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EFFECTS OF RESOURCE CONSTRAINTS ON THE EXPANSION OF THE PALLET INDUSTRY IN LOWER MICHIGAN

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EFFECTS OF RESOURCE CONSTRAINTS ON THE EXPANSION OF THE PALLET INDUSTRY IN LOWER MICHIGAN

By

Alex O. Obiya

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
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DOCTOR OF PHILOSOPHY

Department of Forestry

1986

ABSTRACT

EFFECTS OF RESOURCE CONSTRAINTS ON THE EXPANSION
OF THE PALLET INDUSTRY IN LOWER MICHIGAN

By

Alex O. Obiya

The purpose of this study was to analyze the potential for expansion of pallet industry in Lower Michigan; i.e., spatial analysis of pallet plants vis-a-vis surplus wood areas and markets in the region. This allowed us to determine whether expansion of the pallet industry is likely to be profitable in the region, and if positive, what should be the potential locations for future pallet plants in the Lower Michigan area? This was accomplished in the content of resource constraint analysis and its impact on the locational aspects of the pallet industry in the region.

The analytical tool used to solve the problem was firm-location model (actually concerned with establishment location). The purpose of using this model is to ascertain and determine the appropriate "spaces" (routes) that offer the optimal locations for the next pallet plant(s), should industrial expansion take place in the region. If the pallet industry expands, then the results of locational analysis are linked with input-output multipliers to assess potential economic impacts of pallet plants. Hence for the purpose

of economic development strategy, one could quantify income and employment impacts that would accrue to the region from additions of pallet establishments.

However the main finding from analytical results is that the pallet industry in Lower Michigan has excess capacity; i.e., the production capacity of the current plants is not fully being utilized. Only when this excess capacity in the pallet industry is utilized, should an alternative of building new pallet plants in the region be considered. Hence any increased demand for pallet products could be met by increasing production within existing capacity. Though evidence suggests surplus timber in state forests, there is insufficient demand to justify further processing of timber for pallet manufacturing.

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CHAPTER I

INTRODUCTION

GENERAL PROBLEM

The State of Michigan is currently involved in an economic revitalization program in an attempt to diversity its economy and decrease its heavy economic dependence on the automobile industry. One resource base that has not been fully tapped is forest resources. Forest resources are currently under serious investigation with regards to their economic potential to increase job creation in the State. Planners and resource managers are involved in the examination of forest industry with particular reference to creating more employment and income in the state. Currently, the productivity of Michigan's forests has not been fully realized.

Michigan has the opportunity to increase its production in both primary and secondary wood-using industries, particularly in primary manufacturing (James, et al., 1982). Abundant timber resources, a terrain generally conducive to logging and a good road network result in delivered wood costs competitive with wood costs in other regions which have usually been favored for forest industrial development. Michigan also has an advantage in its central location with transportation access to large nearby markets, and a large internal market which consumes more primary timber products than are produced in-state.

In view of the above statements, a more relevant and definitive question to be posed is, "what role could the forest products industries play in attaining the State's economic objectives?". Currently the economic objectives being pursued by the State can be defined as follows:

a) Creation of higher levels of employment.

b) Income growth.

c) Diversification as an insurance against economic instability.

This study will focus only on the first two goals. Hence in this study the third goal will be overlooked although it is significant for economic development analysis.

The theme of this research was to accomplish two related purposes: First on a state-wide basis, identify physical productive capacities of timber in different locations or timbersheds and technological capacities of different plants in the industry. Second, on a location-specific basis analyze and quantify employment and income impacts that would accrue from addition of a wood products establishment.

Certainly the nature and context of this research cannot be probed without examining production modes involved in processing timber in the state. It is in this regard that the research would choose to focus on one industry: Pallet industry.

Whereas the theme of this study was not to research the processing capacities or technological quality of the pallet industry, the capacity factor especially provides the crucial link that enables the realization of the ultimate study objectives.

In an era of sophisticated technology and advantages from economies of scale, introduction of the latest technology plants in surplus wood areas for marketable products would seem appropriate, depending especially on two conditions; (a) if a sufficient product demand exists that can offset production costs, and (b) if the forest products industry has a positive comparative advantage with respect to the same industries in neighboring or competing states.

In an analytical context, three underlying questions to be answered by this research can be structured as follows:

(a) "Where are the surplus-wood areas and how are they spatially related to the current locations and technological capacities of respective plants in the industry?"

(b) "Is there potential for expansion of the pallet industry and where should the next establishment(s) be located in the region?"

(c) "As a result of introducing a new pallet establishment in the economic structure of selected area, how would employment and income be affected?"

It is within this background and scenario that this research effort bases its orientation and approach. Emphasis is on specific locations and one identifiable forest products industry, pallet manufacturing.

The increasing emphasis put on economic planning makes it desirable to develop concepts and techniques for the solution of regional problems/issues such as income growth, employment creation and environmental quality. This can provide scientific guidelines and an analytical framework for policy decisions. Research outcomes should enhance both the quality and access of information available to policy makers and interested parties.

The study results should be useful to the following clients:

i) Policy makers, planners and economists at state levels interested in resource development.

ii) Federal government professionals seeking information and knowledge in the areas of economic accounts, regional development, social welfare and environmental quality of respective regions.

iii) Urban planners and county officials who have to assess the economic impacts of these firms in their communities.

iv) Corporate managers in the wood products industry who seek to evaluate the feasibility of investment projects in the area: labor and wood supply are two key components of production costs in the industry.

STUDY OBJECTIVES

The aim of the research is to contribute knowledge and information about timber supply and economic development of the region. The context of this analysis is that of a feasibility study: assessing the sustainability of current pallet industry's operations and the potential for expansion. The research objective would be accomplished through use of two analytical tools: a FIRM-LOCATION model (actually concerned with establishment location) and INPUT-OUTPUT analysis.

Specific research goals are:

a) To define the region and offer a descriptive picture of the economy.

b) To conduct a spatial analysis of surplus-wood areas and determine technological capacities of existing pallet production plants. This is done in order to determine the potential site for the next plant location in the area. This is achieved through formulation and construction of a firm-location model.

c) To identify major constraints that impact pallet production and consumption.

d) To evaluate employment and income levels and values in response to changes in pallet demand. Input-output multipliers furnish estimates of indirect and induced impacts associated with entry of new pallet plants on the state economy.

e) To determine policy implications of the results. This is basically concerned with answering the question, "what policies ought to be followed given certain economic objectives?".

RESEARCH APPROACH

This research study pursues these five objectives:

(1) Resource Constraint Analysis

The key concepts and issues involved are illustrated in the flowcharts in Figures 1 and 2. This topic looks at:

a) physical capacities of timbersheds in the state.

b) technological capacities and locations of processing plants in the pallet industry.

c) resource, technical, economic and institutional constraints that affect supply and demand relationships in the pallet industry.

d) labor markets: man-power requirements.

(2) Model-building (FIRM-LOCATION model)

a) suitability, testing, and data availability and relevance to study objectives.

b) determination of potential plant locations.

(3) Measurements and Data Collection

Basic data should include:

a) endowments (timber resource base, land, terrain, topography, etc.).

b) technology (pallet plants, machinery, transportation, etc.).

c) regional economy (input-output multipliers, income, employment, prices, final demand, etc.).

d) demography (labor force and occupational profile).

The sources consist mostly of secondary data.

(4) Plant Site Analysis

This involves selection of an efficient site for plant location and derivation of employment and income levels that would accrue to the economy.

(5) General Evaluation

a) assessment and evaluation of results.

b) strategies for state economic development.

c) implications of the model for general use and certain modifications in the data or model which might be desirable.

PLAN OF THE STUDY

This chapter briefly illustrates the nature and context of the study problem. It provides background information which helps to define the problem statement and appropriate research methods. The subsequent chapters may be described briefly as follows:

Chapter 2 discusses the physical and socio-economic characteristics of the Lower Michigan area.

Chapter 3 analyzes the state of the pallet industry in Michigan. Nature of the industry and particular constraints that affect its status are analyzed.

Chapter 4 discusses the firm-location model in detail as to the model structure, suitability and design assumptions. A brief description of the input-output model also is given.

Chapter 5 is the most elaborate for it attempts to detail the necessary input or data requirements needed for the model.

Chapter 6 discusses study results. In addition, problems related to computer runs and their interpretations are examined.

Chapter 7 evaluates efficiency of the economic model and its application as related to resource constraint analysis of the pallet industry.

Chapter 8 concludes the study by summarizing results. Policy recommendations with respect to timber supply and pallet industry expansion are spelt out. In addition, this chapter briefly outlines alternative research techniques that could enhance analysis of the same or related problem(s).

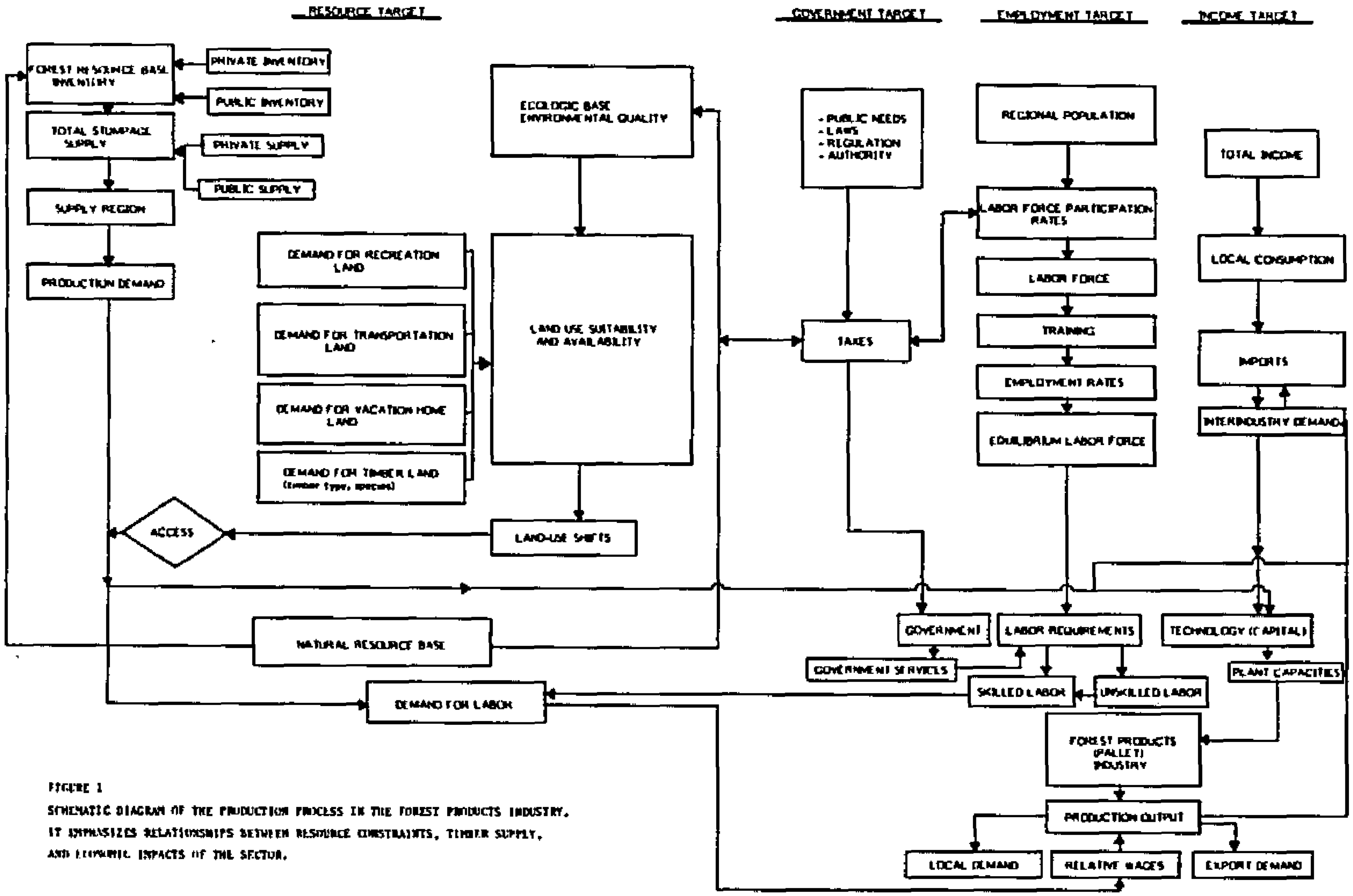


FIGURE 1

SCHEMATIC DIAGRAM OF THE PRODUCTION PROCESS IN THE FOREST PRODUCTS INDUSTRY.
IT EMPHASIZES RELATIONSHIPS BETWEEN RESOURCE CONSTRAINTS, TIMBER SUPPLY,
AND ECONOMIC IMPACTS OF THE SECTOR.

