hardwood	2.01	2.20	2.30
Sawlogs softwood	0.90	1.85	1.94
Sawlogs hardwood	3.00	3.30	3.60
Memphis			
Pulp softwood	7.02	7.37	7.72
Pulp hardwood	17.75	17.32	18.11
Sawlogs softwood	1.70	1.78	1.87
Sawlogs hardwood	47.13	51.84	54.19

First, the change of the right hand side values of timber constraint (equation 3.6) from harvesting levels to scenario levels, 5 and 10 percent from the baseline for softwood and 10 and 20 percent increase for hardwood levels which can be considered sustainable removal rates without depleting the resource base.

Second, changes in the final demand right hand side values of sector 133 (equation 3.3) were made by estimating the amount of total industry output of that sector that represents increasing levels of harvesting rates. To estimate the forward impacts the right hand side values of the final demand for the forestry complex constraint will be changed by an amount that reflects the increase of timber supply.

The changes in employment, value added and industry output that result from contrasting the baseline with those from these two sub-scenarios will be the direct and indirect economic impacts.

The vector of industry output change via their corresponding vector of final demand will be impacted into the IMPLAN regional models to estimate the induced effects. The forest based sectors will be ranked based on their contribution to the regional and state gross output and values in terms of employment, value added and total industry output will be reported.

The value added is the economic variable chosen because it is well known that one of the main policy objectives of Tennessee forestry policy is to promote and foster the growth of economic sectors that make the highest contribution to the state gross product.

CHAPTER IV

REGIONAL AND STATE IMPACTS OF THREE VALUE ADDED STRATEGIES DEVELOPMENT

Introduction

Based on the assumptions of three value added development strategies, regional and state economic impacts in terms of output, value added and employment are evaluated in this chapter. The three value added strategies are import substitution, reduction in roundwood exports and increase in exports of processed wood products, and forest based industry sector output growth scenarios.

The basic approach consists of translating the scenario assumptions in terms of imports or exports of logs, growing stock or harvesting levels and placing them into the Tennessee Agricultural and Industrial Model (TN-AIM). The TN-AIM scenario runs will capture backward and forward direct and indirect effects on aggregate output in the forest based industry groups and state economy. The changes between the base and scenarios runs would be attributed to the each strategy development. The summary of the base run is presented in Table 4.1 and 4.2 in terms of Gross State Product, T.I.O, interregional and out-of-state trade, employment, and harvesting timber levels and their shadow prices by forest based industry groups respectively.

Evaluation of Import Substitution Scenario

The import substitution of competitive logs imports is divided into two sub-scenarios: Scenario I-A, which consists of a reduction of 10 percent in the level of out-of-

Table 4.1 Baseline TNAIM[6] results of value added, T.I.O. interregional and out-of-state trade, and employment for 2D-SIC aggregated wood sectors

	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	millions of dollars					
Value Added						
Wood Products	225.68	380.79	52.14	58.11	245.59	962.32
Furniture	342.47	158.30	217.62	21.25	91.05	830.69
Pulp & Paper	91.03	221.29	317.70	151.51	1,076.39	1,857.92
Total	659.18	760.38	587.46	230.88	1,413.03	3,650.94
T.I.O						
Wood Products	545.78	1,011.39	143.33	198.56	633.375	2,532.43
Furniture	810.20	380.81	505.97	52.23	217.04	1,966.25
Pulp & Pulp	241.07	616.6	830.47	370.11	2,506.39	4,564.63
Total	1,597.05	2,008.8	1,479.77	620.896	3,356.80	9,063.32
Interregional trade						
Imports	5.14	5.51	6.79	0.00	0.00	17.74
Exports	0.00	10.50	0.00	1.43	5.51	17.44
Out-of-state trade						
Imports	10.7	29.13	7.56	3.63	30.80	81.82
Exports	3.74	13.72	2.8	1.97	9.90	32.13
	number of jobs					
Employment						
Wood Products	6,662	10,564	1,506	2,330	7,308	28,370
Furniture	10,339	4,252	6,250	844	2,856	24,541
Paper & Pulp	1,459	3,984	3,914	2,380	10,486	22,224
Total	18,460	18,800	11,671	5,554	20,651	75,135

[6] TNAIM measures direct and indirect effects

Table 4.2 Baseline results of harvesting levels by type of wood for the five Tennessee economic regions

Type of wood	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.
Pulpwood						
Softwood	6.41	10.21	21.15	0.03	7.03	44.83
Hardwood	6.22	32.78	7.67	2.00	15.76	64.43
Sawtimber						
Softwood	2.79	0.31	5.91	0.90	1.71	11.62
Hardwood	10.255	82.13	3.82	3.00	47.13	146.33

state roundwood imports and Scenario I-B, which consists of a reduction of 20 percent on the level of out-of- state imports.

Scenario I-A

The preparation of scenario I-A includes a reduction in regional out-of-state imports of logs by the projected amounts of import substitution developed in chapter III. Additionally, right hand side values of foreign exports are set to the same levels of import reduction to allow an increase in output of the logging sector. Finally, right hand side values of timber constraint are adjusted by the total out-of-state import reduction in millions of dollars to allow an increase in harvesting levels of timber by the same amount.

The results of scenario I-A are presented in Table 4.3 and Table 4.4 which show the values of gross state product, value added, T.I.O, employment, interregional and out-of-state trade, employment, and timber harvesting levels by forest based industry groups and their respective shadow prices.

The total gross state product for this scenario increases about $7.84 million in respect to the value reported in the baseline. The total industry output, value added and employment increase mainly in the wood products industry group in Nashville and Knoxville while output of wood products sector of other regions remain constant. Interregional trade is reduced by 38.5 percent as expected comparing with baseline level. Exporting regions are reducing the exports to meet the new demand due to the reduction of out-of-state imports. Regions which import will increase their imports depending on the amount of imported roundwood. The Knoxville region increases its local production of logs and consequently the amount of interregional imported roundwood is reduced. In

Table 4.3 TNAIM Scenario I-A results of a reduction in 10 percent of out-of-state roundwood for the five Tennessee economic regions

	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	millions of dollars					
Value Added						
Wood Products	226.28	383.53	52.14	58.11	245.59	965.67
Furniture	342.47	158.31	217.62	21.25	91.05	830.71
Pulp & Paper	91.03	221.29	317.70	151.51	1,076.39	1,857.94
Total	659.79	763.14	587.47	230.88	1,413.03	3,654.33
T.I.O						
Wood Products	548.73	1,022.85	143.33	198.56	633.375	2,546.84
Furniture	810.2	380.81	505.97	52.23	217.043	1,966.25
Pulp & Paper	241.078	616.61	830.47	370.11	2,506.40	4,564.66
Total	1,600.00	2,020.27	1,479.77	620.89	3,356.81	9,077.75
Interregional Trade						
Imports	3.11	0.00	7.61	0.00	0.00	10.72
Exports	0.00	7.54	0.00	0.99	2.19	10.72
Out-of-state Trade						
Imports	10.16	25.95	6.74	3.17	27.48	73.63
Exports	3.74	13.72	2.80	1.97	9.91	32.14
	number of jobs					
Employment						
Wood Products	6,683	10,633	1,507	2,330	7,308	28,460
Furniture	10,339	4,252	6,250	844	2,856	24,541
Paper & Pulp	1,460	3,984	3,914	2380	10,487	22,225
Total	18,482	18,869	11,671	5,554	20,651	75,226

Table 4.4. Scenario I-A results harvesting levels by type of wood for the five Tennessee regions

Type of Wood	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Million Cu. Ft.
Pulpwood						
Softwood	6.41	10.21	21.16	0.03	7.03	44.84
Hardwood	8.26	32.78	7.67	2.00	15.76	66.47
Sawtimber						
Softwood	3.71	12.19	5.91	0.90	1.71	24.42
Hardwood	10.25	82.13	3.82	3.00	47.13	146.33

the Chattanooga region, interregional imports are increased since no additional local timber production occurs.

Out-of-state roundwood imports are reduced according to the projection developed for this scenario. Out-of-state roundwood exports are not affected.

Regarding timber supply, it increases only in two regions: Nashville and Knoxville regions. The increase in the Nashville region amounted to 11.88 million cubic feet of softwood sawtimber while in Knoxville it amounted to 2.04 million cubic feet of softwood sawtimber. Table 4.5 summarizes the total economic effects of Scenario I-A by forest based industry groups. Thus, the wood products sector increases its output by $21.81 million, value added by $7.84 million and employment by 206 jobs. The pulp & paper sectors increases only slightly while furniture shows no increase at all. These results are expected since substitution of out-of-state roundwood imports by local production only affects the logging sector. Local log production is increased by the same amount of import reduction. It is worth noting that indirect and induced effects represent almost 56.9 percent of the total impacts in industry output. This is a confirmation about the strong linkages that the logging sector has with local economies.

In conclusion, a reduction of one million dollars in output of imported logs brings to the state an increase of $2.64 million in total industry output, $ 0.97 million in value added and 25 additional jobs to the economy.

Scenario I-B

The results of scenario I-B are presented in table 4.6 and 4.7 and show the values of gross state product, value added, TIO, employment, interregional and out-of-state trade, employment and harvesting levels and shadow prices of types of woods

Table 4.5 Total economic effects of scenario I-A

Industry Group	Economic variable	Direct Effects	Indirect Effects	Induced Effects	Total Effects
		million of dollars			
Wood Products					
	Output	9.41	5.00	7.40	21.81
	Value Added	2.05	1.32	4.43	7.80
	Employment (# jobs)	58	32	115	205
Furniture					
	Output	0.00	0.00	0.00	0.00
	Value Added	0.00	0.00	0.00	0.00
	Employment (# jobs)	0.00	0.00	0.00	0.00
Pulp & Paper					
	Output	0.15	0.005	0.068	0.223
	Value Added	0.002	0.001	0.041	0.044
	Employment (# jobs)	0.13	0.01	1.10	1.24
Total					
	Output	9.42	5.00	7.40	22.03
	Value Added	2.05	1.30	4.47	7.84
	Employment (# jobs)	58	32	116	206

Table 4.6 Scenario I-B results of a reduction in 20 percent of out-of-state roundwood imports for the five Tennessee Economic Regions

	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	million of dollars					
Value Added						
Wood Products	226.28	384.88	52.14	58.11	246.87	968.29
Furniture	342.47	158.31	217.62	21.25	91.05	830.71
Paper & Pulp	91.03	221.30	317.70	151.51	1,076.39	1,857.94
Total	659.79	764.49	587.47	230.88	1,414.32	3,656.96
T.I.O						
Wood Products	548.73	1,028.46	143.33	198.55	639.21	2,558.28
Furniture	810.20	380.82	505.97	52.22	217.04	1,966.25
Paper & Pulp	241.07	616.62	830.47	370.10	2,506.40	4,564.68
Total	1,600.00	2025.90	1,479.77	620.87	3,362.65	9,089.21
Interregional Trade						
Imports	3.29	0.00	8.43	0.00	0.84	12.56
Exports	0.00	11.97	0.00	0.59	0.00	12.56
Out-of-state trade						
Imports	9.63	22.83	5.92	2.79	24.17	65.45
Exports	3.74	13.72	2.80	1.97	9.90	32.13
	number of jobs					
Employment						
Wood Products	6,683	10,667	1,507	2,330	7,347	28,533
Furniture	10,339	4,252	6,250	844	2,856	24,541
Paper & Pulp	1,460	3,9843	3,914	2,380	10,487	22,225
Total	18,481	18,903	11,671	5,553	20,690	75,300

Table 4.7. Scenario I-B harvesting levels by type of wood for the five Tennessee regions

Type of Wood	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Million Cu. Ft.
Pulpwood						
Softwood	6.41	10.21	21.16	0.03	7.03	44.84
Hardwood	6.22	32.78	7.67	2.00	15.76	66.42
Sawtimber						
Softwood	4.83	12.19	5.91	0.90	5.84	29.67
Hardwood	12.30	88.73	3.82	3.00	47.13	154.97

respectively.

The total gross state product increases about $14.16 million in gross state product with respect to the value of the base run.

The total industry output, value added and employment for the wood products sector increases substantially in comparison with the furniture and pulp and paper industry sectors. This result is expected since a reduction of out-of-state imports implies an increase in output of the logging sector to meet the demand of local industries. Interregional trade is reduced in comparison with values of the base run. However, this reduction is lower than Scenario I-A because the Memphis region increases its log production. In this region the additional production of timber basically serve as substitute of the amount of out-of-state roundwood imports. The Nashville region increases its timber production to meet the Chattanooga and Knoxville roundwood demands.

Out-of-state roundwood imports are reduced according to the projected levels. The timber supply increases in Nashville by 11.88 million cubic feet of softwood sawtimber and 6.16 million cubic feet of hardwood sawtimber, Knoxville increases by 2.04 million cubic feet of softwood sawtimber and the Memphis region increases by 4.13 million cubic feet of softwood sawtimber respectively. Table 4.8 shows the total effects of the scenario I-B distributed by wood group sectors. The wood products sector at the state level increases its output by $ 38.52 million, value added by $14.06 and employment increases by 369 jobs.

Evaluation of Reduction of Out-of-state Exports and Further Processing Wood Scenarios

These scenarios will measure the forward impacts of further processing logs

Table 4.8 Total economic effects of scenario I-B by industry group

Industry Group	Economic variable	Direct Effects	Indirect Effects	Induced Effects	Total Effects
		million of dollars			
Wood Products					
	Output	16.89	8.96	12.67	38.52
	Value Added	3.65	2.32	8.09	14.06
	Employment (# jobs)	104	59	206	369
Furniture					
	Output	0.02	0.01	0.36	0.39
	Value Added	0.01	0.005	0.04	0.06
	Employment (# jobs)	0.19	0.26	1.00	1.25
Pulp & Paper					
	Output	0.02	0.01	0.03	0.06
	Value Added	0.01	0.01	0.02	0.04
	Employment (# jobs)	0.00	0.00	0.00	0.00
Total					
	Output	16.92	8.95	13.07	38.63
	Value Added	3.85	2.34	8.14	14.16
	Employment (# jobs)	104	59	206	369

instead of exporting as raw materials. Two sub-scenarios are considered: Scenario II-A, a 10 percent reduction in out-of-state roundwood exports and Scenario II-B, a 20 percent reduction in out-of-state roundwood exports. The preparation of these sub-scenarios includes: First, estimation of the reduction in out-of-state roundwood exports; second, changes in the right hand side forest based final demand flexibility constraint that will reflect proportionally the increase in local demand for logs; third, changes in right hand side values of sector 133 logging to reflect the reduction of roundwood exports; and, finally, changes in the right hand side values of the foreign exports slack constraint by the same amount of the reduction of exports.

Scenario II-A

The results of scenario II-A are presented in Table 4.9 in terms of industry output, value added, interregional and out-of-state trade and employment respectively. The total gross state product increases about $94.27 million with respect to the baseline value. Industry output of wood products, furniture, and pulp and paper sectors increase across all regions. The output of the wood products sectors increase almost fifty percent, the furniture output increases forty percent while the pulp and paper output increases slightly.

Interregional trade does not change with respect to the baseline since by assumption the production of logs by regions are kept at the same levels of the base run (Table 4.10).