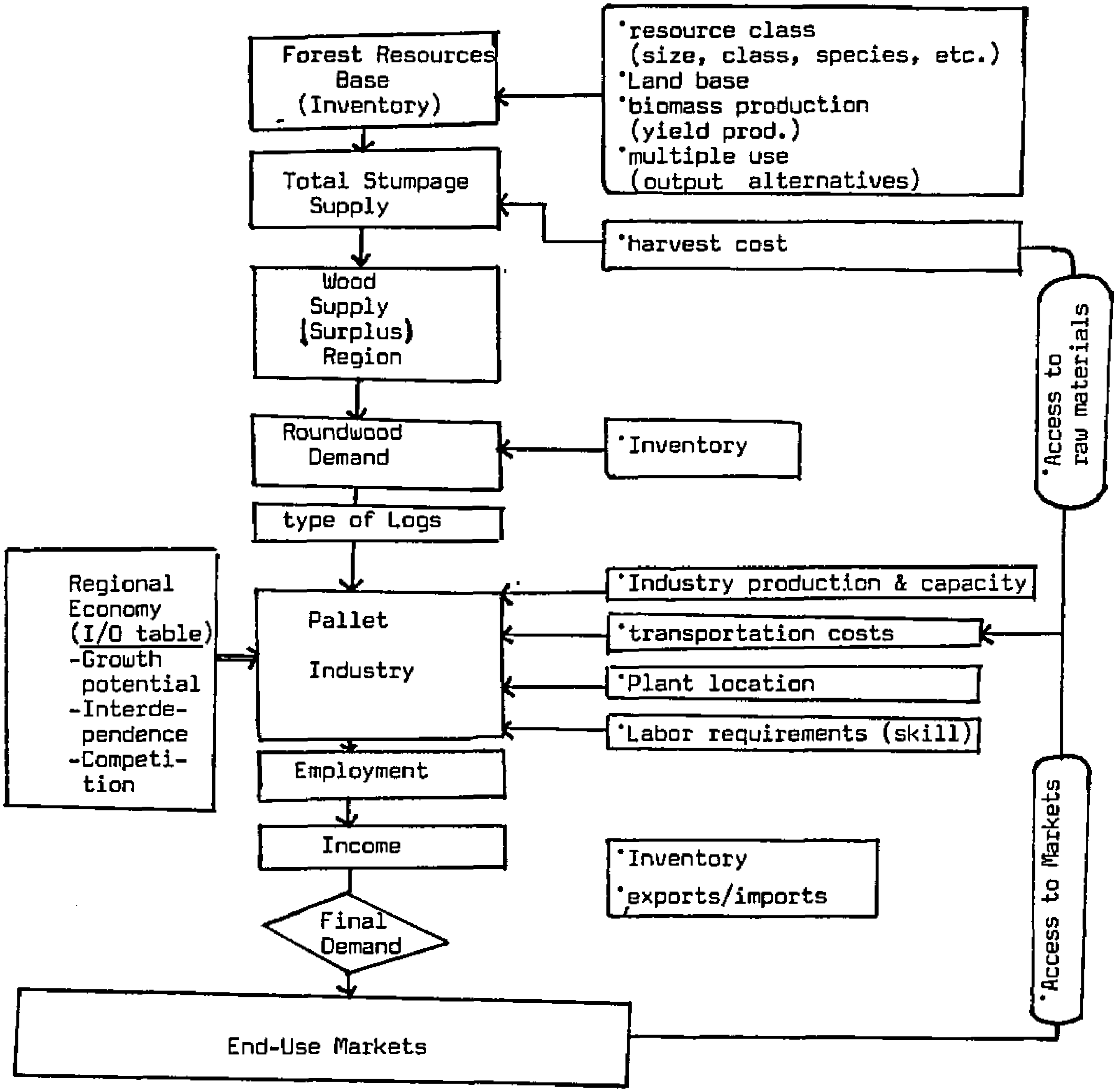


FIGURE 2 - FLOWCHART OF RESOURCE CONSTRAINTS MODEL FOR INDUSTRIAL PRODUCTION AND EXPANSION OF PALLET INDUSTRY

CHAPTER II

DESCRIPTION OF THE STUDY REGION

The region of study is the Lower Michigan region which covers both the Northern Lower Peninsula and Southern Lower Peninsula. Of the 83 counties in the entire state of Michigan, only fifteen counties are in the Upper Peninsula. The latter is a rural area with a natural resource based economy. Hence one can conclude that this study covers the portion of state that has the bulk of human and economic activities in the region (see Figure 3).

POPULATION

According to the 1980 Census of Population, 96.3% of population lived in the Lower Michigan area. Whereas only about 3.7% of the population lived in the Upper Peninsula (this is about 374,000 people). The entire state of Michigan had a population of 9.2 million inhabitants in 1980 (Bureau of Census, 1980). Table 1 shows population growth rates in the region between periods of 1960-1980.

In 1980, the Michigan population could be classified as 71% urban and 29% rural. This can be contrasted to U.S.

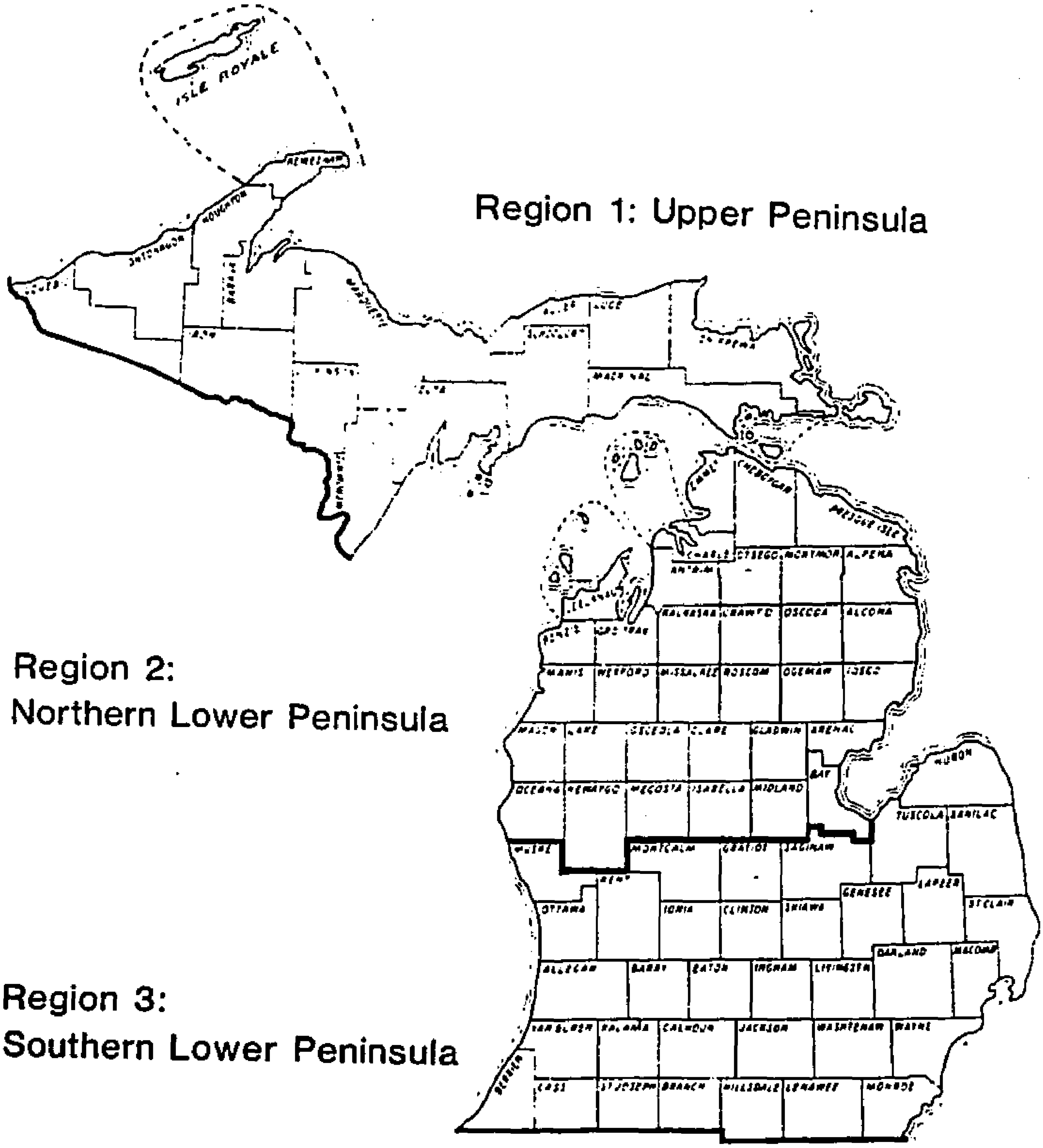


FIGURE 3. MAP OF COUNTIES IN THE STUDY REGION

TABLE 1

POPULATION FIGURES BETWEEN 1960-1980 AND PERCENTAGE CHANGE IN LOWER MICHIGAN

Year	Urban	Rural	Total	% Change
1960	5,739,132	2,084,062	7,823,194	
				13.45
1970	6,566,483	2,308,600	8,875,083	
				4.36
1980	6,551,551	2,710,527	9,262,078	

SOURCE: Bureau of Census, U.S. Census of Population: 1970. Number of Inhabitants, Michigan. (Washington, D.C.: 1982)

demographic trends where the population is approximately 75% urban and 25% rural. Between 1960 and 1970 there was 14% increase in population compared to 4% between 1970-1980. Also during periods between 1975-1980 there was a net out-migration of about a half million people. This figure always tends to be buried in population statistics. In simple terms, this means that more people moved out of the state to other parts of the country than moved in during the same time periods.

INCOME

The state of Michigan had a mean family income of $12,296 in 1969, but taking into account inflation that is equivalent to about $14,876 in 1976 dollars (U.S. Dept. of Commerce, 1976). Personal income is the current income of residents of an area from all sources. It is simply the sum of several hundred individually estimated component flows, both monetary and non-monetary, and it encompasses most forms of income flowing to persons including Federal, State and local governments, households, institutions, and foreign governments. In 1975 total personal income for the state was $57,142 million whereas per capita personal income in the same period was $6,240 (U.S. Dept. of Commerce, 1983). By 1983, total personal income for the state was $104,963 million and per capita personal income was $11,572. Table 2 shows work hours and earnings of a sample of production workers in Michigan.

TABLE 2

HOURS AND EARNINGS OF MANUFACTURING PRODUCTION WORKERS IN MICHIGAN BY INDUSTRY GROUP: 1983

Industry Group	Average		
	weekly hours	hourly earnings	weekly earnings
Durable goods	42.8	$ 12.10	$517.53
Lumber and wood prod.	41.8	7.30	304.93
Furniture & fixtures	40.8	9.14	372.67
Primary metal products	41.4	12.22	505.36
Fabricated metal prod.	42.3	11.38	481.47
Nonelectrical machinery	41.2	11.62	479.21
Electrical machinery	41.9	10.04	420.47
Transportation equip.	44.2	13.32	588.29
Motor vehicle & equip.	44.3	13.45	596.40
Nondurable goods	41.5	9.83	407.71
Food & kindred prod.	41.4	9.87	408.36
Textile mill prod. etc.	42.4	11.81	500.60
Paper & allied prod.	44.5	10.63	472.58
Printing & publishing	37.6	8.91	335.59
Chemicals & allied prod.	41.1	11.41	457.38
TOTAL	42.5	11.62	494.02

SOURCE: Bureau of Labor Statistics. 1984. Employment and Earnings. Washington, D.C. and Michigan Employment Security Commission.

When one looks at earnings from industrial sectors, four industrial sectors form the bulk of earnings in the state. These are manufacturing sectors (38.29%), services (31.45%), retail trade (17.09%) and state and local governments (12.18%). The auto industry accounts for the largest part of manufacturing output. Table 3 indicates the earnings and sectoral distribution. In the context of this study, the pallet industry and other wood products industries are included within the manufacturing sectors.

TABLE 3

LABOR AND PROPRIETORS' EARNINGS COMPONENT OF PERSONAL INCOME BY INDUSTRIAL SECTORS IN MICHIGAN: 1982

SECTOR	Earnings millions of dollars	percentage
Manufacturing	27,219	38.29
Nondurable goods	4,489	6.87
Durable goods	22,334	31.42
Services	12,145	17.09
Retail trade	6,292	8.85
Transportation $ public util.	4,290	6.04
Wholesale trade	3,915	5.51
Construction	2,659	3.74
Finance, insurance $ real estate	3,068	4.32
Farm	749	1.05
Mining	320	0.45
Agricultural services, forestry, & others	168	0.24
State & local govt.	8,660	12.18
Federal, civilian	1,337	1.88
Federal, military	262	0.37
TOTAL	71,082	100.00

SOURCE: Bureau of Economic Analysis. 1982. Regional Economics System. U.S. Department of Commerce, Washington, D.C.

EMPLOYMENT

Table 4 indicates that the greatest employment by economic activities is in the manufacturing sectors. It has been estimated that 835,980 persons were employed in Michigan's manufacturing establishments during 1983. The most important groups ranked by employment were transportation equipment, machinery except electrical, fabricated metal products and primary metal industries. These sectors account for 64% of the State's 1983 manufacturing employment. These have been the same industries dominating the economic landscape as far as jobs are concerned since 1972. The most important counties in the state ranked by employment are Wayne, Macomb and Oakland, all located in the southern portion of the state. These counties account for about 50% of employment in Michigan.

Three other significant sectors are wholesale and retail trade, services and transportation, communication and utilities. Table 5 further classifies distribution of industrial establishments by employment size. Approximately 66% of establishments employ 19 or fewer people. Hence most Michigan employers are small businesses. The pallet industry fits in this pattern - it is mostly composed of small establishments throughout the state. Nevertheless employment in wood-based manufacturing is estimated at 57,220. Some 78% of the total employment is in southern lower Michigan because of the concentration of secondary manufacturing in this region. Primary manufacturing employment is spread all over the state with about 59% of the total in Lower Michigan (James et al., 1982).

TABLE 4

EMPLOYMENT, PAYROLLS AND AVERAGE WEEKLY EARNINGS IN MICHIGAN BY INDUSTRIAL SECTORS: 1983

SECTORS	Average employment	Payrolls (000)	Average weekly pay
Agriculture, forestry & fisheries	13,367	$ 36,602	$210.06
Mining	8,313	56,954	527.02
Construction	73,281	414,029	434.61
Manufacturing	835,980	5,726,046	527.80
Transportation, comm. & utilities	126,868	794,072	481.46
Wholesale & retail trade	678,013	2,107,675	239.12
Services	589,144	2,285,131	298.36
Finance, insurance & real estate	145,804	648,448	342.11
TOTAL	2,470,770	12,068,957	376.06

SOURCE: Bureau of Research and Statistics. 1984. Michigan Employment Security Commission, special release.

TABLE 5

DISTRIBUTION OF ESTABLISHMENTS BY EMPLOYMENT SIZE IN MICHIGAN: 1977

Number of Persons Employed	All Establishments
MICHIGAN	15627
1 to 4	5413
5 to 9	2227
10 to 19	2607
20 to 49	2621
50 to 99	1261
100 to 249	886
250 to 499	320
500 to 999	142
1000 to 2499	72
2500 employees	78

SOURCE: Bureau of the Census. 1977. Census of Manufacturers. U.S. Department of Commerce.

MANUFACTURING

The total value added by manufacture for the state amounted to $37,566 million in 1977, an increase of approximately 61% from the 1972 figure of $23,376 million. These data are expressed in 1977 dollars. Table 6 summarizes important manufacturing statistics for the state.

The auto industry forms the largest portion of the manufacturing sector in the state. In 1983 about 2 million cars and 697,000 trucks and buses were produced in Michigan. These figures account for about 30% of total cars, trucks, and buses produced in the United States (see Table 6). Three key cities or metropolises in Michigan are the production centers for the auto industry; Detroit, Flint and Lansing. Total employment in the motor vehicle industry was 951,100 in Michigan in 1983. Table 7 further highlights the impact of automotive sector on employment in the related industries in the State.

Since the subject of this study is the pallet industry which is included under the wood products industry within the manufacturing sector, a brief outlook of wood-based manufacturing is necessary. The 1980 population of wood-using mills is estimated to be 1,637. This includes 984 mills in the lumber and wood products group, 350 in wood furniture, and 303 in paper and allied products (James et al., 1982). Since we are not dealing with primary processing here, this section concerns secondary manufacturing where inputs from

TABLE 6

MICHIGAN MANUFACTURING DATA: 1977, 1981 & 1983

Item/Year	Value
Number of establishments (1983)	177,279
Number of employees (1983)	2,470,770
Payroll (all employees) (1983) ($1000)	51,637,568
Value added by manufacture (1977) ($1000)	37,566,000
Cost of materials (1977) ($1000)	56,775,000
Value of shipments (1977) ($1000)	93,757,100
New capital expenditures (1977) ($1000)	3,739,200
Value of export shipments (1981) ($1000)	10,275,000
Production of motor vehicles (1983)	
cars	2,077,000
trucks and buses	697,000
Percentage of U.S. auto-production (1983)	
cars	30%
Trucks and buses	29%

SOURCE: Bureau of the Census. Reports-1977, 1981 & 1983. Census of Manufactures. U.S. Department of Commerce.