Out-of-state roundwood imports are maintained at the same levels of the baseline. Out-of-state exports are reduced according to the projections of the scenario, 10 percent less than the level of the base run. Timber supply in all regions is maintained at the same levels reflecting the baseline current production levels. Table 4.11 shows the total

Table 4.9 Scenario II-A results of a reduction of 10 percent out-of-state roundwood exports and its further processing by wood manufacturing industries sectors for the five Tennessee economic regions

	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	million of dollars					
Value Added						
Wood Products	236.21	389.79	53.13	60.36	258.00	997.49
Furniture	342.73	160.38	225.20	23.06	100.34	851.11
Pulp & Paper	91.14	221.33	317.75	151.60	1,077.00	1,858.82
Total	670.08	771.15	596.08	235.02	1,435.34	3,708.04
T.I.O						
Wood Products	575.68	1,031.97	145.75	202.80	659.06	2,614.76
Furniture	810.66	384.65	522.43	52.67	237.24	2,007.65
Pulp & Paper	241.47	617.43	830.62	370.40	2,507.41	4,567.33
Total	1,627.81	2,033.48	1,498.80	625.87	3,403.71	9,189.74
Interregional Trade						
Imports	1.22	3.35	4.94	0.00	0.00	9.52
Exports	0.00	4.94	0.00	1.23	3.35	9.52
Out-of-state Trade						
Imports	10.7	29.13	7.56	3.63	30.8	81.82
Exports	0.83	12.35	2.52	1.77	8.915	26.38
	number of jobs					
Employment						
Wood Products	7,155.9	10,829	1,543	2,388	7,509	29,427
Furniture	10,613	4,364	6,426	866.4	2,930	25,201
Pulp & Paper	1,462	3,986	3,916	2,381	10,493	22,240
Total	19,204	19,179	11,885	5,635	20,932	76,868

Table 4.10. Scenario II-A harvesting levels by type of wood for the five Tennessee regions

Type of Wood	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Quantity Million Cu. Ft.	Million Cu. Ft.
Pulpwood						
Softwood	6.41	10.21	21.16	0.03	7.03	44.84
Hardwood	6.22	32.78	7.67	2.00	15.76	64.43
Sawtimber						
Softwood	2.79	0.31	5.91	0.90	1.71	11.62
Hardwood	10.25	82.13	3.82	3.00	47.13	146.33

Table 4.11 Total economic effects of scenario II-A

Industry Group	Economic variable	Direct Effects	Indirect Effects	Induced Effects	Total Effects
		million of dollars			
Wood Products					
	Output	53.90	28.43	34.63	116.96
	Value Added	21.66	13.71	22.68	58.05
	Employment (# jobs)	678	379	633	1,690
Furniture					
	Output	30.06	11.34	20.39	61.79
	Value Added	14.79	6.37	13.78	34.94
	Employment (# jobs)	485	175	383	1,043
Pulp & Paper					
	Output	2.08	0.62	0.71	3.41
	Value Added	0.65	0.25	0.35	1.25
	Employment (# jobs)	10	6	9	25
Total					
	Output	86.04	40.39	55.73	182.16
	Value Added	37.11	20.35	36.81	94.27
	Employment (# jobs)	1,173	560	1,026	2,758

economic impacts due to the reduction of 10 percent in out-of-state logs exports. The wood product increases its output by $ 116.97 million, its value added by $ 58.05 million and employment by creating 1,690 new jobs. The direct and indirect effects represent 70 percent of the total effects while the remaining 30 percent represent induced effects.

The furniture industry increases its output by $61.8 million, its value added by $ 34.94 million and employment by 1,043 new jobs. The pulp and paper industry sector increases only slightly its output by $3.41 million, its value added by $1.25 million and employment by 25 new jobs. In summary, the reduction of one million dollars of out-of-state exports of roundwood and its further regional processing brings to the state economy an additional $62.11 million in industrial output, $ 32.00 million more in value added, and 941 new jobs.

Scenario II-B

The results of this scenario are presented in table 4.12 and 4.13. The total gross state product of this scenario run increases about $173.1 million with respect to the value of the baseline.

The total forest based industry output increases $287.56 million, which represent 3.1 percent increase with respect to the baseline value. Of this increase in total output, wood products represent 67.1 percent, furniture represents 29.9 percent, while the remaining 2.8 percent correspond to the pulp and paper industry sectors (Table 4.14).

The wood products sector increases its output by $193.08 million, value added by $ 96.29 million and employment by 2,318 jobs. The furniture industry sector increase industry output by $ 86.24 million, value added by $58.71 million and employment by

Table 4.12 Scenario II-B results of reduction of 20 percent in out-of-state roundwood exports and its further processing by wood manufacturing industries sectors for the five Tennessee economic regions

	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	millions of dollars					
Value Added						
Wood Products	237.16	399.86	53.72	61.09	268.18	1,020.01
Furniture	341.64	159.89	235.67	24.78	104.33	866.33
Pulp & Paper	91.97	221.07	316.88	154.28	1,088.18	1,875.40
Total	670.77	80.82	606.27	230.15	1,460.69	3,757.74
T.I.O						
Wood Products	579.33	1,036.67	180.70	200.60	668.38	2,665.71
Furniture	819.32	386.16	540.36	58.82	220.15	2,024.81
Pulp & Paper	241.70	617.62	830.73	374.83	2,506.40	4,571.28
Total	1,640.35	2,040.45	1,551.79	634.25	3,394.93	9,261.86
Interregional Trade						
Imports	50.14	5.51	6.79	0.00	0.00	17.44
Exports	0.00	10.50	0.00	1.43	5.51	17.44
Out-of-state Trade						
Imports	10.7	29.13	7.56	3.63	30.8	81.82
Exports	2.99	10.98	0.00	1.60	7.92	23.49
	number of jobs					
Employment						
Wood Products	7,026	11,167	1,510	2,348	7,768	29,819
Furniture	9,986	4,165	6,427	911	3,049	24,541
Pulp & Paper	1,455	3,971	3,895	2,386	10,551	22,263
Total	19,244	19,870	12,245	5,768	21,772	76,623

4.13 Scenario II-B harvesting levels by type of wood for the five Tennessee regions

Type of Wood	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	Quantity Million Cu Ft	Quantity Million Cu Ft	Quantity Million Cu Ft	Quantity Million Cu Ft	Quantity Million Cu Ft	Quantity Million Cu Ft
Pulpwood						
Softwood	6.41	10.21	21.15	0.03	7.03	44.83
Hardwood	6.22	32.78	7.67	2.00	15.76	64.43
Sawtimber						
Softwood	2.79	0.31	5.91	0.90	1.71	11.62
Hardwood	10.255	82.13	3.82	3.00	47.13	146.33

Table 4.14 Total economic effects of scenario II-B

Industry Group	Economic Variable	Direct Effects	Indirect Effects	Induced Effects	Total Effects
		million of dollars			
Wood Products					
	Output	87.20	46.08	59.80	193.00
	Value Added	35.65	22.01	38.50	96.00
	Employment (# jobs)	930	519	869	2,318
Furniture					
	Output	42.66	15.89	27.68	86.24
	Value Added	24.84	10.67	23.07	58.71
	Employment (# jobs)	652	235	507	1,394
Pulp & Paper					
	Output	5.16	1.54	1.55	8.25
	Value Added	10.09	3.61	4.38	18.10
	Employment (# jobs)	24	15	19	58
Total					
	Output	135.02	63.51	89.03	287.56
	Value Added	70.62	36.18	65.95	173.10
	Employment (# jobs)	1,606	769	1,395	3,770

1,394 jobs. The increases in total output, value added and employment of the pulp and paper sectors are small compared with those reported in the baseline.

In summary, the total economic effects of reducing 20 percent out-of-state log exports and further processing represent to the state economy a net gain of $ 287.54 million in industry output, $ 173.1 million in value added and 3,770 new jobs in employment.

Evaluation of Forestry Complex Output Growth Scenarios

The purpose of these scenarios is to identify which sector among the three categories of wood sectors: wood products, furniture and pulp and paper, maximize regional and state gross state product. Two sub-scenarios were developed: The III-A scenario or an increase in harvesting levels of timber by 5 percent for softwood and 10 percent for hardwoods, and the III-B scenario or an increase in timber harvesting levels of 10 percent for softwood tree species and 20 percent for hardwoods tree species. Preparation work of these scenarios includes first, changes in the right hand side values of timber supply constraint to reflect the new harvesting levels. Second, it includes changes in the right hand side values of final demand for sector 133 logging to reflect an increase in industry output equivalent to the increase in harvesting levels. Third, the right hand side values of the flexibility final demand forest complex sector constraint are changed proportionally to the level of harvesting to reflect the increase in local demand for this additional timber supply.

Scenario III-A

The results of scenario III-A are presented in Table 4.15. The gross state product of this scenario increases $183 million with respect to the baseline value. Across all

Table 4.15 Scenario III-A results of increasing harvest levels by 5 percent for softwood and 10 percent for hardwood and its further processing into wood products for the five Tennessee economic regions

	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	----------millions of dollars----------					
Value Added						
Wood Products	233.5	422.26	54.9	61.52	267.90	1,040.51
Furniture	345.50	168.87	223.45	25.37	96.37	860.13
Pulp & Paper	91.048	221.51	317.73	157.12	1,076.54	1,863.94
Total	670.04	812.64	596.08	244.31	1,440.81	3,764.58
T.I.O						
Wood Products	559.50	1,099.90	148.53	203.67	676.08	2,687.76
Furniture	810.20	400.38	514.70	61.37	225.79	2,012.44
Pulp Paper	241.10	617.32	830.56	381.36	2,506.82	4,577.16
Total	1,610.60	2,117.61	1,493.79	646.49	3,408.69	9,277.36
Interregional Trade						
Imports	10.21	3.81	5.02	2.09	0.00	21.13
Exports	2.09	15.23	0.00	0.00	3.80	21.13
Out-State Trade						
Imports	10.7	29.13	7.56	3.63	30.80	81.82
Exports	3.74	13.72	2.8	1.97	9.90	32.13
	----------number of jobs----------					
Employment						
Wood Products	6,766	11,543	1,557	2,397	7,806	30,069
Furniture	10,339	4,551	6,377	1,000	2,975	25,242
Pulp & Paper	1,460	3,988	3,915	2,427	10,489	22,279
Total	18,565	20,082	11,849	5,824	21,269	77,589

regions, total industry output increases mainly in the wood product sectors, 72 percent, and furniture sector, 22.2 percent respectively.

Interregional trade increases slightly with respect to the baseline. All exporting and importing regions increase their exports and imports. Out-of-state imports and exports remain at the same level of the baseline. Timber supply values are changed based on scenario assumptions of 5 percent for softwood and 10 percent for hardwood (Table 4.16).

Table 4.17 shows the total economic effects of scenario III-A. The wood products sectors increases its output by $222.93 million, its value added by $ 127.46 million and employment by 2,704 new jobs. The furniture industry sector increases its output by $67.65 million, its value added by $ 48.18 and its employment by 1,102 new jobs. The pulp and paper industry sector increases its output only slightly by $15.3 million, its value added by $ 7.92 and employment by 86 new jobs. Across all regions and wood sectors, state industry output increases by $ 305.93 million, value added by $ 183.54 million and employment by 3,892 new jobs. It is worth noting that induced effects represent almost one third of the total effects.

Table 4.18 shows the selected forest based industry sectors that used the increased timber supply and consequently increased their output.

In the Knoxville region, sector sawmills, sector kitchen cabinets and sector special product mills used the additional timber supply.

In the Nashville region among the wood products sectors, industry hardwood dimension and flooring mills sector wood products N.E.C. and sector wood containers increased their output. Among the furniture sector group, sector wood household

4.16 Scenario III-A reduction of exports of roundwood and further processing into wood products: harvesting levels by type of wood for the five Tennessee regions

Type of Wood	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	Quantity Million Cu Ft	Quantity Million Cu Ft	Quantity Million Cu Ft	Quantity Million Cu Ft	Quantity Million Cu Ft	Quantity Million Cu Ft
Pulpwood						
Softwood	6.73	10.72	22.20	0.03	7.37	47.05
Hardwood	6.84	36.05	8.43	2.20	17.32	70.89
Sawtimber						
Softwood	2.93	0.32	6.20	0.94	1.78	23.79
Hardwood	12.91	90.34	4.19	3.30	51.84	162.58

Table 4.17 Total economic effects of scenario III-A

		Direct Effects	Indirect Effects	Induced Effects	Total Effects
		million of dollars			
Wood Products					
	Output	101.34	53.99	67.59	222.93
	Value Added	48.37	29.82	49.15	127.46
	Employment (# jobs)	1,078	620	1,006	2,704
Furniture					
	Output	33.15	13.06	21.44	67.65
	Value Added	20.12	9.32	18.8	48.18
	Employment (# jobs)	507	194	401	1,102
Pulp & Paper					
	Output	9.65	2.87	2.82	15.35
	Value Added	4.44	1.58	1.89	7.92
	Employment (# jobs)	31	23	32	86
Total					
	Output	144.14	69.92	91.85	305.93
	Value Added	72.94	40.65	69.34	183.54
	Employment (# jobs)	1,616	837	1,439	3,892

Table 4.18 Forest based sector that increase their output in scenario III-A

Region	Industry sector	
	Number	Name
Knoxville	134	Sawmills and Planning mills
	136	Special Products Sawmills
	138	Wood Kitchen Cabinets
Nashville	135	Hardwood Dimension and flooring mills
	136	Special Product Sawmills
	141	Wood containers
	147	Wood Products N.E.C
	148	Wood Household furniture
	153	Household furniture N.E.C
	154	Wood Office furniture
	157	Wood partitions and fixtures
Chattanooga	138	Wood Kitchen Cabinets
	149	Upholstered household furniture
	154	Wood Office Furniture
	157	Wood partitions and fixtures
Memphis	135	Hardwood dimension and flooring mills
	147	Wood Products N.E.C
	148	Wood Household furniture
	153	Household Furniture
	154	Wood Office furniture
	157	Wood partitions and fixtures
Tricities	135	Hardwood dimension
	153	Household furniture
	154	Wood Office furniture

furniture and sector wood partitions and fixtures increased production.

In Chattanooga, sector wood kitchen and cabinets and sector upholstered household furniture increased their output. In the Memphis region, sector hardwood dimension and flooring mills and sector wood products N.E.C. of the wood products group increased their output. In the furniture sector group, sector wood household furniture, sector wood partitions and fixtures, sector wood office furniture and sector household furniture show output growth. In the tricities, sectors such as hardwood dimension and flooring mills, sector household furniture, and sector wood office show output increase. In conclusion, increase in timber supply for further processing results primarily in an increase of wood product's output and furniture.

Scenario III-B

The results of scenario III-B are presented in Table 4.19 in terms of gross state product value added, output, employment, and interregional and out-of-state trade. The gross state product increases about $242.56 million with respect to the baseline value. Total industry output increases across all regions and wood products groups. The major increases of output are in the wood products sector and furniture sector. The overall interregional trade, exports and imports increase slightly but some changes in exporting and importing regional round wood volumes take place. Out-of-state trade remains at the same level as the baseline. Timber supply values decrease (Table 4.20) as timber supply increases. Table 4.21 shows the total economic impacts of Scenario II-B. The wood products sector increases its output by $ 293.4 million, value added by $ 165.1 million and employment by 3,784 new jobs. The furniture industry sector increases

Table 4.19 Scenario III-B results of increasing harvest levels by 10 percent for softwoods and 20 percent for hardwoods and its further processing by wood manufacturing industries sectors for the five Tennessee economic regions

	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	millions of dollars					
Value Added						
Wood Products	240.68	434.28	55.57	60.53	272.40	1,063.53
Furniture	346.88	175.94	228.45	22.50	103.87	877.75
Pulp & Paper	91.08	222.43	317.75	151.52	1,076.60	1,859.38
Total	678.64	832.65	601.77	234.55	1,452.87	3,800.00
T.I.O						
Wood Products	570.64	1,126.40	150.43	202.89	687.46	2,737.26
Furniture	810.22	415.02	522.92	53.95	241.29	2,043.44
Pulp & paper	241.23	619.34	830.61	370.15	2,506.99	4,568.32
Total	1,622.09	2,160.76	1,503.96	624.39	3,435.74	9,349.02
Interregional Trade						
Imports	9.81	5.96	5.97	0.00	0.00	21.74
Exports	0.00	13.86	0.00	1.92	5.96	21.74
Out-of-state trade						
Imports	10.7	29.13	7.56	3.63	30.8	81.82
Exports	3.74	13.72	2.8	1.97	9.90	32.13
	number of jobs					
Employment						
Wood Products	6,976	11,908	1,571	2,359	7,930	30,744
Furniture	10,667	4,767	6,700	904	3,309	26,493
Pulp & paper	1,460	3,998	3,915	2,380	10,490	22,244
Total	19,103	20,673	12,186	5,643	21,729	79,481

4.20 Scenario III-B reduction of exports of roundwood and further processing into wood products : harvesting levels by type of wood for the five Tennessee regions

Type of Wood	Knoxville	Nashville	Chattanooga	Tricities	Memphis	State Total
	Quantity Million Cu Ft	Quantity Million Cu Ft	Quantity Million Cu Ft	Quantity Million Cu Ft	Quantity Million Cu Ft	Quantity Million Cu Ft
Pulpwood						
Softwood	7.05	11.23	23.26	0.03	7.72	49.29
Hardwood	7.15	37.69	8.82	2.30	18.11	74.07
Sawtimber						
Softwood	3.07	0.33	6.50	0.99	1.87	12.76
Hardwood	14.14	94.45	4.38	3.60	54.19	170.76

Table 4.21 Total economic effects of scenario III-B

		Direct Effects	Indirect Effects	Induced Effects	Total Effects
		----------million of dollars----------			
Wood Products					
	Output	133.63	71.16	88.65	293.4
	Value Added	61.55	39.66	64.49	165.1
	Employment (# jobs)	1,500	873	1,411	3,784
Furniture					
	Output	55.31	21.83	35.64	112.79
	Value Added	18.18	28.88	27.90	74.97
	Employment (# jobs)	1,136	818	649.5	2,603
Pulp & Paper					
	Output	2.44	1.24	1.23	4.91
	Value Added	1.07	0.38	0.45	1.91
	Employment (# jobs)	11	8.18	11.43	31
Total					
	Output	191.38	94.23	125.52	411.13
	Value Added	80.80	28.92	93.34	242.56
	Employment (# jobs)	2,647	1,699	2,072	6,418

output by $ 112.79 million, value added by $74.97 and employment by 2,603 new jobs. Pulp and paper products group only increases slightly compared with baseline values. Across all regions, state forest based industry output increased by $411.1 million, value added by $242.56 and employment by 6,418 new jobs.