TABLE 7

MOTOR-VEHICLE RELATED EMPLOYMENT BY MAJOR MANUFACTURING INDUSTRIES IN MICHIGAN: SEPTEMBER, 1983

Industry (SIC code)	Number of Employees
Manufacturing	
Durable goods	438,000
Lumber and wood	0
Furniture and fixtures	700
Metals	75,900
Primary metals	22,900
Fabricated metals	53,000
Nonelectrical machinery	31,200
Electrical machinery	6,600
Motor vehicles and equipment	319,500
Assembly	202,900
Parts and accessories	116,600
Other transportation equipment	0
Other durable goods	4,000
Nondurable goods	37,600
Food and kindred	0
Textile mill products and apparel	15,000
Paper and allied	0
Printing and publishing	0
Chemicals, petroleum and related	2,500
Other nondurables goods	20,100

SOURCE: Bureau of Research and Statistics. 1984. Michigan Employment Security Commission, special release.

the former stage are processed further. This is the dominant stage that accounts for 76% of all wood-using mills in the state and is mainly concentrated in the southern lower Michigan. Value added by manufacture in Michigan's wood-processing industries was $1,972 million for 1980. This can be divided into $403 million in lumber and wood products, $404 million in wood furniture and fixtures and $1,165 million in paper and allied products. If other forward and backward economic linkages are tied to the wood products industry the value added to the economy is in excess of $4 billion (James et al., 1982).

LAND USE

Agriculture

Certainly one of the major land-uses in rural Michigan is agriculture. Table 8 shows that since 1940 total land areas in farms decreased from 18 million acres in 1940 to about 11½ million acres in 1982. This is a reflection too of a national trend where there has been a tremendous shift of populations from rural to urban settings.

Ironically, the average size of farms has increased over the years while the total number of farms and total land area has been decreasing. Corn, soybeans, drybeans and alfalfa form the bulk of production yields. Of all the crops, corn gives the greatest total yields as shown in

TABLE 8

NUMBER OF FARMS AND FARM ACREAGE IN MICHIGAN
1940-1982

Year	Number of farms	Average size of farm (acres)	Total land in farms (000 acres)
1940	190,000	97	18,400
1960	118,000	131	15,400
1970	84,000	151	12,700
1980	66,000	173	11,400
1982	65,000	177	11,500

SOURCE: Michigan Agricultural Reporting Service, Michigan Agricultural statistics.

Table 9. In 1981 net farm income for the state was 486 million while net income per farm was $7,361. Cash receipts from livestock and livestock products netted $1,319 million in 1982.

Mining

There is a substantial amount of mining done in Michigan though not as much as in some parts of the country. The state ranks tenth largest amongst all other states. In 1983 the mining sector employed 9,991 people in 512 establishments. Petroleum refining represented 41.9% of value of output in mining in 1982 (Michigan Department of Natural Resources,

TABLE 9

SUMMARY OF SELECTED AGRICULTURAL INFORMATION

Year	Title	Number/Value
1982	Number of workers on farms	
	family	58,000
	hired	45,000
1981	Total ($000,000)	
	gross income	3,321
	production expense	2,893
	net farm income	483
1982	Selected major field crops (yields-bushels)	
	corn	307,380,000
	soybeans	32,240,000
	oats	28,350,000
	wheat	24,600,000
1982	Yields per acre of the crops (bushels/acre)	
	corn	109.0
	soybeans	19.2
	oats	63.0
	wheat	63.0

SOURCE: Michigan Department of Agriculture, Michigan Agricultural Statistics, and Bureau of Economic Analysis, Regional Economics Information.

1982). In the entire state 152,000 barrels of oil per day were produced. Of these, one refinery in Detroit and another in Alma account for 72% of daily amount of crude refined in the state - both produce 111,000 barrels daily. Table 10 shows value of Michigan mineral production of various types.

TABLE 10

VALUE OF MICHIGAN MINERAL PRODUCTION
BY PRODUCT: 1982

Mineral	($000)
Iron ore	333,000
Cement	155,400
Petroleum	1,036,277
Sand & gravel	72,400
Nat. salines	195,063
Copper	35,926
Salt	86,901
Stone	70,910
Lime	32,599
Nat. gas	460,594
Gypsum	6,913
Clay & shale	4,005
Peat	5,144
TOTAL	2,249,132

SOURCE: Michigan Department of Natural Resources. 1982. Michigan Mineral Producers, Lansing, MI.

Forestry

The State of Michigan is well endowed with forest resources, ranking fifth in the nation with 17.5 million acres of commercial forest land. The State owns 22% of the total with this ownership concentrated in the northern portion of the State. Historically, Michigan's forests have been heavily used and by 1935 were reduced to 19.1 million acres of relatively low quality stands from an original area of 35.5 million acres. Restoration began in 1920's and the current situation is one of surplus for major species. The economic situation in the state in recent years has lead to renewed interest in developing the forest resource to broaden the industrial base and provide employment for Michigan residents.

For the purpose of this study, I shall look only at the forest resources in the Lower Michigan area. This includes the Southern Lower Peninsula (SLP) where there is a majority of the state's population and agricultural land. Pressure put on land by increasing populations, urbanization and agriculture have gradually eroded the forest base and left large portions of remaining timber in small woodlots of diverse ownership (Gray, Ellefson and Lothner, 1985). Hence the demand for land has led to higher stumpage prices in the Southern Lower Peninsula than elsewhere in the state. The other portion of state considered in this analysis is the Northern Lower Peninsula (NLP). While certainly more heavily forested and less densely populated than the SLP, it has experienced increasing pressure for recreational land uses which has driven up land values and property taxes, fractionalized ownership and subsequently increased stumpage prices in the region. Despite these conditions, however, 41% of industrial roundwood output comes from the NLP compared to 50% from the Upper Peninsula. When fuelwood use is considered the relative shares become 40% and 37% respectively. Table 11 indicates commercial forest land in the Lower Michigan region by ownership class. Commercial forests in Northern Lower Michigan cover 6.7 million acres and Southern Lower Michigan has 2.8 million acres.

Although until the latter part of the nineteenth century, Michigan forests were predominantly softwood, the current timber inventory is dominated by hardwood species, which account for about 72% of the total volume. Of the hardwoods, maple species dominate followed by aspen species and red oak. Among softwoods, northern white cedar species dominate (though not commercially useful) followed by balsam fir and pine species. Table 12 shows that timer volume is concentrated in the NLP although SLP has substantial volume of hardwood timber.

SUMMARY

Hence Lower Michigan is the more industrialized and populous portion of the state in comparison to the Upper

TABLE 11

COMMERCIAL FOREST LAND IN LOWER MICHIGAN
REGION AND OWNERSHIP CLASS: 1980

Ownership	Northern Lower Michigan		Southern Lower Michigan	
	(thousand of acres)			
National forest	859	(13%)	13	(<1%)
State	1,825	(27%)	149	(6%)
Other public	53	(<1%)	60	(2%)
Forest industry	76	(1%)	n.a.	
Corporation	474	(7%)	141	(6%)
Farm	1,275	(19%)	1,151	(47%)
Other private	2,133	(32%)	949	(39%)
TOTAL (all ownership)	6,695		2,463	

SOURCE: Raile, G. K. and W. B. Smith. 1983. Michigan Forest Statistics. USDA For. Serv. North Central For. Exp. Sta. Res. Bull. NC-67.

TABLE 12

NET TIMBER VOLUME ON COMMERCIAL FOREST LAND
BY SPECIES GROUP AND REGION: 1980

Species group	Northern Lower Michigan	Southern Lower Michigan
Growing stock	(million cu. ft.)	
softwood	1,707	172
hardwood	5,118	2,287
TOTAL	6,825	2,459
	(million bd. ft.)	
Sawtimber		
softwood	3,839	519
hardwood	11,245	7,427
TOTAL	15,082	7,946

SOURCE: Raile, G. K. and W. B. Smith. 1983. Michigan Forest Statistics. USDA For. Serv. North Central For. Exp. Sta. Res. Bull. NC-67.

Peninsula. Largest amounts of jobs by economic activities are in the manufacturing sectors, with the automobile industry leading all other sectors. With respect to wood products sectors, the number of wood-using mills is estimated to be around 1,637. About 60% of these mills belong under the category of lumber and wood products firms which includes the pallet industry. Regarding land-use, Michigan is well endowed with forest resources. It ranks fifth in the nation with 17.5 million acres of commercial forest land. The Northern Lower Peninsula is more heavily forested and less densely populated than the urbanized Southern Lower Peninsula.

CHAPTER III

MICHIGAN PALLET INDUSTRY

TIMBER RESOURCE BASE FOR EXPANSION OF THE PALLET INDUSTRY

Forest land in Michigan covers an area of about 18 million acres or approximately 50% of the total land area. The state's volume of growing stock on commercial forest land increased from 15.1 to 19.1 billion cubic feet between 1966 and 1980, a 26.49% increase (Spencer, 1983). The volume of softwood increased 34% compared to 24% of hardwoods. During this period the largest volume of growing stock occurred in the Northern Lower Peninsula with 6.8 billion cubic feet followed by Southern Lower Peninsula with 2.5 billion cubic feet (see Table 13).

Increases in growing stock have added substantially to the state's sawtimber volume which increased 118% for softwoods and 94% for hardwoods since 1955. Sawtimber is defined as the portion of growing stock which contain at least one 12-foot sawlog or two 8-foot sawlogs. Softwoods must be at least 9" d.b.h. while hardwoods must be at least 11". The increase in sawlog volumes implies a shift in the size class of growing stock in Michigan commercial forest although in 1980 poletimber accounted for 44% of the total stand size classes.

TABLE 13

NET VOLUME OF GROWING STOCK ON COMMERCIAL FOREST LAND BY SPECIES GROUP AND AREA, MICHIGAN: 1980
(In thousand cubic feet)

Species group	All units	Northern Lower Peninsula	Southern Lower Peninsula
SOFTWOODS			
White pines		176,763	66,928
Red pine		452.495	48.798
Jack pine		335,918	13,278
White spruce		38,705	1,718
Black spruce		35,972	---
Balsam fir		115,899	185
Hemlock		64,960	6,810
Tamarack		26,795	4,010
Northern white cedar		431,116	3,929
Other soft woods		28,428	25,939
TOTAL		1,707,051	171,595
HARDWOODS			
Select white oaks		251,160	309,312
Select red oaks		721,458	337,986
Other red oaks		180,189	110,632
Hickory		1,838	103,632
Yellow birch		37,604	7,627
Hard maple		692,984	114,660
Soft maple		748,355	398,435
Beech		121,689	47,446
Ash		251,892	227,908
Balsam poplar		98,083	10,053
Cottonwood		10,261	59,906
Bigtooth aspen		653,639	78,743
Quaking aspen		630,943	76,160
Basswood		325,173	83,569
Yellow-poplar		---	19,425
Black walnut		200	26,573
Black cherry		94,087	116,348
Butternut		278	3,384
Elm		30,117	58,800
Paper birch		256,960	20,122
Other hardwoods		10,705	76,828
TOTAL		5,117,615	2,287,549
All species		6,824,666	2,459,144

SOURCE: Spencer, John S. 1983. Michigan's Fourth Forest Inventory: Timber Volumes and Projections of Timber Supply. U.S.D.A. Forest Service Res. Bull. NC-72.

Currently in Michigan the increase in growing stock is 2.4 times the volume of annual timber removals. For Nothern Lower Peninsula it is 2.5 times while in Southern Lower Peninsula it is 2.4 times as indicated by Table 14. This means that timber harvest can be more than doubled without jeopardizing the long term sustained yield capacity of the state's timber resource.

Hence as Table 14 indicates, for major species there is a substantial gap between net annual growth and removals which implies existence of a large surplus of usable wood. These figures must be interpreted with care, however, as it is not the existence but the availability, location and concentration of timber that will be important in development plans for the pallet industry or other forest products industry. Because of varying management objectives for public and private forests and the realities of harvesting and transportation of timber, the entire resource is not available for timber utilization.

Ownership of commercial forest land in Michigan varies considerably by area with the Upper Peninsula (UP) and Northern Lower Peninsula (NLP) having more public land than the Southern Lower Peninsula (SLP) where more private land prevails. Land ownership patterns tend to influence the size of ownership, productivity and use of timber resources. Ownership of forest land in the UP is dominated by the forest industry, the state and national forest land. The NLP area contains more state land that the UP but substantially less forest

TABLE 14

NET ANNUAL GROWTH AND REMOVALS OF GROWING STOCK ON COMMERCIAL FOREST LAND BY SPECIES GROUP AND AREA, NORTHERN (NLP) AND SOUTHERN (SLP) LOWER MICHIGAN: 1980
(In thousand cubic feet)

	NLP	SLP	NLP	SLP
Species group	Net annual growth/		Annual timber removal	
SOFTWOODS				
White pine	7,359	2,766	872	125
Red pine	32,209	3,181	3,105	1,326
Jack pine	14,588	586	7,999	74
White spruce	2,483	507	87	10
Black spruce	1,081	---	88	---
Balsam fir	1,591	6	842	---
Hemlock	1,360	104	185	26
Tamarack	-1,568	39	438	104
Northern white cedar	14,711	247	1,633	83
Other softwoods	2,584	1,256	---	221
TOTAL	76,398	8,692	15,249	1,969
HARDWOODS				
Select white oaks	5,645	6,892	3,006	5,938
Select red oaks	21,281	9,190	11,720	7,311
Other red oaks	4,565	3,823	3,541	2,532
Hickory	50	2,821	15	632
Yellow birch	799	186	40	14
Hard maple	23,690	3,162	5,310	3,233
Soft maple	42,752	18,397	8,839	5,879
Beech	1,378	605	1,539	756
Ash	13,059	11,900	2,090	2,664
Balsam poplar	1,226	245	784	9
Cotton wood	322	2,157	454	837
Bigtooth aspen	28,441	3,638	25,206	883
Quaking aspen	20,759	4,906	20,023	614
Basswood	9,876	2,892	1,980	1,179
Yellow poplar	---	400	---	---
Black walnut	3	793	---	205
Black cherry	5,876	6,856	---	---
Butternut	7	92	---	---
Elm	-2,502	-3,351	1,731	626
Paper birch	9,155	713	2,579	110
Other hardwoods	267	2,795	418	1,881
TOTAL	186,649	79,112	89,275	35,303
All species	263,047	87,804	104,524	37,272

APPARENT SURPLUS (NLP + SLP) -- [GROWTH - REMOVALS] = 209,055

SOURCE: Spencer, John S. 1983. Michigan's Fourth Forest Inventory: Timber Volumes and Projections of Timber Supply. U.S.D.A. Forest Service.

industry land and more farmer and individual land. The SLP area is dominated by farmer owned and private land (refer to Table 11).