Table 4.22 shows the forest-based industries that come out to additional production in the scenario's solution when timber supply was increased by 10 percent for softwood tree species and 20 percent for hardwood tree species.

Table 4.22 Forest based sector that increase their output in Scenario III-B

Region	Industry sector	
	Number	Name
Knoxville	134	Sawmills and Planning mills
	135	Hardwood dimension and flooring
	136	Special Product Sawmill
	138	Wood Kitchen Cabinets
	147	Wood Prod N.E.C
Nashville	135	Hardwood Dimension and flooring mills
	136	Special Product Sawmills
	137	Millwork
	138	Wood Kitchen Cabinets
	141	Wood containers
	142	Wood Pallets and skids
	147	Wood Products N.E.C
	148	Wood Household furniture
	153	Household furniture N.E.C
	154	Wood Office furniture
	157	Wood partitions and fixtures
	162	Paper mills
Chattanooga	138	Wood Kitchen Cabinets
	149	Upholstered household furniture
	154	Wood Office Furniture
	157	Wood partitions and fixtures
Memphis	135	Hardwood dimension mills
	136	Special Prod sawmill
	138	Wood Kitchen Cabinets
	147	Wood Prod N.E.C
	148	Wood Household Furniture
	149	Upholstered Household Furniture
	153	Household Furniture N.E.C
	154	Wood Office Furniture
	157	Wood pallets and fixtures
Tricities	135	Hardwood Dimension and flooring mills
	153	Household furniture N.E.C
	154	Wood Office furniture
	157	Wood partitions and fixtures
	162	Paper mills

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary and Concluding Comments

Tennessee has sizable timber resources encompassing more than 13.3 million of acres that spread across the state. At the same time many rural counties have been declared as persistent low income non-metro counties characterized by low rates of growth and high rates of unemployment. Tapping the Tennessee forestry resources may play an important role not only in bringing economic growth and new jobs to these depressed areas, but also in stabilizing rural economies and maximizing economic contribution from other non-metro counties.

Forestry industries tend to have strong linkages with suppliers because of their material intensity. That is, forest based industries have a higher rate of material expenditures per job than many other manufacturing sectors. In addition, forest based industries are prevalent in more counties than other processing industries and are likely to favor rural locations.

Tennessee development polices clearly are aimed at attracting agribusiness to Tennessee so that markets for both existing and potential agricultural and forest products are enhanced. In the forest area, these policies clearly are aimed at expanding value added forest opportunities for existing producers and attracting new ones.

In this context, there is a need to develop economic models that help the policy makers foresee the likely impacts of alternative policy actions to assess trade-offs

when one or more alternatives are chosen over other options. Then, models need to incorporate impacts on natural resources when resources limitations and usage consequences are key issues.

This study attempts to measure at aggregate levels the economic impacts on state and regional economies of three development value added strategies: import substitution of roundwood with local production; reduction of out-of-state roundwood exports and increasing the processing into wood products; and finally, a value added sector growth strategy.

The economic effects were analyzed at state and regional levels and measured in terms of gross state product, industry output, value added and employment. The study areas in this study were comprised of five business economic areas (B.E.A): Knoxville, Nashville, Chattanooga, Tricities and Memphis. These study regions were adopted from those developed by the Bureau of Economic Analysis Division of the US Department of Commerce.

To evaluate these development strategies, this study implemented an integrated I/O -Linear programming model that makes use of different analytical tools and data base sources. A non-survey input-output model, IMPLAN, was used to create input-output regional models. A hybrid IMPLAN model was developed for each region incorporating output data of agricultural sectors to improve the overall accuracy of I/O models. The hybrid IMPLAN allows the construction of the baseline economic structure for 1994 for each of the five Tennessee regions. These baseline input-output models supplied I/O coefficients to the second model, the Tennessee Agricultural and Industrial Model (TNAIM). The TNAIM, an integrated input-output- linear programming model contains

information that relates industry sector activities with resources constraints such as timber, land and labor as well as representing the state economy. The alternative scenarios designed to address the objectives of this study were implemented in TNAIM. The TNAIM captures the direct and indirect effects. The solution of these alternative scenarios is then inputted back into the IMPLAN model to estimate the induced effects. The total economic impacts are reported as the summation of direct, indirect (TNAIM solution) and induced effects (IMPLAN solution) in terms of output, employment and value added.

The import substitution development strategy has a positive impact on the regional economic activity. The reduction of 10 percent in out-of-state roundwood imports ($ 8 million) has a net impact of $ 7.84 million state wide. Total industry output increases an additional $22 million, value added increases by $7.84 million and employment by 206 jobs. The substitution of one million dollars of imported roundwood by local production generates $2.64 million in additional industry output, $0.94 million in value added and creates 25 additional jobs. In the wood sector group, total industry output increases in two regions, Nashville and Knoxville, while the output of other regions remains constant.

Similarly, a reduction of 20 percent in out-of-state roundwood imports by replacing it with local production has a positive impact on the state economy. The gross state product increases by $14.16 million, total industry output increases by $ 38.63 million, value added increases by $ 14.16 million, and employment increases by 369 jobs. These increases are mainly in the wood products sector and, to a lesser extent, the furniture sectors.

The second strategy deals with the reduction of out-of state roundwood exports and processing locally into wood products. Two sub-scenarios were implemented, one consisting of a 10 percent reduction of out-of-state roundwood exports and the other of a reduction of 20 percent in out-of-state roundwood exports. The strategy incorporates impacts on forward linkages. Thus, a reduction of 10 percent in out-of-state roundwood exports has a positive impact on the gross state product of about $ 94.27 million, $182.16 million in industry output, $94.2 million in value added and 2,758 jobs in employment. A reduction of one million dollars of out-of-state roundwood exports has a positive impact in total industry output of about $62.11 million, $32.00 million in value added and 941 new jobs in employment. A reduction of 20 percent in out-of-state roundwood exports has a positive impact on the gross state product of about $ 173.10 million, $287 million in output and 3,770 new jobs in employment.

Finally, the last strategy consists of an increase in harvesting timber levels from five to ten percent for softwood tree species and from 10 to 20 percent for hardwood tree species. This scenario attempts to measure the forward impacts by identifying which forestry-based sector will maximize the economic contribution when additional supplies of timber are available for local processing.

The first sub-scenario consists of an increase in five percent and ten percent harvesting levels for softwood and hardwood tree species respectively. The increase in timber supply has positive effects on the gross state product of about $ 183.54 million, output increases by $305.93, and employment increases by 3,892 new jobs. Sectors of the industry segment that increased their output were mainly the industries of wood products and furniture groups. Sectors such as sawmills and planning mills, wood kitchen cabinets

and special wood products increased their output.

The second sub-scenario consists of an increase of 10 and 20 percent harvesting levels of softwood and hardwood tree species, respectively. Across all regions and wood sectors, state industry output increased by $411.13 million, $242.56 million of value added, and 6,416 new jobs in employment. Industry sectors in the wood products and furniture group sectors increased their output maximizing the gross state product. Among the wood products sectors, sector such as sawmills, kitchen cabinets, special products mill, hardwood dimension and flooring mills. In the furniture sector, sectors such as wood household, wood partition and fixtures, household furniture increased their output respectively.

Limitations and Recommendations for Further Research

The application of the integrated approach is faced with several limitations which arise from the nature of the assumptions of the theoretical approaches or the aggregated nature of the databases. One of the most important limitations was the problem of the data used for the construction of the linear programming coefficients. The land and timber coefficients were estimated by using the Forestry Inventory database (FIA) of 1989. This data may not represent current harvesting rates from different owners and technologies involved due to changes in technology and economic conditions. Inventory removal rates may not necessarily be correlated with current harvesting levels that are influenced by other factors including the disposition of the owners to exploit their wood tracts. Timber production, investment, land use changes and forest succession and growth constantly change the composition of forests.

Several limitations arise from using IMPLAN. As an off-the-shelf input-output model, the coefficients included may not accurately represent the production functions that prevail in Tennessee. A Leontief production function main characteristic is constant returns to scale that assumed that all logging and other products are sold. Estimates of trade are often difficult to get for regional input-output models.

A limitation when using the IMPLAN model is that technology is constant and is not differentiable across regions. Regional technology differences could be an important issue in interregional studies. Finally, the I/O Leontief is only reasonable if the behavior of the sector is the same for the whole group that is under consideration.

The aggregation scheme used in this study may have introduced the problem of aggregation bias into the analysis. Multipliers are very sensitive to aggregation. To reduce such bias, disaggregated impacts are recommended. Finally, in developing scenarios Tennessee is isolated from the rest of the world. Thus, changes in import levels of logs and export levels are assumed to occur without having a price impact. The levels of change are relatively small compared to the global economy. However, artificial restrictions in an economy reduce choices and therefore have the potential of changing prices.

Despite the limitations described above, the major contribution of this study was the integration of several analytical tools and data source bases that relate the forestry based industries with the rest of the Tennessee economy and resource constraints such as land, labor and timber in an input-output framework. Such an approach can be extended to other agricultural activities.

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APPENDICES

APPENDIX A

Appendix A.1 Industrial classification of the primary wood products in the forestry sector in Tennessee.

S.I.C.	Industry name	IMPLAN	B.E.A.	Sector
2410	Logging camps & logging contract	160	200100	1
2421	Sawmills & planning mills	161	200200	1
2426	Hardwood Dimension Flooring	162	200300	1
2429	Special products Sawmills	163	200400	1
2431	Millwork	164	206501	1
2434	Wood Kitchen Cabinet	165	200502	1
2435	Hardwood Veneer Manufacturing	166	200600	1
2436	Plywood	166	200600	1
2439	Structural Wood Members	167	200701	1
2610	Pulp Mills	187	240100	1
2620	Paper Mills	188	240200	1
2631	Paper Board Mills	189	240300	1

Sector 1 Primary Wood Products
Sector 2 Secondary Wood Products

Appendix A.2 Industrial classification of wood secondary products in the forestry sector in Tennessee

S.I.C.	Industry name	IMPLAN	B.E.A.	Sector
2441	Wood container	173	210000	2
2448	Wood Pallets and Skids	170	200901	2
2449	Wood products	172	200903	2
2511	Wood household furniture	174	220101	2
2512	Upholstered household furniture	177	220200	2
2517	Wood TV & Radio cabinets	176	220103	2
2519	Household furniture	175	220102	2
2521	Wood office furniture	180	230100	2
2541	Wood portion and fixtures	183	230100	2
2452	Pre-fabricated Wood Buildings	168	200707	2
2491	Wood Preserving	169	200800	2
2492	Particle Board	171	200901	2
2599	Furniture and fixtures	186	230100	2
2650	Paper board containers and boxes	199	250000	2
2655	Fiber cans tubs drums			2
2660	Building paper	192	240602	2
2672	Paper coating and glazing	193	240701	2
2673	Bags except textiles	194	240701	2
2675	Die-cut paper board	195	240703	2
2676	Sanitary paper production	191	240500	2
2677	Envelopes	190	240400	2
2678	Stationary products	197	240705	2
2679	Pressed and molded pulp goods	196	240704	2
2679	Converted paper products	198	240706	2
2861	Gums and Wood chemicals			2

Sector 1 Primary Wood Products
Sector 2 Secondary Wood Products

Table A.3 Number of firms, employees, and other selected statistics for 3D-SIC primary and Secondary wood processing sectors, 1992

Industry Name	No Firms	No of Employees	Value of Shipments	Annual Payroll	Value Added	Cost of Material	Capital Invest.
Primary Industries							
241 Logging	182	0.8	74.3	10.6	29.0	45.3	2.8
242 Sawmills	366	8.2	671.3	142.6	304.8	365.6	14.9
243 Millwork, Veneer	192	3.3	258.4	58.4	114.2	144.0	7.5
263 Paper Mills	6	3.6	802.5	145.7	431.6	376.2	38.1
261,2633 Pulp mills, paperboard Mills	9	6,375	589.1	69.8	330.1	253.4	28.6
Sub-total	755	22,275	2,392.6	427.1	1,209.7	1,184.5	91.9
Secondary Industries							
244 Wood containers	103	1.4	84.5	19.9	38.4	46.1	1.9
245 Wood Buildings	35	2.5	296.3	50.8	115.9	180.6	1.9
249 Misc. Wood Prod	86	1.7	124.3	24.1	48.1	74.8	1.9
251 Household furniture	191	18.2	1,318.5	317.7	694.0	633.7	26.3
252 Office Furniture	21	2.4	286.4	51.8	133.2	155.3	3.1
253 Public Related Buildings	20	1.8	297.3	35.2	83.4	215.2	(D)
254 Partitions, Shelving etc.	43	1.4	118.2	30.2	50.4	67.5	(D)
259 Miscellaneous furniture	31	1.7	182.4	32.1	98.5	82.6	2.1
265 Paperboards	93	6.3	1,055.6	170.0	375.1	678.5	5.2
267 Converted Paper	63	9.2	1,494.1	226.5	673.5	819.0	47.7
Sub-Total	686	46.6	5,257.6	958.3	2,310.5	2,953.3	90.1
Total	1441	68.8	7,653.2	1,385.4	3,520.2	4,137.8	182.0

(D) Disclosure; Source: 1992, Census of Manufactures, Geographic Areas Series: Tennessee. U.S. Department of Commerce, Bureau of the Census

Appendix A.4 Area of timberland by Tennessee B.E.A. regions and stand size class, 1989.

B.E.A. Regions	All Classes	Sawtimber	Poletimber	Sapling-Seedling	Non-stocked
	----------Thousand of Acres ----------				
Chattanooga	1,727	882	490	355	0
Knoxville	2,226	1,322	581	323	0
Tricities	918	530	283	105	0
Nashville	5,889	2,445	2,310	1,128	6
Memphis	2,503	1,375	745	383	0
Total	13,263	6,554	4,409	2,294	6

Source: USDA, Forest Service, 1989 Southern Forest Inventory and Analysis Database.

Appendix A.5 Area of timberland by Tennessee B.E.A. regions and forest type group, 1989.