Because of the heavy use of the state's forests and fire damage of the early 1920's many of Michigan's forests are in stands from 41 to 60 years of age. Half the stands in the state are 50 years or younger. Of the major species the maple-birch type, a long lived species, contains 23% in stands over 90 years of age, the suggested rotation age. Aspen, a shorter lived species, which deteriorates at about 40-60 years, contains about 18% of stands exceeding 60 years of age. Of the softwoods a substantial area are in older stands which are more susceptible to disease, insects and fire. These factors and others result in a high mortality rate of 20% amongst timber species in the state.

In conclusion, while analysis of the timber resource base in the study region suggests that there is a substantial surplus of many species suitable for utilization by the pallet industry, the actual availability of this timber is what will be important to industrial development. Management practices of landowners and ownership objectives of these parties will affect how much of the state's timber resource is available for different uses, including pallet manufacture, now and in the future. Inventory and silvicultural condition of the forest resource base in the state are summarized in Table 15.

TABLE 15

REMOVALS, NET ANNUAL GROWTH AND INVENTORY OF GROWING STOCK ON COMMERCIAL FOREST LAND, MICHIGAN: 1980

(in millions cubic feet)

	Removals			Growth			Inventory		
	All spec.	Soft-woods	Hard-woods	All spec.	Soft-woods	Hard-woods	All spec.	Soft-woods	Hard-woods
NLP	104.5	15.2	89.3	263.0	76.4	186.6	6,824.6	1,707.0	5,117.6
SLP	37.2	1.9	35.3	87.5	8.4	79.1	2,459.4	171.6	2,287.8
REGION	141.7	17.1	124.6	350.5	84.8	265.7	9,284.0	1,878.6	7,405.4

SOURCE: Spencer, John S. 1983. Micrth inventory: Timber volumes and projections of timber supply. U.S.D.A., Forest Service, Res. Bull. NC-60.

NATURE OF THE PALLET INDUSTRY

The pallet industry is one of the newest among the secondary wood processing industries. An extensive pallet industry has become established as a result of the rapidly expanding use of mechanical handling equipment. Unitized loads of industrial and agricultural products are handled by a variety of mechanical handling equipment such as lift trucks, racks, conveyors, slings, and booms (Forest Products Laboratory, 1971). Pallets provide one of the foundations upon which to assemble these loads.

A PALLET - AN INDUSTRIAL COMMODITY

A pallet is an industrial good destined for use in producing other goods and services. The wooden pallet is essentially a packaging device, a generic name for platforms usually made of wood and primarily used as a base for unit loads of material. According to National Wooden Pallet and Container Association, wooden pallets fall into three major categories, as follows:

i) Permanent, reusable pallets, which provide the lowest cost per use. They can be employed by captive use by one company or in cooperative pallet sharing pools. About 60% of wooden pallets comprise of this type.

ii) Expendible shipping pallets, used on a single trip to carry a unit load from a manufacturing plant to a delivery point. About 30% of wooden pallets are expendible type.

iii) Special purpose pallets, including lightweight re-usable pallets for handling bulky materials of low density, drum or keg pallets and pallets that permit entry of forks over and under the deckboards. This type of pallets accounts for about 10% of pallets.

Some of the advantages of using pallets are: a) they form an efficient package that is compatible with land, sea, and air carriers, b) they move easily over conveyors and into automatic palletizers, c) their unique nature makes them suitable for rapid movement by a variety of mechanical equipment such as conventional forklifts, hand pallet jacks, overhead cranes and slings, and d) their production from low grade lumber make them economically feasible.

Ninety percent of all pallets sold are wooden stick built units. The remaining 10% of the market is comprised of plastic, aluminium, steel, foam, corrugated medium and molded wood. The most common pallet sizes are 48" x 40", 42" x 42" and 48" x 48" because of their easy use across railroad freight cars and the average truck body. Table 16 shows that 43.8% of pallets sold in the market place includes a variety of sizes, each representing under 1% of total productions. This accounts for the fact that there are literally thousands of pallet size classifications and designs.

TABLE 16

THE TEN MOST COMMON PALLET SIZES USED IN U.S.: 1981

Sizes	% of total production
48" x 40"	28.5
42" x 42"	5.4
40" x 48"	4.8
48" x 48"	4.2
48" x 42"	3.2
40" x 40"	2.9
36" x 48"	2.4
36" x 36"	2.2
48" x 36"	1.3
44" x 44"	1.3
All others	43.8
TOTAL	100.0

SOURCE: National Wooden Pallet and Container Association. 1981.

PALLET MANUFACTURE IN MICHIGAN

In all of Michigan in 1980, there were 198 pallet plants. Of these only 15 firms operate in the Upper Peninsula, the remaining 185 firms are in the Lower Michigan area, the focus of the study region (Heinen et al., 1983). Hence the production locations follow trends similar to most industries in the state as indicated in earlier sections. In 1982 the total value of shipments for the state was $71.8 million, as shown in Table 17. Approximately 40% of value of shipments is a result of value added by manufacture.

In terms of number of establishments, Michigan with 198 ranks second nationwide to Ohio (218 establishments).

TABLE 17

STATISTICS OF WOOD PALLETS AND SKIDS SECTOR FOR MICHIGAN: 1982

Title	Value/number
All employees	
number (1000's)	1.3
annual payroll (millions)	14.2
Production workers	
number (1000's)	1.1
hours (millions)	1.9
wages (millions)	10.4
Value added by manufacture (millions $)	28.9
Costs of materials (millions $)	41.8
Value of Shipments (millions $)	71.8
New capital expenditure (millions)	1.5

SOURCE: U.S. Department of Commerce. 182. Bureau of the Census: Census of Manufacturing.

Michigan is followed by Pennsylvania with 185 establishments. Evidently one can observe that all those states are traditionally heavy industrial states that manufacture heavy machinery, agricultural equipment, automobiles, steel and so forth (Bureau of the Census, 1982). According to the 1983 (second quarter) Bureau of Labor Statistics, total employment in the pallet industry (SIC 2448) in Michigan was 1446 with total wages of $3.83 million. Table 18 indicates number of establishments by employment-size classes. As can be seen, 82% of firms employed 19 or fewer employees in 1982.

TABLE 18

NUMBER OF ESTABLISHMENTS BY EMPLOYMENT-SIZE CLASS

Average number of employees	# of establishment
1 to 4	40
5 - 9	25
10 - 19	21
20 - 49	18
50 - 99	0
100 - 249	1

SOURCE: U.S. Department of Commerce. 1982. Bureau of the Census: Census of Manufacturing.

VERTICAL INTEGRATION MODEL OF A PALLET FIRM

Standard Pallet Manufacturing Process and Technology of a Pallet Firm

The purpose of drawing a pallet firm's technological and organizational structure is to realize how resources, machines, materials, and human capital are mobilized for economical production. The diagram of a plant's structure traces how a unit of pallet product starts out as a tree species in a forest ecosystem and is eventually transformed through use of capital and labor into the ultimate product that a consumer buys in the market. In short, this is a vertical integration model of a typical firm used in this research topic. According to the Forest Products Laboratory (1971), such a pallet plant would have a maximum capacity not exceeding 500 units per 8-hour day. As an estimate this requires a lumber supply of between 10,000 to 15,000 board feet per day. The employment size for the firm might be 16-18 people. Occupational profile and skills can be divided as follows:

1 Supervisor and Repairman

4 Operators for cutup and lumber breakdown operation

3 Cutup and residue off bearers

6-8 Nailers

1 Nailing off-bearer

1 Lift truck operator

Raw material that is fed into the production process is in the form of logs, cut-to-size lumber or roundwood that is further reduced to size by sawmill or planer.

The flow process diagram permits visualization of the movement of material on a floor plan. It indicates the production process materials go through to manufacture pallets from logs. All the equipment in the operation are connected by a system of conveyors which makes for an efficient operation.

Unskilled or semi-skilled labor can be used to operate the assembly. There is ample space around each machine to allow for operation of equipment, convenience of workers, installation of handling devices, maintenance, and repair needs. Also storage areas are provided where finished products can be stored for two reasons: (a) emergency needs in case of a plant breakdown, and (b) inventory for temporary surpluses. In the plant a certain degree of flexibility is shown in the flow diagram: some deckboards are chamfered and then directed to the assembly to be used as bottom leading edge deckboards or stringers that can be diverted to the notching operation for construction of pallets.

Pallet assembly techniques have vastly improved in recent years. Nailing technology has advanced from the original hand nailing method of assembly in the 1950s to present pneumatic guns, nailers and stapling machines. This equipment is conducive for short production runs, special pallet designs, pallet repairs and salvage operations.

Plant layout takes into account plans for future expansions or means of increasing production to take advantage of increased sales and market growth. Provision is also given to the manufacture of other items that make use of all or most of the same raw materials and machinery. Such related products as car blocking and bracing, dunnage, furniture squares, cut stock, box, and crate material can also be manufactured. At a Lansing pallet firm the author toured, the plant produced box and crate materials in addition to manufacture of pallets.

One of the by-products in pallet manufacture is the residue. A typical pallet manufacturing plant that processes 15,000 board feet of rough lumber daily will generate 18 to 24 tons of residue (Eichler, 1976). In disposing of residue, efforts should be made to locate or develop uses to promote maximum whole tree utilization. Pallet plants located in areas where dairy farms are located can usually dispose of green sawdust and shavings to farmers as animal bedding. Also systems are in operation that use this residue as fuel, especially those manufacturers that operate their own dry kilns and need to stay on a year-around basis. The economies of scale concept enters into consideration as only plants that require large amounts of steam will find this method economically sound. Sometimes efficient wood residue utilization results in increased profit revenue for a wooden pallet manufacturer. However rules and regulations regarding environmental pollution and solid waste disposal impacts utilization level of residue and hence economic feasibility of its use.

Some of the terms defining different equipment and production processes are too obvious to illustrate separately. However some of the technical terms unique to the pallet manufacturing process are defined below in the diagrams. Also, principal parts of a wooden pallet are included in the definitions. Figure 4 shows the flow process chart involved in the manufacture of pallets. Figure 5 illustrates the key features of a wooden pallet as a product (National Wooden Pallet and Container Association, 1982).

DECKBOARDS - These are structural members that make up the faces of a pallet. There are referred to as top and bottom deckboards. The top deck is the surface that carries the load. The bottom deck is the surface that helps distribute the load when the pallet is at rest.

CHAMFERER - This is a machine that produces chamfer. This is a beveled edge on the top side of bottom deckboards for purpose of easing entry and exit of forks and pallet truck load wheels. Chamfers are also required on the underside of top deckboards or reversible pallets.

CUTOFF - This is a remote control trim and cutoff saw designed to cut rough lumber cants to exact length.

RIPSAW - This is a single or double roughing planer used for sizing cants to proper thickness.

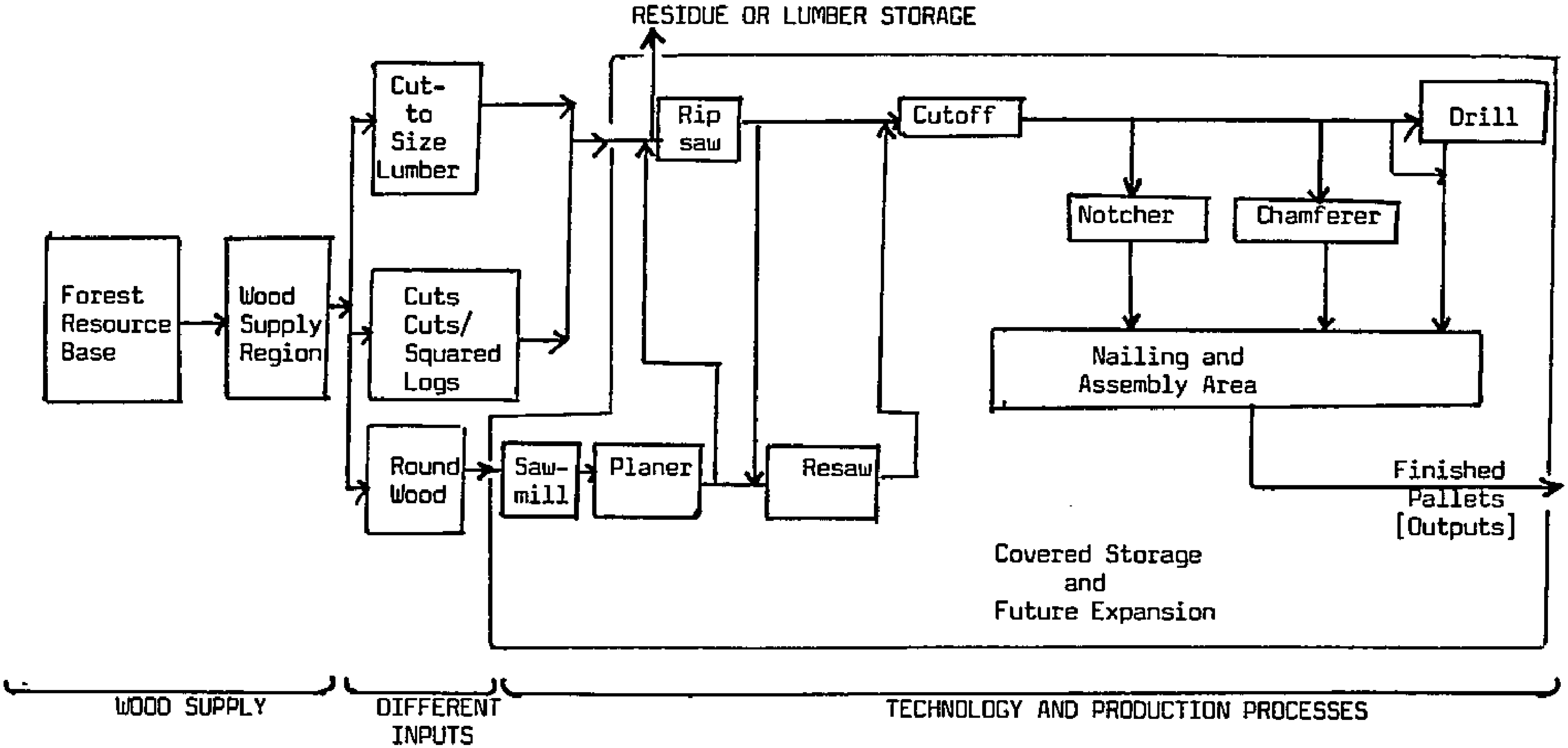


FIGURE 4 - MANUFACTURING PROCESS OF A PALLET FIRM

SOURCE: Adapted from U.S. Forest Product Laboratory, 1971. Pallet Plank Layout, p. 98.