B.E.A. Regions	All Groups	Softwood	Softwood-Hardwood	Hardwood	Non-stocked
	----------	----------	Thousand of Acres	----------	----------
Chattanooga	1,723	451	313	959	0
Knoxville	2,213	194	408	1,611	0
Tricities	912	67	150	695	0
Nashville	5,924	440	515	4,969	6
Memphis	2,491	246	204	2,041	0
Total	13,263	1,399	1,591	10,270	6

Source: USDA, Forest Service, 1989 Southern Forest Inventory and Analysis Database.

Appendix A.6 Average net annual growth of growing stock and sawtimber on timberland by economic region and type of wood.

Economic Regions	Growing Stock		Sawtimber	
	Softwood	Hardwood	Softwood	Hardwood
	Millions of Cubic feet		Millions of Board feet	
Chattanooga	34	55	134	202
Knoxville	16.3	99	92	420
Tricities	6	42	32	182
Nashville	25	214	66	858
Memphis	19	127	57	502
Total	100.3	537	381	2,164

Source: USDA, Forest Service, 1989 Southern Forest Inventory and Analysis Database.

Appendix A.7. Average net annual removals of growing stock and sawtimber on timberland by economic region and type of wood.

Region Economic	Growing Stock		Sawtimber	
	Softwood	Hardwood	Softwood	Hardwood
	Millions of Cubic feet		Millions of Board feet	
Chattanooga	18.4	11.5	56	30.6
Knoxville	10.3	16.1	38.8	66
Tricities	2	6.1	1	19.6
Nashville	9.9	97.3	33	396.4
Memphis	11.5	33.1	34	154
Total	52.1	167.2	162.8	666.6

Source: Forestry Inventory Analysis, Forest Service, USDA

Appendix A.8 Comparison of annual rates of growth and removals of softwood and hardwood between Tennessee and some neighboring states

State name	Species Group	Survey Year	Growth	Removal	Ratio G/R
			Millions Cu. Ft.	Millions Cu. Ft.	
Alabama	Softwood	1990	636.1	697.1	0.91
	Hardwood		532.7	362.3	1.47
Arkansas	Softwood	1988	339.5	383.1	0.89
	Hardwood		326.9	239.6	1.36
Georgia	Softwood	1988	770.1	921.1	0.84
	Hardwood		417.5	314.2	1.33
North Carolina	Softwood	1990	546	490.6	1.11
	Hardwood		513.2	400.4	1.28
Mississippi	Softwood	1984	574.3	661.3	0.87
	Hardwood		426	452	0.94
Tennessee	Softwood	1989	87.1	47.2	1.85
	Hardwood		451.4	176.2	2.56
Virginia	Softwood	1991	297.6	237.1	1.26
	Hardwood		463.5	326	1.42

Source: Pacheco, et. al. 1996.

APPENDIX B

Appendix B.1 Knoxville region main economic indicators 1994

SECTOR	T.I.O	Employment	Valued Added	P.C.E	Exports	Imports
	$ Million	Nº of jobs	$ Million	$ Million	$ Million	$ Million
Agriculture	271.8	18,718	185.2	18.7	167.4	49.2
Mining	188.6	1,943	125.9	1.1	124.9	31.8
Construction	2765.2	38,150	1504.2	0.0	205.9	701.9
Manufacturing	11053.2	87,284	4572.4	726.7	7850.3	3906.9
Trans. Comm. Util	2118.2	18,955	872.2	430.2	379.6	426.4
Trade	4819.5	109,042	3120.3	2694.1	802.2	727.7
Banking and Finance	4175.7	21,596	2622.3	2036.1	836.0	564.1
Services	7077.8	138,535	4542.8	3088.6	1724.1	1208.4
State Local Government	2059.7	61,801	1739.7	180.3	262.2	86.3
Federal Government	971.2	14,020	553.7	91.3	447.1	0.0
Total region	35500.8	510,044	19838.9	9267.6	12800.2	7702.9

Source : IMPLAN 1994

Appendix B.2 Knoxville region percent market share by main economic sector 1994

Sector	T.I.O	Employment	Valued Added	P.C.E	Exports	Imports
			Percent			
Agriculture	0.77	3.67	0.93	0.20	1.31	0.64
Mining	0.53	0.38	0.63	0.01	0.98	0.41
Construction	7.79	7.48	7.58	0.00	1.61	9.11
Manufacturing	31.13	17.11	23.05	7.84	61.33	50.72
Trans. Comm. Util	5.97	3.72	4.40	4.64	2.97	5.54
Trade	13.58	21.38	15.73	29.07	6.27	9.45
Banking and Finance	11.76	4.23	13.22	21.97	6.53	7.32
Services	19.94	27.16	22.90	33.33	13.47	15.69
State Local Government	5.80	12.12	8.77	1.95	2.05	1.12
Federal Government	2.74	2.75	2.79	0.99	3.49	0.00
Total Region	100	100	100	100	100	100

Appendix B.3 Nashville region main economic indicators 1994

SECTOR	T.I.O	Employment	Value Added	P.C.E	Export	Import
	$ Million	N of Jobs	$ Million	$ Million	$ Million	$ Million
Agriculture	1,094.1	51,233	606.1	67.9	641.9	265.5
Mining	217.3	2,370	150.7	4.3	175.5	32.1
Construction	5,709.1	78,087	3,115.4	0.0	310.3	1413.6
Manufacturing	34,065.3	202,981	11,973.5	1,894.2	24,718.9	13414.0
Trans. Comm. Util	5,940.0	46,863	2,544.0	1,098.5	1,576.3	1219.5
Trade	11,425.4	230,152	7,395.0	6,019.1	1,510.0	1633.1
Banking and Finance	10,982.6	63,894	6,710.8	4,829.4	2,591.2	1475.2
Services	37,458.0	302,329	23,266.7	16,738.3	8,792.2	5447.1
State Local Government	3,551.1	108622	3,055.9	388.4	288.6	122.8
Federal Government	1,525.0	28,348	936.7	180.3	514.6	0.0
Total Region	111,968.1	1,114,879	59,755.1	31,220.8	41,119.9	25,023.2

Appendix B.4 Nashville percentual share by main economic sectors 1994

SECTOR	T.I.O	Employment	Value Added	P.C.E	Exports	Imports
			Percent			
Agriculture	0.98	4.60	1.01	0.22	1.56	1.06
Mining	0.19	0.21	0.25	0.01	0.43	0.13
Construction	5.10	7.00	5.21	0.00	0.75	5.65
Manufacturing	30.42	18.21	20.04	6.07	60.11	53.61
Trans. Comm. Util	5.31	4.20	4.26	3.52	3.83	4.87
Trade	10.20	20.64	12.38	19.28	3.67	6.53
Banking and Finance	9.81	5.73	11.23	15.47	6.30	5.90
Services	33.45	27.12	38.94	53.61	21.38	21.77
State Local Government	3.17	9.74	5.11	1.24	0.70	0.49
Federal Government	1.36	2.54	1.57	0.58	1.25	0.00
Total Region	100	100	100	100	100	100

Source: IMPLAN 1994

Appendix B.5 Chattanooga region main economic indicators by major sectors 1994

SECTOR	T.I.O	Employment	Value Added	P.C.E	Exports	Imports
	$ Million	No of jobs	$ million	$ Million	$ Million	$ Million
Agriculture	233.7	7,660	99.5	14.9	108.0	96.46
Mining	114.4	830	62.1	1.0	86.6	26.71
Construction	1,505.8	20,330	825.5	0.0	0.0	392.84
Manufacturing	9,820.8	71,892	3711.3	548.6	6,742.7	3,292.66
Trans. Comm. Util	1,308.3	11,530	538.3	236.6	137.3	322.41
Trade	2,951.7	67,100	1922.9	1,595.8	533.1	450.21
Banking and Finance	1,662.8	14,863	758.0	410.3	867.3	502.80
Services	8,775.6	81,126	2478.9	1,886.4	637.2	53.82
State Local Government	1,152.1	32,804	965.6	110.4	133.5	980.88
Federal Government	3,097.6	13,958	1199.9	131.8	2,499.2	0.00
Total Region	30,623.3	322,093	12562.4	4,936.2	11,745.2	6,118.78

Source: IMPLAN 1994

Appendix B.6 Chattanooga region market share by major economic sectors 1994

SECTOR	T.I.O	Employment	Value Added	P.C.E	Exports	Imports
			Percent			
Agriculture	0.76	2.38	0.79	0.30	0.91	1.57
Mining	0.37	0.26	0.49	0.02	0.73	0.43
Construction	4.92	6.31	6.57	0.00	0.00	6.42
Manufacturing	32.07	22.32	29.54	11.11	57.40	53.81
Trans. Comm Util	4.27	3.58	4.29	4.79	1.16	5.26
Trade	9.64	20.83	15.31	32.33	4.53	7.35
Banking and Finance	5.43	4.61	6.03	8.31	7.38	8.21
Services	28.66	25.19	19.73	38.22	5.42	0.87
State Local Government	3.76	10.18	7.69	2.24	1.13	16.03
Federal Government	10.12	4.33	9.55	2.67	21.27	0.00
Total Region	100.00	100.00	100.00	100.00	100.00	100.00

Source: IMPLAN 1994

Appendix B.7 Tricities Region main economic indicators 1994

SECTOR	T.I.O	Employment	Value Added	P.C.E	Exports	Imports
	$ Million	No of jobs	$ million	$ Million	$ Million	$ Million
Agriculture	190.98	13,634	123.23	7.36	143.39	37.44
Mining	14.04	272	9.41	0.28	10.82	2.58
Construction	1,197.65	17,478	637.56	0.00	168.98	302.12
Manufacturing	7,016.52	58,285	2,646.24	368.94	4,760.25	2,440.52
Trans., Comm. Util	906.13	8,197	373.09	176.12	171.12	190.85
Trade	1,937.05	47,172	1,237.92	1,146.52	222.27	328.33
Banking and Finance	1,418.32	7,386	904.13	845.18	88.39	203.89
Services	2,600.48	55,860	1,700.89	1,302.34	653.17	433.47
State and Local Government	739.24	23,598	639.88	70.50	65.38	28.15
Federal Government	333.34	6,445	205.19	37.76	118.68	0.00
Total Region	16,353.74	238,327	8,477.54	3,954.99	6,402.45	3,967.35

Source : IMPLAN 1994

Appendix B.8 Tricities Region percent shares by major economic sectors 1994

SECTOR	T.I.O	Employment	Value Added	P.C.E	Exports	Imports
			Percent			
Agriculture	1.17	5.72	1.45	0.19	2.24	0.94
Mining	0.09	0.11	0.11	0.01	0.17	0.07
Construction	7.32	7.33	7.52	0.00	2.64	7.62
Manufacturing	42.90	24.46	31.21	9.33	74.35	61.52
Trans., Comm., Util	5.54	3.44	4.40	4.45	2.67	4.81
Trade	11.84	19.79	14.60	28.99	3.47	8.28
Banking and Finance	8.67	3.10	10.66	21.37	1.38	5.14
Service	15.90	23.44	20.06	32.93	10.20	10.93
State and Local Government	4.52	9.90	7.55	1.78	1.02	0.71
Federal government	2.04	2.70	2.42	0.95	1.85	0.00
Total Region	100	100	100	100	100	100

Source: IMPLAN 1994

Appendix B.9 Memphis Region main economic indicators by major economic sectors 1994

SECTOR	T.I.O	Employment	Value Added	P.C.E	Exports	Imports
	$ Million	No of jobs	$ million	$ Million	$ Million	$ Million
Agriculture	944.94	23,461	453.80	24.31	566.47	238.92
Mining	119.80	1,681	81.50	2.48	102.07	18.52
Construction	3,,954.50	52,769	2,176.97	0.00	0.00	909.72
Manufacturing	20,689.91	134,396	8,397.89	1,772.77	13,654.92	6,871.86
Trans. Comm. Util	7,319.91	63,797	3,052.91	684.16	4,127.18	1,666.43
Trade	11,786.46	207,127	7,513.88	4,774.65	3,312.53	1,606.74
Banking and Finance	8,476.49	45,083	5,220.28	3,603.96	2,050.40	1,079.67
Services	10,422.32	219,941	6,783.64	5,260.86	1,709.91	1,546.85
State Local Government	3,593.45	93,746	2,943.99	327.78	599.46	152.03
Federal Government	1,591.39	38,963	1,265.51	149.45	384.57	0.00
Total region	68,899.18	880,964	37,890.36	16,600.40	26,507.50	14,090.74

Source: IMPLAN 1994

Appendix B.10 Memphis Region market shares by major economics sectors 1994

SECTOR	T.I.O	Employment	Value Added	P.C.E	Exports	Imports
			Percent			
Agriculture	1.37	2.66	1.20	0.15	2.14	1.70
Mining	0.17	0.19	0.22	0.01	0.39	0.13
Construction	5.74	5.99	5.75	0.00	0.00	6.46
Manufacturing	30.03	15.26	22.16	10.68	51.51	48.77
Trans. Comm. and Util	10.62	7.24	8.06	4.12	15.57	11.83
Trade	17.11	23.51	19.83	28.76	12.50	11.40
Banking and finance	12.30	5.12	13.78	21.71	7.74	7.66
Services	15.13	24.97	17.90	31.69	6.45	10.98
State Local Government	5.22	10.64	7.77	1.97	2.26	1.08
Federal Government	2.31	4.42	3.34	0.90	1.45	0.00
Total Region	100	100	100	100	100	100

Source: IMPLAN 1994

Appendix B.11 Forestry complex Knoxville region main economic indicators 1994

INDUSTRY SECTOR	T.I.O.	Employment	Value Added	P.C.E	Export	Import	Location quotient
	$ Million	No. of Jobs	$ Million	$ Million	$ Million	$ Million	Ratio
162 Paper Mills, Except Building Paper	12.90	59	6.11	0.02	12.82	3.87	0.07
163 Paperboard Mills	14.92	34	5.92	0.02	14.83	5.14	0.21
164 Paperboard Containers and Boxes	126.52	793	41.17	0.65	25.96	68.10	0.75
165 Paper Coated & Laminated Packaging	1.00	5	0.47	0.01	0.95	0.34	0.02
166 Paper Coated & Laminated N.E.C.	3.72	26	1.52	0.04	3.55	1.42	0.85
167 Paper plastic	5.87	40	2.24	0.01	5.80	2.33	0.18
169 Die-cut Paper and Board	1.93	15	0.91	0.00	1.91	0.81	0.07
173 Converted Paper Products, N.E.C	73.19	519	32.38	0.36	71.35	26.82	0.25
PAPER AND ALLIED PRODUCTS	240.05	1491	90.73	1.10	137.18	108.83	0.41
22 Forest Products	1.18	76	1.09	0.01	1.07	0.04	0.83
24 Forestry Products	7.81	36	1.08	0.02	7.75	4.58	0.53
133 Logging Camps and Logging Contractors	18.31	126	3.66	0.00	2.89	12.06	0.72
134 Sawmills and Planing Mills, General	35.08	271	9.37	0.01	2.96	8.32	0.38
135 Hardwood Dimension and Flooring Mills	111.23	1,655	55.89	0.20	57.79	30.47	1.69
136 Special Product Sawmills, N.E.C	0.97	19	0.39	0.00	0.05	0.12	1.57
137 Millwork	29.04	363	12.57	0.02	1.13	10.73	1.08
138 Wood Kitchen Cabinets	42.44	733	22.83	0.02	20.22	11.83	2.04
140 Structural Wood Members, N.E.C	29.33	274	10.15	0.01	15.28	12.35	2.68
142 Wood Pallets and Skids	10.63	164	4.55	0.01	4.45	3.42	0.67
143 Mobile Homes	183.47	1,772	72.62	0.02	174.65	73.86	3.14

Appendix B.11 Forestry complex Knoxville region main economic indicators 1994 (continued)

INDUSTRY SECTOR	T.I.O.	Employment	Value Added	P.C.E.	Export	Import	Location Quotient
	$ Million	No. of Jobs	$ Million	$ Million	$ Million	$ Million	Ratio
144 Prefabricated Wood Buildings	48.63	365	15.67	0.04	47.02	19.24	5.40
146 Reconstituted Wood Products	4.59	23	0.80	0.00	0.26	2.09	1.03
147 Wood Products, N.E.C	14.20	280	7.42	4.12	4.08	3.92	0.80
WOOD PRODUCTS	536.91	6157	218.09	4.46	339.60	193.05	1.45
148 Wood Household Furniture	197.03	2,928	85.78	21.49	129.24	58.23	2.96
149 Upholstered Household Furniture	314.32	4,594	133.92	21.88	245.81	95.21	2.56
150 Furniture metal	100.46	1,162	41.92	12.78	75.22	35.65	0.96
152 Wood TV and Radio Cabinets	56.56	764	27.84	0.74	48.16	19.36	3.96
153 Household Furniture, N.E.C	2.83	60	1.65	0.56	1.93	0.52	2.13
154 Wood Office Furniture	0.10	2	0.06	0.00	0.09	0.02	0.07
156 Public Building Furniture	123.25	1,006	47.96	0.74	83.11	45.06	1.45
157 Wood Partitions and Fixtures	1.49	28	0.73	0.00	0.30	0.48	0.22
160 Furniture and Fixtures, N.E.C	114.69	855	44.58	0.47	110.75	63.93	4.38
FURNITURE AND FIXTURES	910.72	11,399	384.43	58.66	694.60	318.45	2.18
TOTAL REGION	1687.67	19,047	693.24	64.22	1171.38	620.33	

Source : IMPLAN 1994

Appendix B.12 Forestry Complex Nashville Region main economic indicators by economic sector

INDUSTRY SECTOR	T.I.O.	Employment	Value Added	P.C.E.	Exports	Imports	Location quotient
161 Pulp Mills	0.36	1	0.14	0.00	0.36	0.09	0.00
162 Paper Mills, Except Building Paper	8.60	39	4.12	0.01	8.55	2.36	0.02
164 Paperboard Containers and Boxes	263.09	1,706	80.21	1.29	13.01	144.57	0.73
165 Paper Coated & Laminated Packaging	97.13	566	40.56	0.72	92.66	35.31	1.147
166 Paper Coated & Laminated N.E.C.	17.83	131	6.75	0.13	17.01	6.90	1.94
167 paper plastic	87.05	601	32.40	0.21	85.91	33.86	1.22
168 Bags, Paper	63.59	413	26.60	0.08	62.97	21.50	2.65
169 Die-cut Paper and Board	2.10	22	0.68	0.00	2.06	1.12	0.04
170 Sanitary Paper Products	3.50	6	1.62	0.02	3.40	1.29	
171 Envelopes	46.98	422	18.27	0.01	46.72	20.48	0.47
173 Converted Paper Products, N.E.C	27.29	227	10.29	0.16	26.52	10.91	0.04
PAPER AND ALLIED PRODUCTS	618	4,134	222	3	359	278	0.52
22 Forest Products	4.76	300	4.32	0.02	4.31	0.18	1.49
24 Forestry Products	43.80	169	9.18	0.09	43.36	21.72	1.13
133 Logging Camps and Logging Contractors	70.46	452	16.77	0.00	10.80	45.03	1.170
134 Sawmills and Planing Mills, General	314.12	2,369	88.85	0.04	106.48	85.99	1.53
135 Hardwood Dimension and Flooring Mills	151.73	2,243	76.60	0.36	114.47	20.43	1.04
136 Special Product Sawmills, N.E.C	0.57	9	0.28	0.00	0.03	0.11	0.33
137 Millwork	31.67	396	13.73	0.02	1.23	7.82	0.53
138 Wood Kitchen Cabinets	48.07	836	25.78	0.05	10.33	11.26	1.05
140 Structural Wood Members, N.E.C	11.83	121	3.52	0.00	0.56	2.65	0.53
141 Wood Containers	9.52	155	3.95	0.01	4.89	1.85	0.858
142 Wood Pallets and Skids	37.62	640	14.31	0.02	18.78	7.24	1.19156
143 Mobile Homes	110.25	937	49.59	0.01	109.97	38.56	0.75
144 Prefabricated Wood Buildings	4.83	34	1.70	0.02	4.63	1.39	0.22
145 Wood Preserving	2.65	10	0.55	0.00	0.06	0.65	0.10

Appendix B.12 Forestry Complex Nashville Region main economic indicators by economic sector (continued)

INDUSTRY SECTOR	T.I.O.	Employment	Value Added	P.C.E.	Exports	Imports	Location Quotient
146 Reconstituted Wood Products	4.54	21	1.11	0.00	0.22	1.65	0.42
147 Wood Products, N.E.C	66.43	1,169	36.58	10.72	37.80	12.45	1.51
WOOD PRODUCTS	912.839	9861	346.86	11.36	467.92	258.98	1.05
148 Wood Household Furniture	92.49	1,384	40.00	45.91	21.95	22.96	0.63
149 Upholstered Household Furniture	51.85	745	22.48	35.87	6.61	15.71	0.188
150 Furniture metal	347.91	2,992	156.24	37.86	86.98	117.42	1.126
152 Wood TV and Radio Cabinets	2.98	50	1.16	0.25	0.12	1.15	0.11
153 Household Furniture, N.E.C	0.24	7	0.12	0.13	0.02	0.05	0.11
154 Wood Office Furniture	0.76	17	0.42	0.01	0.56	0.18	0.25
156 Public Building Furniture	172.85	1,395	68.16	1.42	28.40	64.46	0.91
157 Wood Partitions and Fixtures	26.07	419	14.18	0.09	3.73	6.99	1.47
160 Furniture and Fixtures, N.E.C	34.04	274	12.00	0.18	31.08	19.61	0.63
FURNITURE AND FIXTURES	729	7,283	315	122	179	249	0.63
TOTAL REGION	2259.54	21,278	883.24	135.70	1006.54	785.90	

Appendix B.13 Forestry complex Chattanooga main economic indicators by major economic sector 1994

INDUSTRY SECTOR	T.I.O	Employment	Value Added	P.C.E	Export	Import	Location quotient
161 Pulp Mills	40.66	125	15.85	0.04	40.11	12.58	1.62
162 Paper Mills, Except Building Paper	338.48	1,497	163.22	0.36	336.50	102.96	2.80
163 Paperboard Mills	155.33	461	41.65	0.16	154.03	66.89	4.50
164 Paperboard Containers and Boxes	214.27	1,335	70.58	0.41	118.07	114.95	1.98
166 Paper Coated & Laminated N.E.C.	1.24	11	0.36	0.01	1.18	0.54	0.57
167 other plastic paper	80.30	481	25.96	0.20	79.08	32.52	3.39
169 Die-cut Paper and Board	0.33	3	0.11	0.00	0.32	0.18	0.02
171 Envelopes	0.29	3	0.11	0.00	0.28	0.14	0.01
173 Converted Paper Products, N.E.C	0.69	5	0.27	0.00	0.67	0.28	0.00
PAPER AND ALLIED PRODUCTS	831.60	3,921	318.09	1.18	730.24	331.04	1.71
22 Forest Products	0.47	39	0.42	0.00	0.41	0.02	0.67
24 Forestry Products	11.71	55	0.84	0.01	11.67	7.74	1.28
133 Logging Camps and Logging Contractors	13.31	88	2.98	0.00	2.19	8.97	0.79
134 Sawmills and Planing Mills, General	21.02	173	4.90	0.00	1.95	9.87	0.39
135 Hardwood Dimension and Flooring Mills	5.12	79	2.50	0.01	0.15	1.62	0.13
137 Millwork	7.21	81	3.42	0.01	0.25	2.57	0.38
138 Wood Kitchen Cabinets	10.31	163	5.77	0.01	1.46	2.86	0.71
140 Structural Wood Members, N.E.C	11.84	106	4.35	0.00	4.60	5.05	1.63
141 Wood Containers	1.56	27	0.59	0.00	0.59	0.62	0.52
142 Wood Pallets and Skids	9.63	158	3.81	0.01	5.32	3.69	1.02
144 Prefabricated Wood Buildings	0.73	6	0.22	0.00	0.70	0.34	0.14
145 Wood Preserving	8.65	35	1.63	0.01	2.72	4.06	1.25
146 Reconstituted Wood Products	4.45	21	1.01	0.00	0.25	1.83	1.48
147 Wood Products, N.E.C	17.32	351	8.91	2.95	10.00	5.11	1.57
WOOD PRODUCTS	123.33	1382.00	41.36	3.00	42.26	54.35	0.51
148 Wood Household Furniture	43.11	647	8.91	12.21	21.92	94.36	1.03

Appendix B.13 Forestry complex Chattanooga main economic indicators by major economic sector 1994 (continued)

INDUSTRY SECTOR	T.I.O.	Employment	Value Added	P.C.E.	Export	Import	Location Quotient
149 Upholstered Household Furniture	285.63	4,075	18.62	18.00	224.69	4.57	3.58
150 Furniture metal	12.35	160	124.87	3.04	7.97	0.21	0.21
152 Wood TV and Radio Cabinets	0.55	9	4.72	0.02	0.03	1.52	0.07
154 Wood Office Furniture	7.38	95	0.22	0.07	4.60	53.84	4.88
156 Public Building Furniture	160.50	1,279	4.90	1.95	115.42	2.59	2.90
157 Wood Partitions and Fixtures	9.36	152	64.19	0.05	1.32	2.59	1.85
FURNITURE AND FIXTURES	509.53	6,417	226.45	35.29	374.64	157.10	1.88
TOTAL REGION	1464.46	11720	585.90	39.48	1147.14	542.48	

Source: IMPLAN 1994

Appendix B.14 Forestry complex Tricites region main economic indicators by major economic sector 1994

INDUSTRY SECTOR	T.I.O	Employment	Value Added	P.C.E.	Exports	Imports	Location Quotient
Paper Mills, Except Building Paper	77.56	318	39.25	0.07	77.13	21.01	0.80
Paperboard Containers and Boxes	121.10	722	42.92	0.30	56.87	61.65	1.44
Paper Coated & Laminated N.E.C.	2.29	17	0.88	0.01	2.21	0.84	1.18
Bags, Paper	0.47	3	0.19	0.00	0.47	0.15	0.09
Envelopes	2.22	20	0.86	0.00	2.21	1.00	0.10
Converted Paper Products, N.E.C	166.45	1,300	67.40	0.97	162.55	65.18	1.33
Paper and allied products	370.10	2380.00	151.51	1.35	301.45	149.83	1.40
Forest Products	0.47	30	0.43	0.00	0.43	0.02	0.69
Forestry Products	12.76	44	3.45	0.01	12.74	5.70	1.38
Logging Camps and Logging Contractors	10.47	72	2.12	0.00	1.52	7.24	0.87
Sawmills and Planing Mills, General	58.33	427	17.54	0.01	5.77	20.48	1.29
Hardwood Dimension and Flooring Mills	10.41	139	5.57	0.03	4.41	1.59	0.30
Millwork	12.56	164	5.25	0.01	0.47	3.22	1.03
Wood Kitchen Cabinets	6.94	119	3.76	0.01	0.05	1.31	0.70
Structural Wood Members, N.E.C	11.20	104	3.95	0.00	5.08	2.52	2.16
Wood Pallets and Skids	5.02	83	1.96	0.00	2.31	1.10	0.72
Prefabricated Wood Buildings	0.43	3	0.13	0.00	0.41	0.14	0.09
Wood Preserving	53.73	221	9.19	0.07	46.45	14.33	10.68
Reconstituted Wood Products	9.55	45	2.15	0.01	2.11	3.08	4.28
Wood Products, N.E.C	4.05	81	2.11	1.45	0.80	0.81	0.49

Appendix B.14 Forestry complex Tricites region main economic indicators by major economic sector 1994 (continued)

INDUSTRY SECTOR	T.I.O.	Employment	Value Added	P.C.E.	Exports	Imports	Location Quotient
Wood Products	195.93	1532	57.60	1.60	82.57	61.53	0.77
Wood Household Furniture	36.80	612	14.08	9.96	18.33	8.33	1.31
Upholstered Household Furniture	0.28	4	0.12	0.25	0.02	0.08	0.00
Furniture metal	66.37	812	26.46	7.48	49.69	23.20	1.43
Household Furniture, N.E.C	4.87	102	2.84	0.36	3.79	0.64	7.71
Wood Office Furniture	3.71	61	2.34	0.03	2.13	0.65	4.23
Public Building Furniture	6.56	65	1.87	0.05	0.28	2.58	0.19
Furniture and fixtures	118.58	1656	47.73	18.12	74.24	35.48	0.67
TOTAL	684.60	5,568	256.83	21.07	458.26	246.83	

Source: IMPLAN 1994

Appendix B.15 Forestry Complex Memphis Region main economic indicators by major economic sectors

INDUSTRY SECTOR	T.I.O	Employment	Value Added	P.C.E	Export	Import	Location Quotient
	$ Million	N of Jobs	$ Million	$ Million	$ Million	$ Million	Ratios
161 Pulp Mills	222.32	608	95.43	0.35	219.69	61.32	2.88
162 Paper Mills, Except Building Paper	652.84	3,174	293.40	0.61	648.56	190.47	2.17
163 Paperboard Mills	197.22	479	73.19	0.18	196.07	65.86	1.71
164 Paperboard Containers and Boxes	300.33	1,856	100.28	1.09	19.22	151.84	1.01
165 Paper Coated & Laminated Packaging	144.45	785	64.13	1.25	138.23	45.77	2.01
168 Bags, Paper	36.16	228	15.55	0.05	35.82	10.72	0.59
169 Die-cut Paper and Board	1.20	11	0.44	0.00	1.18	0.58	0.09
170 Sanitary Paper Products	662.44	1,174	311.36	3.13	648.18	230.73	3.36
171 Envelopes	18.32	161	7.32	0.00	18.22	7.50	ERR
173 Converted Paper Products, N.E.C	271.35	2,013	115.41	1.89	263.91	94.12	2.85
Paper and allied products	2506.63	10489.00	1076.50	8.57	2189.08	858.92	2.91
22 Forest Products	1.90	108	1.71	0.02	1.70	0.07	0.68
24 Forestry Products	25.33	104	4.02	0.04	25.12	12.62	0.89
133 Logging Camps and Logging Contractors	48.66	323	10.61	0.00	7.64	32.21	1.06
134 Sawmills and Planing Mills, General	128.04	1,013	32.49	0.03	12.06	45.83	0.83
135 Hardwood Dimension and Flooring Mills	121.72	1,805	61.32	0.50	93.87	22.28	1.06
136 Special Product Sawmills, N.E.C	2.69	45	1.23	0.00	0.65	0.52	2.14
137 Millwork	82.64	1,027	35.93	0.07	32.63	21.82	1.76
138 Wood Kitchen Cabinets	17.54	322	9.17	0.03	0.26	3.89	0.52
139 Veneer and Plywood	20.56	170	5.61	0.00	1.78	7.34	3.48
140 Structural Wood Members, N.E.C	1.32	13	0.40	0.00	0.06	0.38	0.07
141 Wood Containers	18.15	314	6.92	0.03	10.91	3.92	2.20
142 Wood Pallets and Skids	24.14	431	8.52	0.03	2.38	6.19	1.02

Appendix B.15 Forestry Complex Memphis Region main economic indicators by major economic sectors (continued)