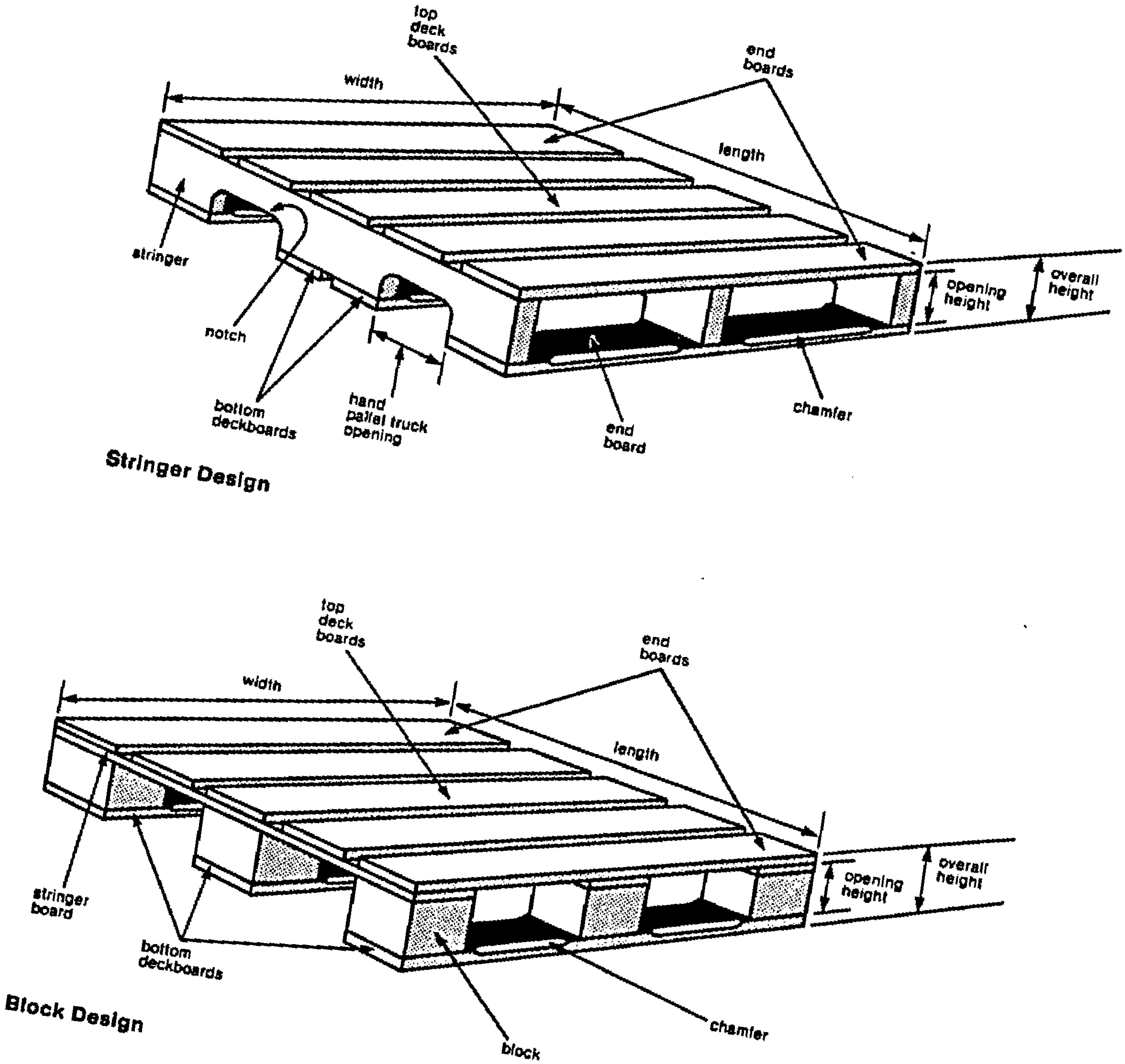


FIGURE 5. PRINCIPAL PARTS OF WOODEN PALLETS.
Source: Adapted from National Wooden Pallet and Container Association. 1982.

RESAW - This is a single or preferably double arbor multiple gang machine that is commonly used to process cants into pallet parts.

PLANER - If a pallet manufacturer is involved in logging or buying stumpage the planer reduces small logs into cants for processing in a circular gang resaw or band resaw.

NAILING - Next to the material used, fasteners or nails (gun or hand nails) constitute the most important element of wooden pallet construction. The acceptable number of nails at each joint or bearing points varies with the width of the deck-boards.

STRINGERS - These are wood runners-structural members to which deckboards are fastened.

NOTCHER - This is a machine that produces notched stringers. A notched stringer is a stringer that has openings cut out for insertion and withdrawal of pallet lifting equipment.

CONSTRAINTS THAT AFFECT PALLET PRODUCTION AND CONSUMPTION

Timber Species

Though normally pallet parts originate from the lower grades of either hardwood or softwood species, significance of timber species cannot be underestimated. Wooden pallets are made from hardwoods, softwoods (or both), and plywood. Each source offers certain advantages. Strength and quality of a particular timber species is closely related to its density and weight. The moisture content of wood that goes into pallets is significant. Many pallets are built from green or partially green lumber because of lower cost. Moisture content also varies with the type of tree species. Usually dense hardwoods are used at high moisture contents to facilitate nailing. On the other hand, the lower density hardwoods and moist softwoods are easily nailed regardless of moisture content. The average weight of some commercial species at 20 percent moisture content are listed in Table 19. The table represents the moisture condition that might be reached by lumber in stickered outdoor piles after drying from 3 months to a year (Forest Products Laboratory, 1971). This table also typifies most species of wood used in the production of pallets. The softest textured softwoods fall into Class A, the intermediate species in Class B and the densest hardwoods in Class C.

The lumber in any pallet should not contain any defects that might weaken the part or hinder proper fastening or nailing (i.e., there should be no knots in nailing areas), in the middle portions of the deckboards (where the greatest bending stresses are imposed), and in certain portions of stringers or blocks. Nevertheless, not all lumber imperfections affect the structural strength of pallet parts, and therefore are acceptable within limitations. These include season checks, pinworm holes, mineral streaks, wanes (barky edges), and stains (Sardos, 1982).

TABLE 19

CLASSES AND WEIGHTS OF WOOD GROUPS USED IN PALLET CONSTRUCTION

Species	Weight (lb.) per 1,000 board feet at 20% moisture content	Species	Weight (lb.) per 1,000 board feet at 20% moisture content
	CLASS A		
Aspen (popple)	2,250	Fir, white	2,370
Basswood	2,060	Hemlock, eastern	2,470
Buckeye	2,180	Pine (except southern)	2,470
Cedar	2,250	Redwood	3,110
Cottonwood	2,370	Spruce	2,370
Fir, subalpine	2,000	Willow	2,180
Fir, balsam	2,180		
Fir, noble	2,370		
	CLASS B		
Ash (except white)	3,100	Magnolia	3,000
Baldcypress	2,720	Maple, soft	2,870
Butternut	2,310	Pine, southern	3,290
Douglas-fir	2,940	Sycamore	3,000
Elm, soft	3,000	Tamarack	3,170
Gum, sweet	3,000	Tupelo	3,000
Hemlock, western	2,720	Yellow-poplar	2,590
Larch, western	3,120		
	CLASS C		
Ash, white	3,620	Hickory	4,240
Beech	3,680	Maple, hard	3,680
Birch, yellow	3,620	Oak	3,680
Elm, rock	3,750	Pecan	3,960
Hackberry	3,180		

SOURCE: U.S. Forest Products Laboratory. 1971.

Competition

As emphasized earlier, ninety percent of all pallets are wood pallets. The remaining ten percent are metalic, plastic, corrugated medium, molded wood pallets, and combination of materials (Wallin, 1985). Hence this indicates existence of elements of substitutability and complimentarity of the products to satisfy a given demand in the market. Amongst the major competition to the wooden pallet is the pallet made from molded wood.

In the molded wood market the Inca pallet dominates. This is a pallet molded from wood fiber particleboard. The process has been used in Europe since the early 1970's and pallets are now produced by this process at the Litco plant in Dover, Ohio. It is the only plant of its kind in the United States. In comparison to wooden pallets, advantages of Inca pallets are: a) it is 60% lighter than a comparable wood pallet, b) it is reusable, c) it is stackable in storage and transportation, and d) it is an identifiable specialized product which facilitates effective marketing strategy (heterogeneity). For the pallet industry in Michigan, the Inca pallet offers further competition due to its strategic plant location in Ohio. The location is ideal for serving the Eastern and Midwestern industrial centres and drawing on plentiful wood supplies of the surrounding region, especially Michigan, which is well endowed with surplus timber. The Inca pallet market can stretch to a 500-mile radius and still be cost competitive in contrast to the narrow distance of wood pallets (100-150 miles).

Also another innovation is the PALLETECH technology developed by the Institute of Wood Research at Michigan Technological University (MTU). This is a patented process for the manufacture of industrial grade, molded wood, materials handling pallets. According to Nies (1985), the resultant pallet would offer: a) superior strength characteristics, b) marketable qualities of uniformity, c) nestability, d) reusability, 3) design flexibility, and f) neat appearance. In addition it can be designed and manufactured to accommodate almost all material handling situations. Although the PALLETECH concept would offer competition to the Inca molded pallet, they nevertheless provide revolutionary change in materials handling approach and would cut into the traditional wooden pallet market. They threaten to offer the customer greater price stability and quality consistency in comparison to the traditional wood pallets.

Demand

A pallet is an industrial commodity in that it is a good that derives its demand from the demands for final consumer goods. During boom times in the business cycle buyers often buy pallets to accommodate inventory buildup as well as actual consumer demand. On the other hand during recession or slow economic growth periods, pallet buying is low due to factors such as inventory reductions, activated use of reusable pallets and high costs of warehousing and transportation (Brindley, 1982). In essence pallet demand fluctuates more than typical consumer demand, which is a common characteristic of industrial goods. In economic theory one can postulate that the overall industry-wide demand for pallets is inelastic. But at the same time, in regional or local markets such as cities in Michigan, pallet manufacturers would find that their demand curves are elastic. This means that a significant increase in pallet prices would result in large decrease in demand at a particular site. Schuller and Wallin (1983) conducted several studies using economic models to analyze U.S. pallet markets. With respect to our current analysis it is irrelevant to get into the mechanics of their models but it suffices to highlight several key findings with respect to the pallet demand functions. They found that the key variables that affect pallet demand nationwide (and could be applied to Michigan in general terms) were pallet price, the industrial and food production index and the relative price of pallets to wage rates for laborers in materials handling. Since our study region is heavily dependent on the automotive and food industries, one can assume that production output (now and future) of these sectors form some of the key predictors for pallet demand and use according to findings from previous studies.

Role of Price in the Pallet Industry

The significance of price for a pallet depends upon the buyer's understanding of the nature of the product. A pallet, which is mostly a homogenous product tends to be very competitive. Because of low differentiation between manufacturers, the pallet buyer has little loyalty to specific pallet producers. Buyers see a homogenous product as being generic. With relative abundance of surplus timber and heavy industrial activity in the state, there is bound to be stiff competition between firms to survive and operate profitably. Dominance by any one firm in any market is determined by its economic advantage of location, resources and production efficiency. The one crucial issue that affects all pallet business operators is the wood price. Pallet selling price is the single most important market factor in the pallet industry. Price based on intended use and the result of competitive bidding is the criteria for most pallet purchases. The last section emphasized how sensitive pallet prices are to the economic health of the economy.

According to Nies (1985), current delivered unit pallet prices fall into three ranges:

I) $2.50 to $4.50

For a firm this market is characterized by order of 10 to 500 units mostly of expendible sizes from 28" x 28" to 36" x 40". Small pallet firms tend to dominate this portion of market and face fierce price competition.

II) $5.00 to $7.00

This is typified by orders of 1000 to 60,000 units, considerably fewer sizes. This market has a significant number of large producers, face stiff competition and undetermined mixture of expendible and reusable pallets. Part of the reason prices may be higher is because they are reusable.

III) $7.00 to $12.00

This market is comprised of federal agencies buying for the U.S. Government and private industry ordering special use pallets. In Michigan two agencies that would be major consumers of pallets are the Defense agency and Federal Prison System.

PALLET MARKET STRUCTURE

Unique to the pallet industry is that buyers rather than sellers dictate nature of product and terms of trade in the market place. They control the market in terms of price and delivery schedules. Buyers rather than sellers differentiate products. This condition results in the proliferation of different pallet types and sizes found in the market place. Relative to the economic size of the seller firm, the pallet buyer or customer is usually very large and diversified. Hence the purchaser establishes the type of product required for their business venture.

Since pallets are low value products, manufacturers tend to locate 100 to 150 miles of industrialized centers. In Michigan some of these centers are Detroit, Flint, Lansing, Grand Rapids, and Kalamazoo. Since quoted pallet prices include shipping and handling costs, manufacturers close to the market are at a competitive advantage when seeking new business. As distance diminishes from the customer and producer increases, the advantage too diminishes. This further supports the effort in this study to cover only the Lower Michigan regions which includes the metropolis and industrial centers. For the most part, the major consumers of pallets such as the auto industry, food industry and government are located in the southern portion of the state.

COMPARATIVE ADVANTAGE

No discussion of the Michigan pallet industry would be complete without some reference to the State's comparative advantage. Looking at the number and sizes of pallet plants in the state, it is apparent that it is a highly volatile and competitive industry. The firms' economic growth rates should reflect the ability of the pallet industry in the state to compete effectively with other states in the Midwest for raw materials and market share. The relatively simplistic nature of a pallet makes it fairly easy for an operator to enter the industry on a small scale (easy entry and exit). Other inducements are; relatively simple production technology minimal startup capital, cheap unskilled labor, and low grade raw materials.

The competitive nature (and hence its comparative advantage) of the industry makes it imperative that a pallet manufacturer keep abreast of technological changes, raw material supplies and market locations. Incidentally Michigan happens to have abundance of each of these resources due to economies of scale (concentrated industrial centers), surplus timber resources and large markets such as Detroit, Flint, Lansing and Kalamazoo.

In summary, this means that the pallet industry in the state would offer industrial customers greater price stability. Pallet price is the one key variable that determines the competitive edge for the state's pallet industry. This price should not only reflect the consequences of cost dynamics involving intra-firm competition between wood pallets and other pallet forms but also inter-industry competition with other wood products sectors in the state. The latter is a result of inter-industry competition for timber supplies. As an example of competition, industries such as pulp and paper and wood furniture might compete successfully against the pallet industry. Some of their advantages might be generally lower transportation rates and ability to outbid small competitors such as pallet firms for stumpage values with still enough profit margin left to operate efficiently. Nevertheless, it still appears that with manipulation of forest resources and ample technological advances in the state, resource owners and business operators could exert greater influence on pallet costs, hence pallet prices to the advantage of pallet industry.

CHAPTER IV

MODEL DEVELOPMENT

GOAL OF THE FIRM-LOCATION MODEL

The essential goal of this model is to assess spatial distribution of existing firms and wood supply regions in order to determine potential site(s) for locating the next plant(s) in the region. The computer model that is used in this study is a modification of Hoover's Industrial Location Model Number 6*.