INDUSTRY SECTOR	T.I.O.	Employment	Value Added	P.C.E.	Export	Import	Location Quotient
	$ Million	No. of Jobs	$ Million	$ Million	$ Million	$ Million	Ratios
143 Mobile Homes	85.69	701	39.78	0.01	85.53	29.04	0.71
146 Reconstituted Wood Products	5.24	25	1.09	0.01	0.29	2.00	0.64
147 Wood Products, N.E.C	16.72	243	9.92	6.40	2.69	3.02	0.40
Wood Products	600.34	6644.00	228.74	7.16	277.58	191.14	0.90
148 Wood Household Furniture	30.96	404	15.15	23.88	0.92	6.49	0.24
149 Upholstered Household Furniture	99.48	1,422	43.42	31.49	49.84	28.91	0.46
150 Furniture metal	249.95	2,173	106.07	28.37	62.32	83.97	1.04
152 Wood TV and Radio Cabinets	20.74	342	8.35	1.84	14.78	6.81	1.02
153 Household Furniture, N.E.C	0.03	1	0.02	0.02	0.00	0.00	0.02
154 Wood Office Furniture	0.71	10	0.46	0.01	0.54	0.12	0.19
156 Public Building Furniture	47.64	447	15.24	0.50	24.08	19.17	0.37
157 Wood Partitions and Fixtures	11.88	182	6.64	0.05	1.41	2.87	0.81
160 Furniture and Fixtures, N.E.C	5.64	49	1.80	0.06	4.11	3.07	0.14
Furniture and Fixtures	467.02	5030	197.14	86.23	157.99	151.42	0.55
TOTAL REGION	3573.99	22,163	1502.39	101.96	2624.65	1201.47	

Source: IMPLAN 1994

APPENDIX C

AGGREGATION SCHEME

I.1.- UNAGGREGATED NON-FOREST SECTORS

I.1.1 AGRICULTURAL SECTORS

1 Dairy Farm Products
2 Poultry and Eggs
3 Ranch Fed Cattle
4 Range Fed Cattle
5 Cattle Feedlots
6 Sheep, Lambs and Goats
7 Hogs, Pigs and Swine
8 Other Meat Animal Products
9 Miscellaneous Livestock
10 Cotton
11 Food Grains
12 Feed Grains
13 Hay and Pasture
14 Grass Seeds
15 Tobacco
16 Fruits
17 Tree Nuts
18 Vegetables
19 Sugar Crops
20 Miscellaneous Crops
21 Oil Bearing Crops
23 Greenhouse and Nursery Products
25 Commercial Fishing
27 Landscape and Horticultural Services

I.1.2 OTHERS UNAGGREGATED SECTORS

37 Coal Mining
433 Railroads and Related Services
434 Local, Interurban Passenger Transit
435 Motor Freight Transport and Warehousing
436 Water Transportation
437 Air Transportation
438 Pipe Lines, Except Natural Gas
447 Wholesale Trade
456 Banking
457 Credit Agencies
458 Security and Commodity Brokers
459 Insurance Carriers
460 Insurance Agents and Brokers

463 Hotels and Lodging Places
474 Personnel Supply Services
494 Legal Services
519 Federal Government - Military
522 State & Local Government - Education
525 Domestic Services

I.2.- UNAGGREGATED FOREST RELATED INDUSTRIES

I.2.1 PRIMARY FOREST PRODUCTS

22 Forest Products
24 Forestry Products
26 Agricultural, Forestry, Fishery Services
133 Logging Camps and Logging Contractors
134 Sawmills and Planing Mills, General
136 Special Product Sawmills, N.E.C
139 Veneer and Plywood
161 Pulp Mills
162 Paper Mills, Except Building Paper
163 Paperboard Mills

I.2.2 SECONDARY FOREST PRODUCTS

135 Hardwood Dimension and Flooring Mills
137 Millwork
138 Wood Kitchen Cabinets
140 Structural Wood Members, N.E.C
141 Wood Containers
142 Wood Pallets and Skids
143 Mobile Homes
144 Prefabricated Wood Buildings
145 Wood Preserving
146 Reconstituted Wood Products
147 Wood Products, N.E.C
148 Wood Household Furniture
149 Upholstered Household Furniture
152 Wood TV and Radio Cabinets
153 Household Furniture, N.E.C
154 Wood Office Furniture
156 Public Building Furniture
157 Wood Partitions and Fixtures
160 Furniture and Fixtures, N.E.C
164 Paperboard Containers and Boxes
165 Paper Coated & Laminated Packaging
166 Paper Coated & Laminated N.E.C.
168 Bags, Paper
169 Die-cut Paper and Board
170 Sanitary Paper Products

171 Envelopes
173 Converted Paper Products, N.E.C
201 Gum and Wood Chemicals

I.3. AGGREGATE ECONOMIC SECTOR

AGG METAL MINING

28 Iron Ores
29 Copper Ores
30 Lead and Zinc Ores
31 Gold Ores
32 Silver Ores
33 Ferroalloy Ores, Except Vanadium
34 Metal Mining Services
35 Uranium-radium-vanadium Ores
36 Metal Ores, Not Elsewhere Classified

AGG OIL & GAS EXTRACT

38 Natural Gas & Crude Petroleum
39 Natural Gas Liquids
57 Maintenance and Repair Oil and Gas Wells

AGG NON-METALLIC MINING

40 Dimension Stone
41 Sand and Gravel
42 Clay, Ceramic, Refractory Minerals, N.E.C.
43 Potash, Soda, and Borate Minerals
44 Phosphate Rock
45 Chemical, Fertilizer Mineral Mining, N.E.C.
46 Nonmetallic Minerals (Except Fuels) Service
47 Misc. Nonmetallic Minerals, N.E.C.

AGG CONSTRUCTION

48 New Residential Structures
49 New Industrial and Commercial Buildings
50 New Utility Structures
51 New Highways and Streets
52 New Farm Structures
53 New Mineral Extraction Facilities
54 New Government Facilities
55 Maintenance and Repair, Residential
56 Maintenance and Repair Other Facilities

AGG FOOD PROCESSING

58 Meat Packing Plants
59 Sausages and Other Prepared Meats
60 Poultry Processing
61 Creamery Butter
62 Cheese, Natural and Processed
63 Condensed and Evaporated Milk
64 Ice Cream and Frozen Desserts
65 Fluid Milk
66 Canned Specialties
67 Canned Fruits and Vegetables
68 Dehydrated Food Products
69 Pickles, Sauces, and Salad Dressings
70 Frozen Fruits, Juices and Vegetables
71 Frozen Specialties
72 Flour and Other Grain Mill Products
73 Cereal Preparations
74 Rice Milling
75 Blended and Prepared Flour
76 Wet Corn Milling
77 Dog, Cat, and Other Pet Food
78 Prepared Feeds, N.E.C
79 Bread, Cake, and Related Products
80 Cookies and Crackers
81 Sugar
82 Confectionery Products
83 Chocolate and Cocoa Products
84 Chewing Gum
85 Salted and Roasted Nuts & Seeds
86 Cottonseed Oil Mills
87 Soybean Oil Mills
88 Vegetable Oil Mills, N.E.C
89 Animal and Marine Fats and Oils
90 Shortening and Cooking Oils
91 Malt Beverages
92 Malt
93 Wines, Brandy, and Brandy Spirits
94 Distilled Liquor, Except Brandy
95 Bottled and Canned Soft Drinks & Water
96 Flavoring Extracts and Syrups, N.E.C.
97 Canned and Cured Sea Foods
98 Prepared Fresh Or Frozen Fish Or Seafood
99 Roasted Coffee
100 Potato Chips & Similar Snacks
101 Manufactured Ice
102 Macaroni and Spaghetti
103 Food Preparations, N.E.C

AGG TOBACCO PRODUCTS

104 Cigarettes
105 Cigars
106 Chewing and Smoking Tobacco
107 Tobacco Stemming and Redrying

AGG TEXTILES

108 Broadwoven Fabric Mills and Finishing
109 Narrow Fabric Mills
110 Women's Hosiery, Except Socks
111 Hosiery, N.E.C
112 Knit Outerwear Mills
113 Knit Underwear Mills
114 Knit Fabric Mills
115 Knitting Mills, N.E.C.
116 Yarn Mills and Finishing Of Textiles, N.E.C.
117 Carpets and Rugs
118 Thread Mills
119 Coated Fabrics, Not Rubberized
120 Tire Cord and Fabric
121 Nonwoven Fabrics
122 Cordage and Twine
123 Textile Goods, N.E.C

AGG APPAREL

124 Apparel Made From Purchased Material
125 Curtains and Draperies
126 House furnishings, N.E.C
127 Textile Bags
128 Canvas Products
129 Pleating and Stitching
130 Automotive and Apparel Trimmings
131 Stiff Machine Embroideries
132 Fabricated Textile Products, N.E.C.

AGG METAL & OTHER MATERIAL FURNITURE

150 Metal Household Furniture
151 Mattresses and Bedsprings
155 Metal Office Furniture
158 Metal Partitions and Fixtures
159 Blinds, Shades, and Drapery Hardware

AGG OTHER PLASTIC AND PAPER

167 Bags, Plastic
172 Stationery Products

AGG PRINTING & PUBLISHING

174 Newspapers
175 Periodicals
176 Book Publishing
177 Book Printing
178 Miscellaneous Publishing
179 Commercial Printing
180 Manifold Business Forms
181 Greeting Card Publishing
182 Bank books and Loose-leaf Binder
183 Bookbinding & Related
184 Typesetting
185 Plate Making

AGG CHEMICALS AND ALLIED

186 Alkalis & Chlorine
187 Industrial Gases
188 Inorganic Pigments
189 Inorganic Chemicals N.E.C.
190 Cyclic Crude's, Inter. & Indus. Organic Chem.
191 Plastics Materials and Resins
192 Synthetic Rubber
193 Cellulose Man-made Fibers
194 Organic Fibers, Noncellulosic
195 Drugs
196 Soap and Detergents
197 Polishes and Sanitation Goods
198 Surface Active Agents
199 Toilet preparations
200 Paints and Allied Products
202 Nitrogenous and Phosphoric Fertilizers
203 Fertilizers, Mixing Only
204 Agricultural Chemicals, N.E.C
205 Adhesives and Sealant
206 Explosives
207 Printing Ink
208 Carbon Black
209 Chemical Preparations, N.E.C

AGG PETROLEUM & RELATED PROD

210 Petroleum Refining
211 Paving Mixtures and Blocks
212 Asphalt Felts and Coatings
213 Lubricating Oils and Greases
214 Petroleum and Coal Products, N.E.C.

AGG RUBBER & MISC. PROD

215 Tires and Inner Tubes
216 Rubber and Plastics Footwear
217 Rubber and Plastics Hose and Belting
218 Gaskets, Packing and Sealing Devices
219 Fabricated Rubber Products, N.E.C.
220 Miscellaneous Plastics Products

AGG LEATHER & LEATHER PROD

221 Leather Tanning and Finishing
222 Footwear Cut Stock
223 House Slippers
224 Shoes, Except Rubber
225 Leather Gloves and Mittens
226 Luggage
227 Women's Handbags and Purses
228 Personal Leather Goods
229 Leather Goods, N.E.C

AGG STONE & CLAY AND GLASS PROD

230 Glass and Glass Products, Exc. Containers
231 Glass Containers
232 Cement, Hydraulic
233 Brick and Structural Clay Tile
234 Ceramic Wall and Floor Tile
235 Clay Refractors
236 Structural Clay Products, N.E.C
237 Vitreous Plumbing Fixtures
238 Vitreous China Food Utensils
239 Fine Earthenware Food Utensils
240 Porcelain Electrical Supplies
241 Pottery Products, N.E.C
242 Concrete Block and Brick
243 Concrete Products, N.E.C
244 Ready-mixed Concrete
245 Lime
246 Gypsum Products
247 Cut Stone and Stone Products
248 Abrasive Products
249 Asbestos Products
250 Minerals, Ground Or Treated
251 Mineral Wool
252 Non clay Refractors
253 Nonmetallic Mineral Products, N.E.C.

AGG PRIMARY METAL PROD

254 Blast Furnaces and Steel Mills
255 Electro metallurgical Products
256 Steel Wire and Related Products
257 Cold Finishing Of Steel Shapes
258 Steel Pipe and Tubes
259 Iron and Steel Foundries
260 Primary Copper
261 Primary Aluminum
262 Primary Nonferrous Metals, N.E.C.
263 Secondary Nonferrous Metals
264 Copper Rolling and Drawing
265 Aluminum Rolling and Drawing
266 Nonferrous Rolling and Drawing, N.E.C.
267 Nonferrous Wire Drawing and Insulating
268 Aluminum Foundries
269 Brass, Bronze, and Copper Foundries
270 Nonferrous Castings, N.E.C.
271 Metal Heat Treating
272 Primary Metal Products, N.E.C

AGG FABRICATED METAL

273 Metal Cans
274 Metal Barrels, Drums and Pails
275 Cutlery
276 Hand and Edge Tools, N.E.C.
277 Hand Saws and Saw Blades
278 Hardware, N.E.C.
279 Metal Sanitary Ware
280 Plumbing Fixture Fittings and Trim
281 Heating Equipment, Except Electric
282 Fabricated Structural Metal
283 Metal Doors, Sash, and Trim
284 Fabricated Plate Work (Boiler Shops)
285 Sheet Metal Work
286 Architectural Metal Work
287 Prefabricated Metal Buildings
288 Miscellaneous Metal Work
289 Screw Machine Products and Bolts, Etc.
290 Iron and Steel Forging
291 Nonferrous Forging
292 Automotive Stampings
293 Crowns and Closures
294 Metal Stampings, N.E.C.
295 Plating and Polishing
296 Metal Coating and Allied Service

297 Small Arms Ammunition
298 Ammunition, Except For Small Arms, N.E.C.
299 Small Arms
300 Other Ordnance and Accessories
301 Industrial and Fluid Valves
302 Steel Springs, Except Wire
303 Pipe, Valves, and Pipe Fittings
304 Miscellaneous Fabricated Wire Products
305 Metal Foil and Leaf
306 Fabricated Metal Products, N.E.C.

AGG INDUSTRIAL MACHINERY

307 Steam Engines and Turbines
308 Internal Combustion Engines, N.E.C.
309 Farm Machinery and Equipment
310 Lawn and Garden Equipment
311 Construction Machinery and Equipment
312 Mining Machinery, Except Oil Field
313 Oil Field Machinery
314 Elevators and Moving Stairways
315 Conveyors and Conveying Equipment
316 Hoists, Cranes, and Monorails
317 Industrial Trucks and Tractors
318 Machine Tools, Metal Cutting Types
319 Machine Tools, Metal Forming Types
320 Industrial Patterns
321 Special Dies and Tools and Accessories
323 Rolling Mill Machinery
324 Welding Apparatus
325 Metalworking Machinery, N.E.C.
331 Special Industry Machinery N.E.C.
332 Pumps and Compressors
333 Ball and Roller Bearings
334 Blowers and Fans
335 Packaging Machinery
336 Power Transmission Equipment
337 Industrial Furnaces and Ovens
338 General Industrial Machinery, N.E.C
339 Electronic Computers
340 Computer Storage Devices
341 Computer Terminals
342 Computer Peripheral Equipment,
343 Calculating and Accounting Machines
344 Typewriters and Office Machines N.E.C.
345 Automatic Merchandising Machine
346 Commercial Laundry Equipment
347 Refrigeration and Heating Equipment
348 Measuring and Dispensing Pumps

349 Service Industry Machines, N.E.C.
350 Carburetors, Pistons, Rings, Valves
351 Fluid Power Cylinders & Actuators
352 Fluid Power Pumps & Motors
353 Scales and Balances
354 Industrial Machines N.E.C.
355 Transformers
356 Switch gear and Switchboard Apparatus
357 Motors and Generators
358 Carbon and Graphite Products
359 Relays & Industrial Controls
360 Electrical Industrial Apparatus, N.E.C.
361 Household Cooking Equipment
362 Household Refrigerators and Freezers
363 Household Laundry Equipment
364 Electric Housewares and Fans
365 Household Vacuum Cleaners
366 Household Appliances, N.E.C.
367 Electric Lamps
368 Wiring Devices
369 Lighting Fixtures and Equipment
370 Radio and TV Receiving Sets
371 Phonograph Records and Tape
372 Telephone and Telegraph Apparatus
373 Radio and TV Communication Equipment
374 Communications Equipment N.E.C.
375 Electron Tubes
376 Printed Circuit Boards
377 Semiconductors and Related Devices
378 Electronic Components, N.E.C.
379 Storage Batteries
380 Primary Batteries, Dry and Wet
381 Engine Electrical Equipment
382 Magnetic & Optical Recording Media
383 Electrical Equipment, N.E.C.

AGG TRANSPORTATION EQUIPMENT

384 Motor Vehicles
386 Motor Vehicle Parts and Accessories
385 Truck and Bus Bodies
387 Truck Trailers
388 Motor Homes
389 Aircraft
390 Aircraft and Missile Engines and Parts
391 Aircraft and Missile Equipment,
392 Ship Building and Repairing
393 Boat Building and Repairing
394 Railroad Equipment

395 Motorcycles, Bicycles, and Parts
396 Complete Guided Missiles
397 Travel Trailers and Camper
398 Tanks and Tank Components
399 Transportation Equipment, N.E.C

AGG SCIENTIFIC EQUIPMENT

400 Search & Navigation Equipment
401 Laboratory Apparatus & Furniture
402 Automatic Temperature Controls
403 Mechanical Measuring Devices
404 Instruments To Measure Electricity
405 Analytical Instruments
406 Optical Instruments & Lenses
407 Surgical and Medical Instrument
408 Surgical Appliances and Supplies
409 Dental Equipment and Supplies
410 x-ray Apparatus
411 Electromedical Apparatus
412 Ophthalmic Goods
413 Photographic Equipment and Supplies

AGG MISCELLANEOUS MANUFACTURING

414 Watches, Clocks, and Parts
415 Jewelry, Precious Metal
416 Silverware and Plated Ware
417 Jewelers Materials and Lapidary Work
418 Musical Instruments
419 Dolls
420 Games, Toys, and Children's Vehicles
421 Sporting and Athletic Goods, N.E.C.
422 Pens and Mechanical Pencils
423 Lead Pencils and Art Goods
424 Marking Devices
425 Carbon Paper and Inked Ribbons
426 Costume Jewelry
427 Fasteners, Buttons, Needles, Pins
428 Brooms and Brushes
429 Signs and Advertising Displays
430 Burial Caskets and Vaults
431 Hard Surface Floor Coverings
432 Manufacturing Industries, N.E.C.

AGG TRANSPORTATION SERVICES

439 Arrangement Of Passenger Transportation
440 Transportation Services

AGG COMMUNICATION

441 Communications, Except Radio and TV
442 Radio and TV Broadcasting

AGG UTILITIES SERVICES

443 Electric Services
444 Gas Production and Distribution
445 Water Supply and Sewerage Systems
446 Sanitary Services and Steam Supply

AGG RETAIL TRADE

448 Building Materials & Gardening
449 General Merchandise Stores
450 Food Stores
451 Automotive Dealers & Service Stations
452 Apparel & Accessory Stores
453 Furniture & Home Furnishings Stores
454 Eating & Drinking
455 Miscellaneous Retail

AGG REAL STATE

461 Owner-occupied Dwellings
462 Real Estate

AGG PERSONAL SERVICES

464 Laundry, Cleaning and Shoe Repair
465 Portrait and Photographic Studios
466 Beauty and Barber Shops
467 Funeral Service and Crematories
468 Miscellaneous Personal Services

AGG BUSINESS SERVICES

469 Advertising
470 Other Business Services
471 Photo finishing, Commercial Photography
472 Services To Buildings
473 Equipment Rental and Leasing
475 Computer and Data Processing Services
476 Detective and Protective Services

AGG AUTOMOTIVE SERVICES

477 Automobile Rental and Leasing
478 Automobile Parking and Car Wash
479 Automobile Repair and Services

AGG MISC REPAIR

480 Electrical Repair Service
481 Watch, Clock, Jewelry and Furniture Repair
482 Miscellaneous Repair Shops

AGG RECREATION & AMUSEMENT

483 Motion Pictures
484 Theatrical Producers, Bands Etc.
485 Bowling Alleys and Pool Halls
486 Commercial Sports Except Racing
487 Racing and Track Operation
488 Amusement and Recreation Services, N.E.C.
489 Membership Sports and Recreation Clubs

AGG OTHER MEDICAL SERVICES

490 Doctors and Dentists
491 Nursing and Protective Care
492 Hospitals
493 Other Medical and Health Services

AGG EDUCATIONAL SERVICES

495 Elementary and Secondary Schools
496 Colleges, Universities, Schools
497 Other Educational Services

AGG SOCIAL SERVICES

498 Job Training & Related Services
499 Child Day Care Services
500 Social Services, N.E.C.
501 Residential Care

AGG NON PROFITS ORGANIZATION

502 Other Nonprofit Organizations
503 Business Associations
504 Labor and Civic Organizations
505 Religious Organizations

AGG PROFESSIONAL SERVICES

506 Engineering, Architectural Services
507 Accounting, Auditing and Bookkeeping
508 Management and Consulting Services
509 Research, Development & Testing Services

AGG STATE & LOCAL NON-ED GOV.

510 Local Government Passenger Transit
511 State and Local Electric Utilities
512 Other State and Local Govt. Enterprises
523 State & Local Government - Non-Education

AGG FEDERAL NON-MILITARY GOV.

513 US Postal Service
514 Federal Electric Utilities
515 Other Federal Government Enterprises
520 Federal Government - Non-Military

AGG SPECIAL SECTORS

516 Non comparable Imports
517 Scrap
518 Used and Secondhand Goods
524 Rest of The World Industry
521 Commodity Credit Corporation
528 Inventory Valuation Adjustment

APPENDICES D and E

Appendix D.1. Average removals cubic feet per acre of pulpwood and sawtimber by ownership type, stand size, land class, species group and land right hand side in acres for Memphis region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of wood (d)	Removal Pulpwood	Removal Sawtimber
				cubic feet/acre	cubic feet/acre
1	1	20	2	0.00	9.85
1	2	20	2	2.78	5.79
1	3	20	2	0.61	6.05
2	1	20	1	1.49	29.72
2	1	20	2	8	46.75
2	2	20	1	119	
2	2	20	2	4.53	10.77
2	3	20	1	13.28	24.8
2	3	20	2	63.76	92.84
3	1	20	1	13.38	98.5
3	1	20	2	25.22	104.64
3	2	20	1	4.49	30.5
3	2	20	2	24.4	105.49
3	3	20	1	34.75	29.02
3	3	20	2	21.36	72.11
4	1	20	1	7.50	68.25
4	1	20	2	26.60	69.69
4	2	20	1	34.59	123.5
4	2	20	2	20.32	49.55
4	3	20	1	84.61	80.94
4	3	20	2	19.03	121.07

Source: Forestry Inventory Analysis, Forest Service, USDA

(a) Ownership type: 1 Public, 2 Forestry industry, 3 farmer, 4 Other private

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked

(c) Land ownership Class: 20 Timberland, 25 Reserve timberland

(d) Type of wood: 1 Hardwood 2 Softwood

Appendix D. 2. Average removals cubic feet per acre of Pulpwood and Sawtimber by ownership type, stand size, land class, species group and land right hand side in acres for Chattanooga region.

Ownership Type(a)	Stand Size(b)	Land Class(c)	Type of Wood (d)	Removal Pulpwood	Removal Sawtimber
				cubic feet/acre	cubic feet/acre
1	1	20	1	53.31	25.29
1	1	20	2	3.10	199.40
1	2	20	1	27.02	19.99
1	2	20	2	14.56	20.97
1	3	20	1	22.76	19.19
1	3	20	2	9.09	101.29
1	4	25	1	36.25	58.60
1	4	25	2	74.36	37.36
2	1	20	2	17.88	16.96
2	2	20	2	6.95	43.79
2	3	20	1	46.31	47.74
2	3	20	2	48.85	22.47
3	1	20	2	17.00	3.07
3	2	20	2	71.05	38.23
3	3	20	1	4.92	78.58
3	3	20	2	5.62	19.60
4	1	20	1	15.05	15.67
4	1	20	2	13.39	70.37
4	2	20	1	104.66	102.4
4	2	20	1	54.07	69.90
4	3	20	1	93.27	106.01
4	3	20	2	45.17	26.92

Source: Forestry Inventory Analysis, Forest Service, USDA

(a) Ownership type: 1 Public, 2 Forestry industry, 3 farmer, 4 Other private

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked

(c) Land ownership Class: 20 Timberland, 25 Reserve timberland

(d) Type of wood: 1 Hardwood 2 Softwood

Appendix D.3 Average removals cubic feet per acre of Pulpwood and Sawtimber by ownership type, stand size, land class and land right hand side in acres for Knoxville region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Removal Pulpwood	Removal Sawtimber
				cubic feet/acre	cubic feet/acre
1	1	20	1	28.84	19.84
1	1	20	2	26.61	40.8
1	2	20	1	4.7	14.83
1	2	20	2	2.69	18.9
1	3	20	1	0.52	10.45
1	3	20	2	20.18	22.03
1	4	25	2	15.7	13.6
2	1	20	2	6.35	22.55
2	2	20	1	10.92	0
2	2	20	2	1.18	7.29
2	3	20	1	5.27	4.6
2	3	20	2	7.14	3.28
3	1	20	2	7.39	47.42
3	2	20	1	2.29	12.53
3	2	20	2	0.68	16.23
3	3	20	1	33.99	74.25
3	3	20	2	23.74	72
4	1	20	1	4.77	25.53
4	1	20	2	27.2	60.41
4	2	20	1	21.25	61.09
4	2	20	2	9.72	14.19
4	3	20	1	37.48	100.79
4	3	20	2	29.78	82.09
4	4	25	2	5.29	29.21

Source: Forestry Inventory Analysis, Forest Service, USDA

(a) Ownership type: 1 Public, 2 Forestry industry, 3 farmer, 4 Other private

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked

(c) Land ownership Class: 20 Timberland, 25 Reserve timberland

(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E. 4. Average removal per acre of Pulpwood and Sawtimber by ownership type, stand size, land class, species group and land right hand side in acres for Nashville region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Removal Pulpwood	Removal Sawtimber
				cubic feet/acre	cubic feet /acre
1	1	20	2	17.59	59.05
1	2	20	2	18.22	37.94
1	3	20	2	6.13	60.56
2	1	20	1	5.08	70.65
2	1	20	2	19.96	40.37
2	2	20	1	86.36	125.72
2	2	20	2	24.57	64.17
2	3	20	1	31.48	29.68
2	3	20	2	116.66	101.88
2	4	20	1	59.98	64.34
2	4	20	2	29.93	44.3
3	1	20	1	13.96	102.27
3	1	20	2	17.43	59.37
3	2	20	1	10.97	4.97
3	2	20	2	18.13	56.09
3	3	20	1	8.63	14.15
3	3	20	2	48.49	110.25
4	1	20	1	16.02	16.04
4	1	20	2	20.69	89.87
4	2	20	1	4.54	10.27
4	2	20	2	24.45	17.12
4	3	20	1	8.37	12.44
4	3	20	2	62.31	91.79

Source: Forestry Inventory Analysis, Forest Service, USDA

(a) Ownership type: 1 Public, 2 Forestry industry, 3 farmer, 4 Other private

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked

(c) Land ownership Class: 20 Timberland, 25 Reserve timberland

(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E. 5. Average removal cubic feet/acre of Pulpwood and Sawtimber by ownership type, stand size, land class and land right hand side in acres for Tricities region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Removal Pulpwood	Removal Sawtimber
				cubic feet/acre	cubic feet /acre
1	1	20	1	8.02	22.1
1	1	20	2	5.4	9.79
1	2	20	2	7.45	58.67
1	3	20	1	3.3	18.46
1	3	20	2	5.94	6.83
1	4	25	1	15.09	5.9
1	4	25	2	93.60	103.81
2	3	20	1	5.03	4.39
2	3	20	2	7.48	3.44
3	1	20	2	8.09	39.587
3	2	20	2	18.8	0
3	3	20	1	6.7	11.7
3	3	20	2	5.7	16.5
4	1	20	2	49.5	46.2
4	2	20	2	11.58	95.45
4	3	20	2	2.73	3.2

Source: Forestry Inventory Analysis, Forest Service, USDA

(a) Ownership type: 1 Public, 2 Forestry industry, 3 farmer, 4 Other private

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked

(c) Land ownership Class: 20 Timberland, 25 Reserve timberland

(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E.6. Average removals acres and cubic feet per $ million TIO of pulpwood and sawtimber by ownership type, stand size, land class, species group and land right hand side in acres for Memphis region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Removal Pulpwood	Removal Sawtimber	Removal Pulpwood	Removal Sawtimber
				Acres /$ million	Acres /$ million	Cu Ft/$ million	Cu Ft/$ million
1	1	20	2	0	33,841	0	333,333.2
1	2	20	2	558,234	57,571	1,551,891	333,333.2
1	3	20	2	2,544,084	55,096	1,551,891	333,333.2
2	1	20	1	1,285,682	10,521	1,915,666	312,695.3
2	1	20	2	193,986	7,130	1,551,891	333,333.2
2	2	20	1	16,098	0	1,915,666	0.0
2	2	20	2	342,581	30,950	1,551,891	333,333.2
2	3	20	1	144,252	12,609	1,915,666	312,695.3
2	3	20	2	24,340	3,590	1,551,891	333,333.2
3	1	20	1	143,174	3,175	1,915,666	312,695.3
3	1	20	2	61,534	3,186	1,551,891	333,333.2
3	2	20	1	426,652	10,252	1,915,666	312,695.3
3	2	20	2	63,602	3,160	1,551,891	333,333.2
3	3	20	1	55,127	10,775	1,915,666	312,695.3
3	3	20	2	72,654	4,623	1,551,891	333,333.2
4	1	20	1	255,422	4,582	1,915,666	312,695.3
4	1	20	2	58,342	4,783	1,551,891	333,333.2
4	2	20	1	55,382	2,532	1,915,666	312,695.3
4	2	20	2	76,373	6,727	1,551,891	333,333.2
4	3	20	1	22,641	3,863	1,915,666	312,695.3
4	3	20	2	81,550	2,753	1,551,891	333,333.2

Source: Forestry Inventory Analysis, Forest Service, USDA

(a) Ownership type: 1 Public, 2 Forestry industry, 3 farmer, 4 Other private
(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E. 7. Average removals acres and cubic feet per $ million of TIO of Pulpwood and Sawtimber by ownership type, stand size, land class, species group and land right hand side in acres for Chattanooga region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Removal Pulpwood	Removal Sawtimber	Removal Pulpwood	Removal Sawtimber
				Acres /$ million	Acres /$ million	Cu Ft/$ million	Cu Ft/$ million
1	1	20	1	35,934	12,364	1,915,665.8	312,695.3
1	1	20	2	500,610	1,672	1,551,891.4	333,333.2
1	2	20	1	70,898	15,643	1,915,665.8	312,695.3
1	2	20	2	106,586	15,896	1,551,891.4	333,333.2
1	3	20	1	84,168	16,295	1,915,665.8	312,695.3
1	3	20	2	170,725	3,291	1,551,891.4	333,333.2
1	4	25	1	52,846	5,336	1,915,665.8	312,695.3
1	4	25	2	20,870	8,922	1,551,891.4	333,333.2
2	1	20	2	86,795	19,654	1,551,891.4	333,333.2
2	2	20	2	223,294	7,612	1,551,891.4	333,333.2
2	3	20	1	41,366	6,550	1,915,665.8	312,695.3
2	3	20	2	31,769	14,835	1,551,891.4	333,333.2
3	1	20	2	91,288	108,578	1,551,891.4	333,333.2
3	2	20	2	21,842	8,719	1,551,891.4	333,333.2
3	3	20	1	389,363	3,979	1,915,665.8	312,695.3
3	3	20	2	276,137	17,007	1,551,891.4	333,333.2
4	1	20	1	127,287	19,955	1,915,665.8	312,695.3
4	1	20	2	115,899	4,737	1,551,891.4	333,333.2
4	2	20	1	18,304	3,054	1,915,665.8	312,695.3
4	2	20	1	35,429	4,473	1,915,665.8	312,695.3
4	3	20	1	20,539	2,950	1,915,665.8	312,695.3
4	3	20	2	34,357	12,382	1,551,891.4	333,333.2

Source: Forestry Inventory Analysis, Forest Service, USDA

(a) Ownership type: 1 Public, 2 Forestry industry, 3 farmer, 4 Other private

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked

(c) Land ownership Class: 20 Timberland, 25 Reserve timberland

(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E.8 Average removals per acres and cubic feet per $ million of TIO of Pulpwood and Sawtimber by ownership type, stand size, land class and land right hand side in acres for Knoxville region.