RESEARCH CONTEXT

Since the objective of the study is to assess the sustainability of current pallet industry's operation need and for expansion, this model attempts to tell where there is room for the expansion of pallet industry and at which production point it should be established. The solution should indicate which "space" or "distributional channel" is available for an additional plant and where it should be established given supply and demand factors. Pallets are not only low-value

*Hoover, Edgar M. 1967. Some programmed models of industry location. Land Econ. 43(3): 303-311.

products but their economic life-cycle or duration of their utility to consumers is short-lived. Hence the product is not only sensitive to market conditions, but more significantly, to variability in production costs. Apart from labor costs, major components of costs involve transportation costs of materials between supply sources and market locations. This explains the emphasis on transportation costs in the location model.

MATHEMATICAL FORMULATION OF A FIRM-LOCATION MODEL

Since we are dealing with a natural resource product which involves both physical and biological variables, Hoover's model is modified to encompass these elements. Hence firm-location model emphasizes spatial and temporal interrelationships between economic activities. Also note three assumptions: a) a standard unit of analysis (of the product) is a pallet unit which is equivalent to 19 board feet per pallet; b) stumpage supply or raw material is measured in board feet; c) costs or prices are in 1984 dollars ($) terms.

Notation

The following notation will be used in the mathematical structure for the location model:

y = timber yield projection by years--where (y=1980, 1985, 1995, . . ., Y)

t = production time periods----where (t = 10, 20, 30, . . . , T)

k = supply region----where (k = 1, 2, 3, . . . , K)

l = production location----where (l = 1, 2, 3, . . . , L)

m = market areas op loci----where (m = 1, 2, 3, . . . M)

i = timber type or raw material----where (i = 1, 0, 3, . . . I)

j = product good manufactured----where (j =

V = raw material/product ratio in tons

MC = marginal cost of pallet production

MR = marginal revenue of a pallet unit

RE = volume of forest resource base in board feet

FD_j = final demand of product j in standardized pallet units (19 bd.ft./pallet)

X_j = wood pallet j sold or consumed in pallet units

Y_{jl} = inventory of product j at plant location l

TC_{jm} = total transfer costs in delivering product j to market m

T_{ikt} = assembly cost--access to raw materials from supply region k to plant location in time period t

A_{ikt} = cost of raw materials i including harvest cost at supply region k in time period t

P_{lt} = production cost (capital + labor costs including normal profits) at plant location l in time period t

T_{lmt} = distribution cost--access to market places from production location l to market m in time period t

MF_{jl} = manufacturing cost of product j at plant location l

E_{ikt} = total stumpage supply of i at each supply region k in time period t in board feet

F_{jlt} = total output j at each production points l in time period t in pallet units

D_{jm} = demand price of the product j at a market m

W_l = capacity of each plant or firm at location l in tons

CW_l = capacity constraint cost (initial limit) in tons at location l

$C'W_l$ = maximum costs beyond initial capacity limit at location l

The purpose of using this model is to ascertain and determine the appropriate "space" that offers the optimal location for the next plant in the region. In order to arrive at an answer, the solution procedure will have to process the following mathematical operations. In each instance the underlying assumptions are described because these are significant if one is to understand the rationale behind the model, as well as the limitations of the results of this study.

PRODUCTION EQUILIBRIUM

The formula set below assumes that the final demand levels can be satisfied from the production levels and the inventory stock:

$$\sum_{L} F_{jl} \quad + \quad \sum_{L} Y_{jl} \quad \geq \quad FD \qquad (1)$$

Further to guarantee this result, an inventory is assumed to be kept for two purposes: (a) to mitigate unforseen shortages, and (b) for storage for temporary or slack demand. Minimal imports into Michigan are assumed. In other words, supply is equated to demand under ideal conditions. Given the nature of pallet industry in Michigan with its numerous firms and varying scales of business operations (establishments with less than 10 employees to those with hundreds of employees), the industry displays characteristics of pure competition between firms to survive. Also this model deals with one homogenous product, the wood pallet. In this respect the model considers competitive relationships between firms in the same industry. Other criteria for perfect competition also apply but to a lesser extent. Hence the firms tend to be competitive in an effort to maximize returns to their investments. Their profit maximization condition would be given by:

$$MR \quad = \quad MC \qquad (1a)$$

A firm will produce units of output up to the point at which the increment to the revenue provided by the last unit sold (MR) is precisely equal to the cost of producing it. Similar results apply for the hiring of inputs or for any other decision that firms must make.

FOREST RESOURCE BASE

Assumption of the formula below is that the volume of raw materials (inputs) available in any supply region is affected by the physical attributes of the forest resource base and other social constraints such as multiple use legislation.

$$E_{ikt} \leq RE \qquad (2)$$

Given these constraints only certain specified timbersheds have surplus wood that serve as sources for roundwood or raw materials.

TRANSFER COSTS

Transfer costs involves the shipment costs from raw material supply areas to production plants, then ultimately to the markets. Distances between raw materials areas, production locations and markets are measured via highways, assuming shortest routes between towns. The formula below indicates this situation:

$$\sum_{k} T_{ikt} + \sum_{m} T_{lmt} = TC \qquad (3)$$

Hence transport costs would reflect rates charged by respective modes utilized. Since firms are assumed to maximize profits and materials and products are completely standardized;

each production location gets its materials from sources that can supply them cheapest and each market is supplied by the production center that can deliver the product at lowest cost.

MANUFACTURING COSTS

The equation below sums costs of raw materials and production processes.

$$V * Z_{ikt} + P_{1t} = MF \tag{4}$$

The material/product ratio represents the amount of input that goes into making one unit of output. Manufacturing costs of the product include both captial and labor costs. Supplies of raw materials as well as products depend on their total costs. Major costs involved in producing and delivering a unit of the product to a consumer, apart from transportation costs, are harvest costs, stumpage prices of various species, capital costs, and labor costs. Variable costs such as labor, transportation, and raw material costs are important in the long run (say 10 to 40 years) from the business point of view because they help guide business decisions such as investments, rate of return, etc. on a day to day basis. Supply functions are affected by such factors as pallet price, hardwood lumber prices (only hardwood used in pallet manufacture), housing starts and pallet manufacturing labor costs.

PALLET PRICE

For each space the total costs are compared with the product demand price at the specific market place. The formula below equates production costs to demand price of a unit output:

$$TC_{jm} \quad + \quad MF_{jl} \quad = \quad D_{jm} \qquad (5)$$

The price of pallets is a reflection of the demand function of the product in both the regional and national economies. Its demand amongst other variables is affected by pallet price, industrial and food production indexes, substitutes, and so forth. The state of the automotive economy (such as sales of automobiles in Michigan and the nature of the business cycle in the national economy (e.g. rapid aggregate economic growth) affects demand for pallets. Pallets are used mostly as a packaging device for material/product handling and shipping. Also, the average production costs which includes labor costs have to be less than the product price so as to leave enough margin for at least normal profit. Normal profit is assured by maintaining positive price-cost differential, the margin not falling below zero at any given time.

PLANT CAPACITY AND CONSTRAINT COSTS

Plant capacity imposes a constraint on the volume of output or product processed. Hence only a certain limit of volume can be produced at any given period. The formula below assumes that a production plant cannot produce any desired output without being limited by capacity constraint:

$$X_j \leq W_1 \quad \text{(tons)} \qquad (6)$$

The capacity constraint could also be translated into economic costs of production by equating capacity constraint output to equivalent production costs. Hence the capacity constraint limit could also appear as cost constraint limit:

$$X_j \leq CW_1 \quad \text{(cost in dollars)} \qquad (6a)$$

However the above formula (6 or 6a) can still be modified to guarantee that the initial capacity constraint is not absolute. Capacity at a production location can be expanded but only at a cost. The costs of expansion (investment) are assumed to be uniform per unit of added output beyond the initial capacity (6 or 6a). Hence for each production point, there is a two-step cost function; one level of costs prevails up to the inital capacity limit and higher cost thereafter.

$$X_j \geq CW_1 \leq C'W_1 \qquad (6b)$$

To simplify the problem and guard against excessive data needs, an assumption is made in this model, that either formula (6a) or (6b) shall yield the same results when the initial capacity is considered non-expansible by setting costs for any output beyond that limit at a prohibitive level when entering data inputs.

DESCRIPTION OF THE COMPUTER PROGRAM

Though location model is the basis of this computer program, it has its variations and modifications from the Location model (see comparisons in the next section). This model has its inputs as timber or lumber and its outputs being pallets. It starts out by introducing into the system total stumpage supplies of available timber for pallet production in lower Michigan. These supplies are then allocated to the selected wood supply regions. From there, timber is shipped to plant locations for processing into pallets. Finally pallets are shipped to the markets for consumption. Hence, technically one can say that if there are (k) supply regions, (l) production locations, and (m) market places in all, there would be (klm) different "spaces" (locations) which can be followed (from wood supply areas to plant locations to market areas) in producing and marketing a unit of output (pallet). The program starts by examining all these spaces in turn and for each one computes and compares the results according to economic criteria. The two established economic criteria ensure that the "spaces" or locations chosen by the model are suitable for either expansion of pallet firm or introduction of a new pallet firm. These criteria are:

First, from each space the total costs of manufacturing and delivering a unit of pallet are compared with demand price in market (m) when sales in that unit are just one unit. The formula is shown below:

$$V * A_k + TC + MC = D_{jm}$$

Where: V = raw material/product ratio

A_k = cost of raw material (harvest cost)

TC = assembly and distribution costs--access to raw materials plus movement to market areas

MC = manufacturing/production cost including labor cost

D_{jm} = demand price of product at market

Secondly, there should be guarantee that even if there is positive demand price over cost, there would be no expansion of the pallet industry if current capacities of firms are not fully utilized. This forms the key decision variable that determines possibilities of expansion or building a new pallet establishment.

Hence some "spaces" or locations based on above criteria are eliminated from any consideration in the course of the program. Remaining spaces would show positive results. This means that another firm(s) is needed to fulfill extra demand or alternatively, expansion of the pallet industry is possible. In this research study this is the space that indicates the "optimum" location zone where the next pallet firm(s) could be established. This would be a suitable place to build a plant in order to maximize returns on investment.

A key variable in the firm-location model is the capacity constraint of pallet firms which determine whether underutilization is the problem. Alternatively the solution could warrant building more plants to satisfy excess demand for pallets.

CONTRASTS BETWEEN THE LOCATION MODEL AND THE COMPUTER PROGRAM

In five key respects, the location model differs from the computer program. These are:

(a) Unit of analysis

In the location model one unit of input is equal to a production output of a typical pallet plant processing 1.3 million board feet of lumber or 68,000 board feet of pallet in a given area. Derivation of production, distribution, and consumption figures are reduced to the same common denominator.

Whereas in the location computer program, unit of analysis is on per ton-hourly basis. Corresponding production, distribution, and consumption figures are reduced to the same basis accordingly.

(b) Inputs

Though the number of established markets are the same in both the location model and the computer program, the number of supply regions and production locations are different. The number of supply regions and production locations are twelve and nine respectively in the location model.

With regards to the computer program, the number of supply regions and production locations are both nine. This was because the computer program was structured in such a way that supply and production points had to be equal to or less than ten.

(c) Production Cost

The location model has constant processing and manufacturing cost depending on a given location. However, the location program has constant processing costs regardless of location but variable processing costs depending on location.

(d) Capacity Assessment

Concerning the location model, initial capacity was considered non-expansible by setting costs for any output beyond that limit at a prohibitive level when entering data inputs. Also capacity values are only set at production plant or location.

The computer program handles this problem in a different manner by considering initial capacity expansible but making second capacity limit non-expansible. It accomplishes this by creating at each source and production point a distinctive two-step cost function. One cost level prevails up to the initial capacity limit and a higher cost thereafter. In addition these capacity values are set at both raw material regions and production plants.

(e) Transport Cost

Transport cost formula for the location model is general in that it can be adapted to most data sets:

$$= T_{klt} + T_{lmt}$$

Where:

T_{klt} = Assembly cost from raw material source k to production plant l at time t.

T_{lmt} = Distribution cost from production plan l to market m at time t.

Since this study involves pallet industry, transport cost formula for the computer program has two shipping stages; (1) raw material as timber, and (2) lumber ready for pallet manufacture in a vertically integrated industrial structure:

(1) lumber shipping:

$$\$\ \text{Cord} = 9.35 + 0.06\ (\text{miles})$$

(2) lumber shipping:

$$\$\ \text{MBF} = 10.25 + 0.14\ (\text{miles})$$

INPUT-OUTPUT MODEL

One of the most widely used tools for making estimates of economic contribution at regional levels is the input-output (I/O) model. In an effort to better understand the economic role of forest based industries in Michigan an input-output model provides a tool of analysis for impact analysis.

Input-output models provide a great deal of detail on the economic transactions that take place within an economy and offer some understanding as to how impacts originating in one sector are transmitted throughout the economy. The I/O technique is a tool which can be utilized to determine economic impacts of changes in final demand given complete quantitative input-output accounts which express intersectoral linkages.

In an input-output analysis some assumptions have to be qualified in order to derive the structure of the model. The key assumptions are: a) each industry in the local economy is dependent upon every other industry; b) sales by firms are dichomatized into intermediate and final uses; c) production functions for each industry are linear and homogenous so that economies and diseconomies of scale are disallowed and inputs must be in fixed proportions; d) prices and wages are assumed constant and no supply constraints exist. with these assumptions, we can represent a typical input-output structure mathematically as (Pleeter, 1979):

$$\sum_{j=1}^{s} \chi_{ij} + \sum_{f=1}^{t} Y_{if} + e_i = X_i \quad (i = 1, 2, 3, . . . s)$$

Where: χ_{ij} = sales of regional industry to regional industry

Y_{if} = sales of regional industry to regional final demand sector

e_i = export sales of regional inudstry

X_i = total sales of regional industry i

s = number of industries

t = number of final demand sectors excludign exports

The input side of the model is represented by:

$$\sum_{i=1}^{s} X_{ij} + \sum_{p=1}^{t} V_{pj} + m_j = X_j$$

Where: X_j = total purchases in industry

V_{pj} = value-added by final payment sector in industry

m_j = imports by industry

Structure - Input-output model

Input-output model depicting forest products sectors was recently completed (Chappelle, et al., 1986). It focussed on interactions of the forest products sectors with one another and with other sectors of the State's economy. Primary data for the year 1980 from firms in forest-based industries were combined with secondary data for other sectors to construct an input-output model of the State. Michigan's economy was organized into endogenous sectors according to the Standard Industrial Classification (SIC) system. Sectors were highlighted so as to provide detailed information on the forest products industry. The sectors were aggregated into ten Michigan forest products industry sectors plus three additional sectors representing roundwood producers (stumpage sellers) developed from primary data collection. In addition, remaining sectors of the model were reduced to 38 sectors based on to their relative size in Michigan's economy as measured by value-added, employment, payroll, and value of shipments. Exogenous sectors of the model included three major categories: households, government and out-of-state trade. Government sectors are split into federal, state and local components. The payment row includes depreciation on cpaital, profits, and any other activity not accounted for by available data. The final demand column includes inventory accumulation, capital formation, and other sales not determined by available data.