Ownership Type (a)	Stand Size (a)	Land Class (c)	Type of Wood (d)	Removal Pulpwood	Removal Sawtimber	Removal Pulpwood	Removal Sawtimber
				Acres /$ million	Acres /$ million	Cu Ft/$ million	Cu Ft/$ million
1	1	20	1	66424	15761	1915666	312695
1	1	20	2	58320	8170	1551891	333333
1	2	20	1	407588	21085	1915666	312695
1	2	20	2	576911	17637	1551891	333333
1	3	20	1	3683973	29923	1915666	312695
1	3	20	2	76902	15131	1551891	333333
1	4	25	2	98847	24510	1551891	333333
2	1	20	2	244392	14782	1551891	333333
2	2	20	1	175427	0	1915666	0
2	2	20	2	1315162	45725	1551891	333333
2	3	20	1	363504	67977	1915666	312695
2	3	20	2	217352	101626	1551891	333333
3	1	20	2	209999	7029	1551891	333333
3	2	20	1	836535	24956	1915666	312695
3	2	20	2	2282193	20538	1551891	333333
3	3	20	1	56360	4211	1915666	312695
3	3	20	2	65370	4630	1551891	333333
4	1	20	1	401607	12248	1915666	312695
4	1	20	2	57055	5518	1551891	333333
4	2	20	1	90149	5119	1915666	312695
4	2	20	2	159660	23491	1551891	333333
4	3	20	1	51112	3102	1915666	312695
4	3	20	2	52112	4061	1551891	333333
4	4	25	2	293363	11412	1551891	333333

Source: Forestry Inventory Analysis, Forest Service, USDA

(a) Ownership type: 1 Public, 2 Forestry industry, 3 farmer, 4 Other private (b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked

(c) Land ownership Class: 20 Timberland, 25 Reserve timberland

(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E. 9. Average removal acres and cubic feet per $ Million TIO of Pulpwood and Sawtimber by ownership type, stand size, land class, species group and land right hand side in acres for Nashville region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Removal Pulpwood	Removal Sawtimber	Removal Pulpwood	Removal Sawtimber
				Acres /$ million	Acres /$ million	Cu Ft/$ million	Cu Ft/$ million
1	1	20	2	88226	5645	1,551,891.4	333,333.2
1	2	20	2	85175	8786	1,551,891.4	333,333.2
1	3	20	2	253163	5504	1,551,891.4	333,333.2
2	1	20	1	377100	4426	1,915,665.8	312,695.3
2	1	20	2	77750	8257	1,551,891.4	333,333.2
2	2	20	1	22182	2487	1,915,665.8	312,695.3
2	2	20	2	63162	5195	1,551,891.4	333,333.2
2	3	20	1	60853	10536	1,915,665.8	312,695.3
2	3	20	2	13303	3272	1,551,891.4	333,333.2
2	4	20	1	31938	4860	1,915,665.8	312,695.3
2	4	20	2	51851	7524	1,551,891.4	333,333.2
3	1	20	1	137225	3058	1,915,665.8	312,695.3
3	1	20	2	89036	5615	1,551,891.4	333,333.2
3	2	20	1	174628	62917	1,915,665.8	312,695.3
3	2	20	2	85598	5943	1,551,891.4	333,333.2
3	3	20	1	221977	22099	1,915,665.8	312,695.3
3	3	20	2	32004	3023	1,551,891.4	333,333.2
4	1	20	1	119580	19495	1,915,665.8	312,695.3
4	1	20	2	75007	3709	1,551,891.4	333,333.2
4	2	20	1	421953	30447	1,915,665.8	312,695.3
4	2	20	2	63472	19470	1,551,891.4	333,333.2
4	3	20	1	228873	25136	1,915,665.8	312,695.3
4	3	20	2	24906	3631	1,551,891.4	333,333.2

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E. 10. Average removal acres and cubic feet per $ Million TIO of Pulpwood and Sawtimber by ownership type, stand size, land class and land right hand side in acres for Tricities region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Species Group (d)	Removal Pulpwood	Removal Sawtimber	Removal Pulpwood	Removal Sawtimber
				Acres /$ million	Acres /$ million	Cu Ft/$ million	Cu Ft/$ million
1	1	20	1	238,861	14,143	1,915,665.8	312,570.4
1	1	20	2	287,387	34,035	1,551,891.4	333,200.0
1	2	20	2	208,308	5,679	1,551,891.4	333,200.0
1	3	20	1	580,505	16,932	1,915,665.8	312,570.4
1	3	20	2	261,261	48,785	1,551,891.4	333,200.0
1	4	25	1	126,949	52,978	1,915,665.8	312,570.4
1	4	25	2	20,467	3,208	1,915,665.8	333,200.0
2	3	20	1	308,527	71,201	1,551,891.4	312,570.4
2	3	20	2	207,472	96,860	1,551,891.4	333,200.0
3	1	20	2	191,828	8,417	1,551,891.4	333,200.0
3	2	20	2	82,547	0.00	1,551,891.4	0.0
3	3	20	1	285,920	26,715	1,915,665.8	312,570.4
3	3	20	2	272,262	20,194	1,551,891.4	333,200.0
4	1	20	2	31,351	7,212	1,551,891.4	333,200.0
4	2	20	2	134,015	3,491	1,551,891.4	333,200.0
4	3	20	2	568,458	104,125	1,551,891.4	333,200.0

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E.11. Land RHS by ownership type, stand size, land class, species group in acres for Memphis region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Land RHS
				Acres
1	1	20	2	164,406
1	2	20	2	52,564
1	3	20	2	6,116
2	1	20	1	21,283
2	1	20	2	60,574
2	2	20	1	28,429
2	2	20	2	28,429
2	3	20	1	25,786
2	3	20	2	32,075
3	1	20	1	41,357
3	1	20	2	460,548
3	2	20	1	40,585
3	2	20	2	177,844
3	3	20	1	39,172
3	3	20	2	76,525
4	1	20	1	37,245
4	1	20	2	583,350
4	2	20	1	41,507
4	2	20	2	373,563
4	3	20	1	111,490
4	3	20	2	82,405

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E. 12. Land RHS by ownership type, stand size, land class, species group for Chattanooga region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Land RHS
				Acres
1	1	20	1	110,171
1	1	20	2	93,849
1	2	20	1	59,959
1	2	20	2	23,433
1	3	20	1	33,199
1	3	20	2	33,199
1	4	25	1	16,504
1	4	25	2	16,504
2	1	20	2	68,198
2	2	20	2	86,338
2	3	20	1	23,561
2	3	20	2	23,561
3	1	20	2	130,675
3	2	20	2	72,208
3	3	20	1	20,487
3	3	20	2	20,487
4	1	20	1	147,223
4	1	20	2	327,690
4	2	20	1	137,555
4	2	20	1	109,401
4	3	20	1	106,554
4	3	20	2	89,823

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E.13 Land RHS by ownership type, stand size, land class in acres for Knoxville region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Land RHS
				acres
1	1	20	1	54,286
1	1	20	2	101,709
1	2	20	1	48,087
1	2	20	2	34,818
1	3	20	1	8,440
1	3	20	2	8,440
1	4	25	2	5,800
2	1	20	2	8,500
2	2	20	1	6,974
2	2	20	2	13,015
2	3	20	1	4,350
2	3	20	2	4,281
3	1	20	2	412,301
3	2	20	1	53,046
3	2	20	2	101,159
3	3	20	1	47,456
3	3	20	2	47,457
4	1	20	1	392,517
4	1	20	2	345,297
4	2	20	1	120,776
4	2	20	2	202,154
4	3	20	1	65,591
4	3	20	2	133,774
4	4	25	2	5,800

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E. 14. Land RHS by ownership type, stand size, land class, species group in acres for Nashville region.

Ownership Type (a)	Stand Size (b)	Land Class (c)	Type of Wood (d)	Land RHS
				Acres
1	1	20	2	190,040
1	2	20	2	147,347
1	3	20	2	53,745
2	1	20	1	23,488
2	1	20	2	190,041
2	2	20	1	48,726
2	2	20	2	250,208
2	3	20	1	72,783
2	3	20	2	84,381
2	4	20	1	2,860
2	4	20	2	2,860
3	1	20	1	69,085
3	1	20	2	724,986
3	2	20	1	53,651
3	2	20	2	683,324
3	3	20	1	95,221
3	3	20	2	247,303
4	1	20	1	185,946
4	1	20	2	1,049,576
4	2	20	1	179,244
4	2	20	2	941,031
4	3	20	1	131,428
4	3	20	2	503,185

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E. 15. Land RHS by ownership type, stand size, land class and in acres for Tricities region.

Ownership Type(a)	Stand Size(b)	Land Class(c)	Type of Wood(d)	Land RHS
				acres
1	1	20	1	76,584
1	1	20	2	92,059
1	2	20	2	104,341
1	3	20	1	7,607
1	3	20	2	4,487
1	4	25	1	14,154
1	4	25	2	14,154
2	3	20	1	3,017
2	3	20	2	2,703
3	1	20	2	123,818
3	2	20	2	82,975
3	3	20	1	19,303
3	3	20	2	14,043
4	1	20	2	234,192
4	2	20	2	94,841
4	3	20	2	52,482

(b) Stand size : 1 sawtimber, 2 poletimber, 3 seedling & sapling, 4 non-stocked
(c) Land ownership Class: 20 Timberland, 25 Reserve timberland
(d) Type of wood: 1 Hardwood 2 Softwood

Appendix E.16. County Timber production of Pulp and sawlogs of softwood And hardwood.

County name	Region	Pulp softwood	Pulp hardwood	Sawlogs softwood	Sawlogs hardwood
		Cords	Cords	MBF	MBF
Anderson	44	2,490	5,926	45	7,805
Bedford	71	0	0	18	1,242
Benton	73	6,916	18,464	152	262
Bledsoe	43	16,629	13,406	316	1,544
Blount	44	20,635	1,514	429	3,382
Bradley	43	18,991	7,002	497	119
Campbell	44	0	0	20	780
Cannon	71	0	1,362	257	1,360
Carroll	73	5,327	10,456	382	14,232
Carter	45	0	3,937	769	1,956
Cheatham	71	0	0	0	3,290
Chester	73	7,634	9,312	241	5,661
Claiborne	44	24	2,176	29	9,851
Clay	71	12	2,123	0	8,500
Cocke	44	6,029	13,684	670	1,240
Coffee	71	5	5,010	95	1,255
Crockett	73	26	0	0	0
Cumberland	71	19,526	10,859	2,295	8,955
Davidson	71	0	0	14	2
De Kalb	71	0	0	1	23
Decatur	73	888	5,303	834	8,616
Dickson	71	0	0	0	20,720
Dyer	73	0	0	0	3,500
Fayette	73	14	0	24	466
Fentress	71	6,040	52	1,713	3,119
Franklin	71	169	9,936	17	10,219
Gibson	73	30	441	1,237	376
Giles	71	9,832	8,124	0	13,271
Grainger	44	0	975	288	2,892
Greene	45	2,385	11,262	1,272	3,768
Grundy	71	10,975	22,969	1,157	6,077
Hamblen	44	0	126	83	7,059
Hamilton	43	37,454	6,806	10,770	822
Hancock	44	0	3,043	97	283
Hardeman	73	7,463	15,412	7,391	38,750

Appendix E 16. Continued.

County name	Region	Pulp softwood	Pulp hardwood	Sawlogs softwood	Sawlogs hardwood
		Cords	Cords	MBF	MBF
Hardin	73	26,476	25,234	5,243	13,232
Hawkins	45	0	5,332	523	6,619
Haywood	73	2	0	155	3,790
Henderson	73	2,405	2,924	141	6,133
Henry	73	3,799	17,725	7,250	31,750
Hickman	71	4,423	53,299	93	11,050
Houston	71	434	6,622	0	17,904
Humphreys	71	298	16,818	19	7,198
Jackson	71	0	0	155	1,393
Jefferson	44	0	0	155	20
Johnson	45	0	2,647	7,004	5,329
Knox	44	3,002	21	0	0
Lake	73	0	0	0	0
Lauderdale	73	0	0	0	6,500
Lawrence	71	9,512	14,717	218	14,302
Lewis	71	9,049	23,768	188	8,119
Lincoln	71	144	5,266	616	9,520
Loudon	44	693	538	44	479
Macon	71	48	289	0	49,050
Madison	73	219	1,375	0	15,950
Marion	43	10,081	22,892	630	2,684
Marshall	71	0	20	17	3,236
Maury	71	28	531	0	3,750
Mcminn	43	49,727	10,700	930	326
Mcnairy	73	36,988	39,762	2,708	15,909
Meigs	43	32,224	11,915	423	776
Monroe	43	39,498	10,385	12,691	7,846
Montgomery	71	2,961	971	0	25,450
Moore	71	0	114	0	100
Morgan	44	18,200	5,159	2,573	9,621
Obion	73	0	0	0	18,217
Overton	71	1,002	3,161	515	16,024
Perry	71	2,147	43,874	1,160	10,744
Pickett	71	0	1,644	3,000	12,000
Polk	43	18,044	5,556	2,087	231

Appendix E.16 Continued.

County name	Region	Pulp softwood	Pulp hardwood	Sawlogs softwood	Sawlogs hardwood
		Cords	Cords	MBF	MBF
Putnam	71	475	3,163	2,835	18,225
Rhea	43	36,068	6,385	220	328
Roane	44	42,897	8,067	214	6,581
Robertson	71	0	0	94	6,406
Rutherford	71	0	0	2,350	1,600
Scott	44	1,457	843	4,922	5,768
Sequatchie	43	29,590	10,349	123	150
Sevier	44	3,786	3,044	114	407
Shelby	73	913	0	0	801
Smith	71	0	109	803	4,537
Stewart	71	1,635	30,011	1,775	9,682
Sullivan	45	0	524	322	654
Sumner	71	0	0	0	5,004
Tipton	73	0	669	278	760
Trousdale	71	0	0	0	0
Unicoi	45	2,153	6,335	610	1,720
Union	44	0	0	92	155
Van Buren	71	16,502	9,698	55	2,633
Warren	71	0	9,060	391	17,924
Washington	45	0	805	527	4,643
Wayne	71	25,005	89,549	613	16,246
Weakley	73	11,375	22,739	0	3,320
White	71	1,358	10,973	2,320	26,754
Williamson	71	4,120	0	0	6,700
Wilson	71	0	0	8	30

Appendix E.17. F.O.B. Sawmill delivered prices of softwood and hardwood sawtimber and softwood and hardwood pulp by quarters.

quarter	Pulp Softwood	Pulp Hardwood	Sawtimber Softwood	Sawtimber Hardwood
	$/cord	$/cord	$ x MBF	$ x MBF
1 quater	48.65	44.83	187	198
2 quarter	49.15	45.49	290	315
3 quarter	51.11	49.85	312	273
4 quarter	49.27	43.16	344	301
Total	49.545	45.8325	283.25	271.75

VITA

VITA

Jorge A Huarachi was born in Lima Peru in June 22 of 1953. He attended "The Salesian " primary and secondary school until 1970. The following year he was admitted to the Agrarian National University La Molina (Lima, Peru) for pursuing the degree in Animal Science. He attended this school until 1975 and obtained the degree of Bachelor in Animal Science. In 1984, he was admitted to the school of business administration for graduates, ESAN (Lima, Peru) where he got his M.B.A with marketing concentration. In 1989, he was admitted to the English Language Institute, Knoxville (USA). He attended the University of Tennessee until 1992, where he earned the Masters Degree in Agricultural Economics. In 1994, Mr. Huarachi entered the doctoral program in Agricultural Economics with focus on production economics at the University of Tennessee in Knoxville. In addition, he worked on research projects. His Doctor of Philosophy (Ph.D.) degree was conferred in May 1999.