MULTIPLIER ANALYSIS FROM STATE'S INPUT-OUTPUT MODEL

Chatterji (1983) notes that input-output analysis has two major advantages. First, it is an excellent accounting method, which brings out a clear picture of the economy and points out sources of data inadequacy. Secondly, and more importantly as used in the Michigan study is in deciding planning strategy - i.e. to find out the required output levels of the sectors so that the stipulated final demands can be satisfied. To do so from the input-output table, the input-output coefficients are first estimated as:

$$a_{ij} = \chi_{ij} / X_j$$

Where: χ_{ij} = total amount of input coming from i sector to the j sector

X_j = output of the j sector

If A - stands for the direct production coefficient matrix, then the fundamental equation is:

$$X = (I - A) F$$

Where: A = $[a_{ij}]$ input-output (technology) matrix

F = the vector for final demands

X = the vector of total output

I = an identity matrix

One should note that the inverted Leontief matrix (1-A) is a multiplier matrix itself in that it provides information on the amount of sales generated by all sectors of the regional economy when final demands is increased by one dollar. As emphasized by (Chappelle, et al., 1986):

> Normally in economic development analysis we are interested in calculating various types of multipliers which will indicate magnitudes of impacts likely to occur in the regional economy if a certain strategy is pursued in contrast to some other strategy.

There are three basic types of multipliers:

1) A sales (output) multiplier for a column or industry can be computed by adding up the entries of a column of the inverted Leontief matrix. The household sector is normally excluded. However some authors calculate both Type I and Type II sales multipliers. Sales Multiplier indicates, for a given industry, the level of economic transactions that results from a dollar of sales in the economy. Higher output multipliers show higher degree of interdependence among industries in the economy.

2) Income multipliers, can be categorized into two ways. The type I multiplier indicates the direct and indirect changes in income by the next dollar of final demand. Type II goes further to portray the totality of direct, indirect and induced

changes in income as a result of a dollar's expenditure in the economy. In the type II multiplier process the household is endogenous or within the processing sector.

3) Employment multipliers form another set of multipliers. They assess impacts on employment from dollar sales on the economy. These multipliers are significant in regional analysis because one can quantify the resultant employment from say, a policy of industrial expansion (Diamond, 1977). The approach to the analysis can be that of the Moore and Peterson method (Moore & Peterson, 1955). Employment - production functions sector-by-sector are calculated. Type I and type II multipliers are then determined similar to the procedure followed in calculating type I and type II income multipliers. They are derived by multiplying the State productivity ratios by employment. Employment then becomes a function of income since changes in employment reflect changes in demand.

PALLET INDUSTRY MULTIPLIERS IN THE STATE

Table 20 below indicates sales transactions between wood pallets and skids sector and all other endogenous sectors (thirty six sectors) of the Michigan economy. The results are from the input-output study conducted by Chappelle et al., (1986). The table is read by going down the column; and first finding the amount of sales the pallet sector transacts in the economy and how much other sectors purchase from the pallet industry.

TABLE 20

TRANSACTIONS MATRIX FOR THE PALLET INDUSTRY IN MICHIGAN. 1980

Selling sector		(Thousand dollars) Wood Pallets and Skids 73320
Buying sectors	(Thousand dollars) -final M.S.U. sectors-	
1	Livestock; other ag. prod.	2994
2	Metals, Minerals, Crude petro, etc.	0
3	Construction	2449
4	Meat prod; Dairy; Beverages; Grain; etc.	52
5	Textile & Apparel	0
6	National forests	0
7	State forests	0
8	Other stumpage sellers	0
9	Logging contractors	0
10	Sawmills and planing mils	1987
11	Millwork, flooring, structural members	750
12	Wood furniture & Fixtures	738
13	Wood pallets and skids	9399
14	Veneer & plywood; other lumber & wood prods.	4664
15	Integrated pulp & paper; Particle board	4704
16	Paper mills (non-integrated), except building paper mills; Building paper & building board mills	2437
17	Paperboard containers & boxes	13624
18	Other paper products; Converted paper & paper board products	199
19	Printing & Publishing	47
20	Chemicals; Plastics; Drugs; Allied products	3728
21	Petroleum refining	0
22	Rubber & leather products	606
23	Stone, clay, galss, & concrete products	390
24	Primary metal industries	0
25	Fabricated metal products, except machinery and tans. equipment	8372
26	Machinery	415
27	Trans. equipment	1026
28	Misc. manufacturing	13224
29	Transportation & Communication	416
30	Electrical & gas utilities	209
31	Water & sanitary service	0
32	Wholesale & retail trade	81
33	Finance, insurance and real estate (F.I.R.E.)	3
34	Other services	270
35	Government Enterprises	152
36	Households	384

SOURCE: Chappelle, E. E.; Heinen, S. E.; James, L. E.; Kittleson, K. M. and Olson, D. D. (1986). Economic impacts of Michgian forest industries; A partially survey-based input-output study.

Table 21 indicates technical coefficient matrix derived from transactions matrix in Table 20. The sectors numbered are the same ones as in the transactions table. Reading the table down the column should add to the value of 1 or thereabout. It shows how the average dollar of expenditure by wood pallet and skids sector (purchasing sector) is distributed to selling sectors. In other words, it reflects input expenditures used to produce a product or service (in this case a pallet unit). Purchases from all other payments and imports (sector 37) is included in this table.

Sales multipliers described earlier are determined on both type I and II basis. Wood pallets and skids sector have a type I multiplier of 1.875 and type II multipliers of 2.875. While sales or output multipliers are not as useful as income and employment multipliers, they nevertheless portray magnitude of direct and indirect requirements per unit of final demand.

Income multipliers that show the amount generated by additional dollar of final demand have a type I multiplier of 1.917 and type II multiplier of 2.491 pertaining to the wood pallets sector. As a matter of fact, it has the highest multipliers of any forest product sectors in the State. Hence it is the forest products sector having the capability to contribute the highest income per dollar spent on it.

Wood pallets and skids sector have type I employment mutiplier of 1.732 and type II employment multiplier of 2.069.

TABLE 21

TECHNICAL COEFFICIENT MATRIX FOR PALLET INDUSTRY IN MICHIGAN

Purchasing sector	Wood pallets and skids	1
Selling sectors	-Final M.S.U. sectors	
	1	0
	2	.00367
	3	0
	4	0
	5	0
	6	.00128
	7	.01806
	8	.02846
	9	.02757
	10	.15498
	11	.01483
	12	.00062
	13	.09288
	14	.01590
	15	0
	16	0
	17	0
	18	0
	19	.00030
	20	0
	21	.00679
	22	.00037
	23	0
	24	.00007
	25	.00880
	26	.00294
	27	.01030
	28	.00558
	29	.03139
	30	.03156
	31	.00062
	32	.00882
	33	.02649
	34	.00746
	35	.03937
	36	.22242
	37	.23759

SOURCE: Chappelle, D. E.; Suzanne, S. E.; James, L. M.; Kittleson, K. M. and D. D. Olson. (1986). Economic impacts of Michigan forest industries: A partially survey-based input-output study.

In summary, when one ranks the wood pallets sector amongst the ten forest product sectors in the State, it is found overall to rank first in income multipliers (type I and II) and ranks second in sales multipliers (type I and II) based on the Michigan study. Taking into account shortcomings of multipliers such as their ignoring effects of economies of scale, impacts of input constraints and so forth, the input-output analysis indicates that the wood pallet sector is a worthwhile venture to explore for economic development purposes. If income maximization is the policy objective then it should have priority.

CHAPTER V

DATA, AGGREGATIONS, AND MODEL INPUTS

FUNCTIONING OF THE MODEL

Input or exogenous variables in the model are:

(1) wood supply;

(2) harvest costs;

(3) transport costs--hauling distances;

(4) production costs;

(5) plant capacities--scenarios include 25%, 50%, 75% & 100% capacities;

(6) spatial units--on the basis of aggregation of counties.

Decision variables or endogenous variables influence the results of the model. These are:

(1) wood surplus areas;

(2) current plant locations or production points;

(3) end-use markets or loci;

(4) demand prices of pallets;

The model should then be able to answer the following solution:

Is there "<u>space</u>" for expansion of pallet industry and where should the next firm(s) be "<u>optimally</u>" located in the region?

In other words, the model should solve for the potential production or market point that would give the firm(s) the highest returns in terms of both:

a) <u>profits</u>---positive margin of demand price over cost,

and b) <u>capacity</u>---in terms of available capacity.

STUMPAGE SUPPLY TO THE INDUSTRY

Pallets are generally constructed using lower grades of either hardwood or softwood lumber. Lumber for pallets generally come from two sources: a lower grade of lumber from "grade" sawmills and a mixed quality, ungraded material from logs and bolts sawn at pallet mills (Pepke et al., 1977).

The Michigan pallet industry in 1981 consumed in total 280.8 million board feet of lumber (Table 22). According to these data, 72 percent of the supply is furnished by hardwood lumber, the rest by softwood. This agrees well with a national trend of about 75 percent of a pallet unit being made from hardwood. Hence the pallet industry is one of the largest users of hardwood per unit product basis. According to these data, it can be seen that the total lumber consumption by the pallet industry in Michigan has remained about constant since 1973.

TABLE 22

LUMBER USED IN PALLET MANUFACTURING IN MICHIGAN
(Millions Bd. Ft.)

Year	Hardwood Lumber	Softwood Lumber	Total	Percentage of Hardwood
1981	200.8	80	280.8	71.5
1977	196.9	83.4	280.4	70.3
1973	198.0	79.2	277.2	71.4

SOURCE: Grey, Ellefson and Lothner. 1985. Timber supply and demand: A Lake States Regional Perspective.

Apart from lumber, another source for pallet manufacture is low quality plywood and veneer. Table 23 indicates that in 1981 44.6 million square feet of plywood and veneer was utilized in pallet manufacturing. As opposed to lumber where there was consistency in the consumption rate between 1977 and 1981, plywood and veneer increased about 20% in consumption in the same time period.

SUPPLY REGIONS FOR RAW MATERIALS

An in-depth look was taken of forest inventory survey data for the Lower Michigan area. This permitted determination of volumes of timber available for utilization by forest industry. Stumpage is further divided on a county level basis. The stumpage level is assumed to cover raw materials

TABLE 23

PLYWOOD AND VENEER USED IN PALLET MANUFACTURE IN MICHIGAN
(3/8-inch basis)

Year	State Consumption (million sq. ft.)
1981	44.6
1977	37.1
1973	26.1

SOURCE: Grey, Ellefson and Lothner. 1985. Timber supply and demand: A Lake States Regional perspective.

or logs that are more than adequate to sustain both current capacities of the pallet plants and also fulfill future demand if pallet industrial expansion takes place in the region. Forests in Michigan cover an area of about 18 million acres or approximately 50% of the total land area (Spencer, 1984). Commercial forests account for nearly 17.5 million acres which can be divided as shown in Table 24.

Although the largest area of commercial forest is in the Northern Lower Peninsula, the most concentrated commercial forest is in the Upper Peninsula (Table 25). Nevertheless, Northern Lower Peninsula had the greatest increase in volume between 1966 (4945 million cubic feet) and 1980 (6825 million cubic feet). Therefore that area experienced the greatest percentage volume increase of 38%, as opposed

TABLE 24

AREA OF LAND BY FOREST SURVEY UNIT AND LAND CLASS, MICHIGAN 1980

(thousands of acres)

Forest Survey Unit	Commercial Forest Land
Eastern Upper Peninsula	3801.6
Western Upper Peninsula	4529.6
Northern Lower Peninsula	6694.6
Southern Lower Peninsula	2463.4

SOURCE: Spencer Jr. 1983. Michigan's Fourth Forest Inventory: Area.

TABLE 25

AREA OF COMMERCIAL FOREST LAND AND PERCENTAGE OF THE TOTAL LAND AREA BY SURVEY UNIT, MICHIGAN 1980

Survey Unit	Area of commercial forest (millions of acres)	Commercial forest as a % of total land area
Eastern Upper Peninsula	3.8	76
Western Upper Peninsula	4.5	82
Northern Lower Peninsula	6.7	59
Southern Lower Peninsula	2.5	17
	17.5	48

SOURCE: Spencer, John and J. T. Hahn. 1984. Michigan's Fourth Forest Inventory: Timber volumes and projections of timber supply.

to an average of 25% for Upper Peninsula and 26% for Southern Lower Peninsula in the same period (Spencer, 1984).

Since 41% of roundwood output comes from the Northern Lower Peninsula as opposed to a very low percentage from the heavily urbanized Southern Lower Peninsula, that area should be the focus as a source of timber for use as raw materials for the pallet industry. Also a study of apparent annual timber surpluses in the northern two-thirds of the state showed further abundance of timber in the Northern Lower Peninsula (Michigan Department of Natural Resources, 1982). Evidence shown in Table 26 suggests that substantial opportunity exists to base new industry or expand existing industry on the timber surplus.

The apparent timber surplus was determined by totaling annual net growth and mortality. Timber trend removals were deducted from this total. In addition, fiber requirements of recent major industrial expansions were deducted from this total. Mortality of 25% is considered significant because some of it is potentially available as low quality fiber. Further, both increased efficiency in silvicultural treatment and utilization in wood harvesting could convert mortality value into a useful raw material and hence increase wood supply to the forest products industry. It is also important to utilize low quality material to open the growing space for better trees.

Since the unit of analysis in this study is the county, attempt is made to focus on the timber resources data available

TABLE 26

APPARENT TIMBER SURPLUSES NORTHERN LOWER PENINSULA: 1980
(volume in cords)

Products groups	Hardwood	Softwood
Sawtimber *	881,138	339,381
Poletimber **	195,444	374,657
Mortality	486,316	126,582
Sub-total	1,562,898	840,620
TOTAL	2,403,518	

SOURCE: Michigan Department of Natural Resources. Forestry Division. Report--Apparent annual timber surpluses for Northern two-thirds of Michigan.

*Sawtimber is defined as the portion of growing stock trees which contain at least one 12 foot sawlog or two eight foot sawlogs. Softwood must be at least 9" d.b.h. while hardwoods must be at least 11".

**Poletimber is defined as growing stock trees of commercial species at least 5' d.b.h. but smaller than sawtimber.

on a county basis. Again the major sources of supply of timber are Northern Lower Peninsula and five counties in the Southern Lower Peninsula. Counties in Table 27 meet two minimum criteria in order to be counted as source of wood supply. These are a) Each county should have a growing stock of at least 100+ million cubic feet and/or b) All the counties average 50% of commercial forest as a percentage of land area. The rationale for these criteria is that these figures represent current stumpage capacity (about 571MBF) which is more than adequate to supply a pallet plant with logs (consumes about 1.5 MBF annually) and other wood products firms for a long period of time. Even taking into account constraints imposed upon the timber resource base by multiple-use and sustained yield acts, there would be still a surplus of available timber. As can be seen in Table 27, all counties in the Northern Lower Peninsula with the exceptions of Bay, Arenac, and Isabella counties can serve as sources of wood supply. In the Southern Lower Peninsula only five counties - Allegan, Berry, Kent, Montcalm and Muskegon have substantial timber resources. All these counties can serve current existing pallet firms as well as future expanded operations.

The regional forest inventory data were aggregated on the basis of counties in Table 28 in order to form a wood supply region for the pallet industry.

All counties within a supply region are assumed to have substantial excess amount of timber not only to sustain existing pallet plants but also any additional demand required

TABLE 27

AREA OF LAND AND NET VOLUME ON COMMERCIAL FORESTS BY COUNTY, MICHIGAN: 1980

County	Commercial forest as a % of land area (percentages)	Net volume of growing stock (1000's cu. ft)
Alcona	71	313,422
Alpena	60	229,438
Antrim	51	204,488
Benzie	60	143,591
Charlevoix	52	223,281
Cheboygan	79	366,166
Clare	59	198,788
Crawford	76	229,246
Emmet	66	256,988
Gladwin	60	161,384
Grand Traverse	51	164,917
Iosco	65	225,748
Kalkasa	70	190,384
Lake	82	303,726
Leelanau	34	112,604
Manistee	64	244,928
Mason	47	152,245
Mecosta	34	104,234
Midland	44	135,385
Missaukee	57	185,718
Montmorency	85	229,593
Newaygo	57	326,936
Oceana	43	147,041
Ogemaw	60	226,851
Osceola	42	196,236
Oscoda	85	248,446
Otsego	77	286,118
Presque Isle	64	253,992
Roscommon	74	305,689
Wexford	70	267,049
SOUTHERN LOWER MICHIGAN		
Allegan	26	160,301
Barry	31	147,582
Kent	22	117,307
Montcalm	32	147,371
Muskegon	51	160,911

SOURCE: Spencer Jr. and J. T. Hahn. 1984. Michigan's Fourth Forest Inventory: Timber volumes and projections of timber supply.

TABLE 28

AGGREGATION OF COUNTIES INTO WOOD SUPPLY REGIONS

Counties	Supply Region
Allegan, Barry, Kent	1
Otsego, Montgomery, Alpena	2
Crawford, Oscoda, Alcona	3
Roscommon, Ogemaw, Iosco	4
Clare, Gladwin, Midland	5
Osceola, Mecosta, Montcalm	6
Grand Traverse, Leelanau, Benzie	7
Manistee, Mason, Oceana, Muskegon	8
Charlevoix, Antrim, Kalkaska, Missaukee	9

by new plant(s). The counties are shown in Figure 6. Timber is assumed to be accessible and forest ownerships ready to fulfil any slack of demand in the pallet industry.

PLANT LOCATIONS IN LOWER MICHIGAN

According to the Michigan directory of forest products manufactures, the whole State of Michigan has 198 pallet firms. In the study area the total number of pallet firms is 183 (Heinen and Ramm, 1980). Hence virtually all the Michigan plants are located in this area (about 92% of the firms in the state). As shown in Figure 7 most firms are

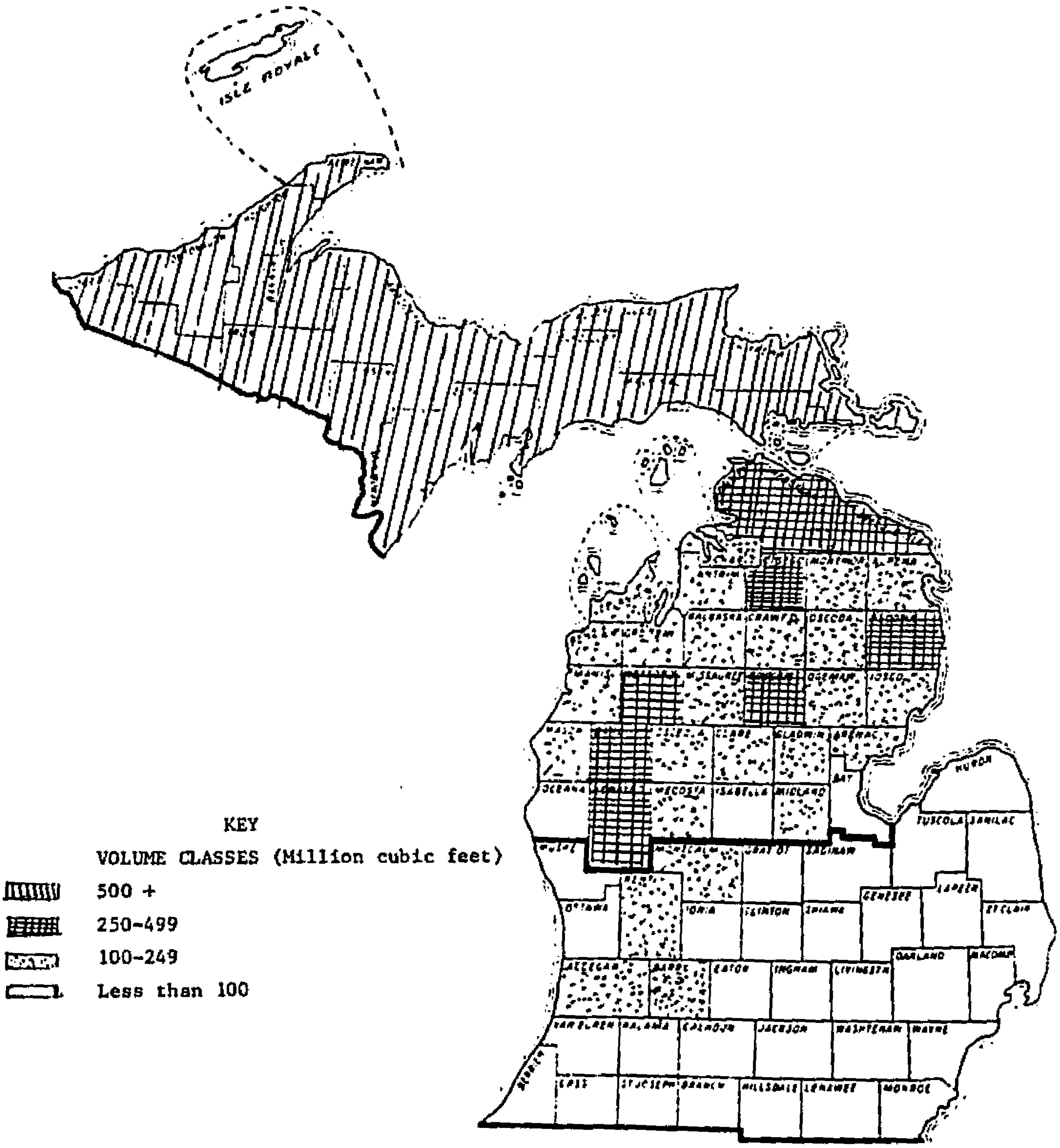


FIGURE 6. GROWING-STOCK VOLUME IN MICHIGAN COUNTIES BY VOLUME (1980).

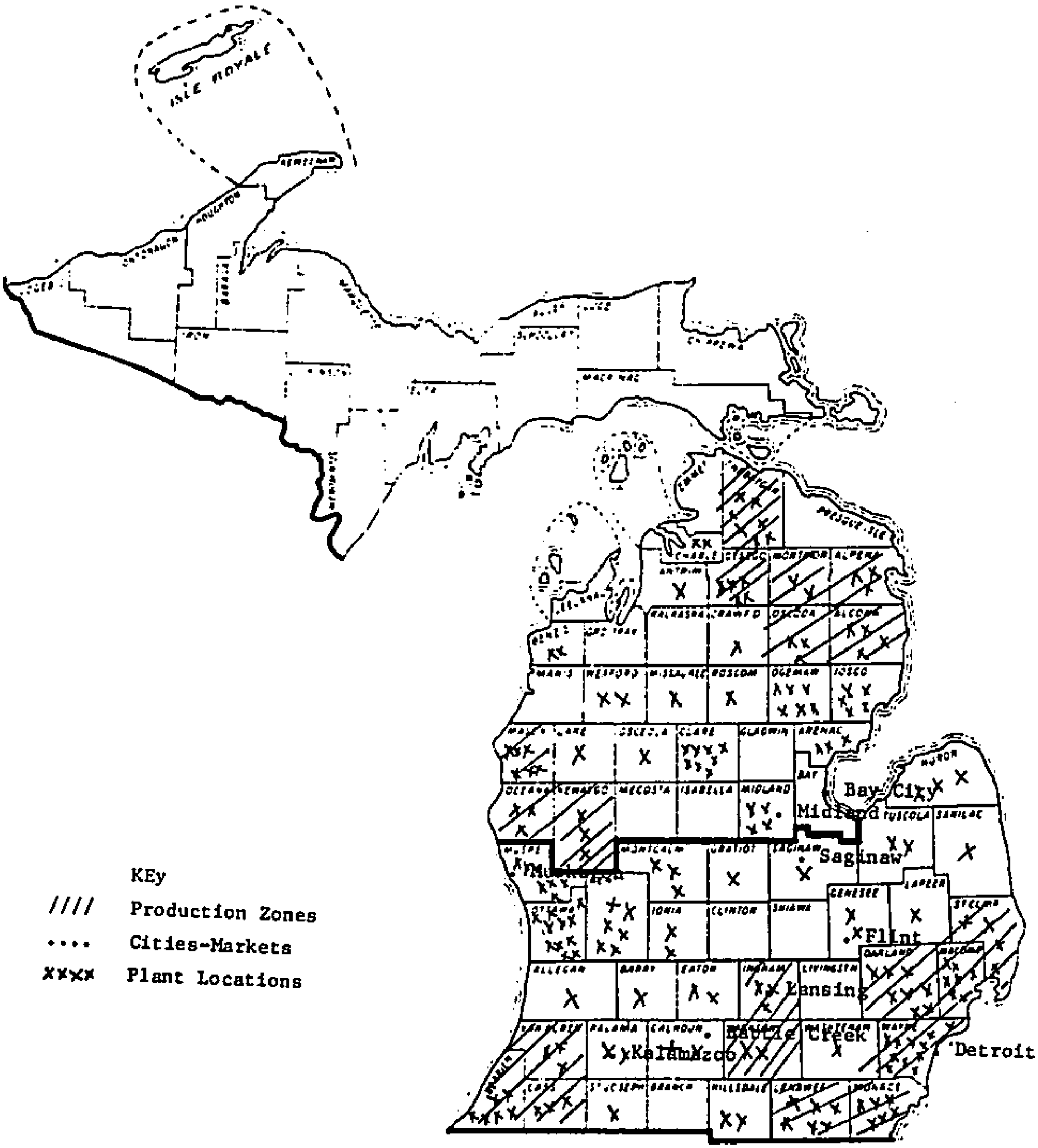


FIGURE 7. PLANT LOCATIONS, PRODUCTION ZONES, AND CITIES (MARKETS).

clustered spatially throughout lower Michigan but the heaviest concentrations are in the southeastern area of the state.

On a county basis, three counties account for the largest concentrations of pallet firms because of heavy industrialization and urbanization of the counties (agglomeration effect): Wayne, Oakland and Macomb. One major pallet consumer-automobile industry and related firms are located in these counties. Since pallet plants are concentrated in certain portions of state, for the sake of simplicity and functioning of the model, the production zones are aggregated on the basis of counties in those areas (Table 29). Basis of inclusion within a production zone is that each of the adjoining counties have at least three or more plants and any wood supply region could use the same highway or railway network to transport logs or timber simultaneously to various pallet plants within a production zone. Also for reasons of economies of scale and access to end-use markets, these production zones are not only suitable for location of current plants but also for new pallet plant(s), should the need arise.

WOOD PALLET MARKETS

The use of wooden pallets for shipping and warehousing manufactured goods has increased rapidly not only in Michigan but throughout the U.S. Because of transportation costs pallet producers are oriented to their market centers. In Michigan they ship to their local markets and industrial

TABLE 29

AGGREGATION OF COUNTIES INTO PRODUCTION ZONES

Counties	Production Zone Identifier
Berrien, Van Buren, Cass	1
Muskegon, Ottawa, Kent	2
Oceana, Newaygo, Montcalm, Mason	3
Oscoda, Alpena, Iosco, Arena, Ogemaw	4
Clare, Midland	5
Jackson, Ingham	6
St. Clair, Macomb, Oakland, Wayne	7
Monroe, Lenawee	8
Cheboygan, Otsego	9

centers such as Flint, Lansing, Kalamazoo, Grand Rapids, Detroit and Toledo, Ohio (border town) (see figure 7). These are local centers of commerce, industry and government. These metropolitan areas, with the exception of Jackson, have 100,000 or more inhabitants (County Business Patterns, 1982). These metropolitan areas also provide three market segments that consume the largest amounts of pallets (Nies, 1985): (a) food, (b) automotive, and (c) government. Cities such as Flint, Lansing, Detroit, Toledo are centers of automobile industry. Hence they furnish markets for pallets. The Kalamazoo-Battle Creek area is a well-known food industry center. Pallets for shipping and warehousing purposes are in demand there. The smallest city - Jackson is included because it serves as center for an important state government function. It has one of the largest prison systems in the country and utilizes pallets for food transfer.

Aggregation of urban areas into market areas for pallet consumption is undertaken in order to facilitate location analysis. Neighboring cities are grouped into the following market loci as shown in Table 30.

TABLE 30

AGGREGATION OF CITIES INTO MARKET AREAS

Urban Cities	Number of Market Areas
Jackson	A
Lansing-East Lansing	B
Flint	C
Muskegon, Grand Rapids	D
Ann Arbor, Detroit, Toledo	E
Kalamazoo-Battle Creek	F
Midland, Bay City, Saginaw	G

The formation of market loci assumes that production zones are geared towards serving any of these market areas. These are the ultimate consumption areas for pallets in the state.

DEMAND PRICES OF PALLETS

There are numerous small pallet manufacturing firms in the state. Approximately 82% of the firms are small-to-medium size, employing less than 20 persons (Bureau of Census, 1982). Price based on intended use and competitive bidding are the criterion for most pallet purchases. There are a multiplicity of factors that affect the worth of a wood pallet in the market place. Some of these are (a) buyer dominance of wood pallet market, (b) nature of the product being expendible or reusable, (c) extent of access to end-use markets, (d) easy availability of raw materials, (e) existence of substitutes, and (f) numerous pallet types and sizes. Because a pallet is a product that comes in numerous different sizes and designs, it is difficult to stipulate uniform universal pricing mechanism. One form often used is specified by Nies (1985) in Table 31.

However, this analysis follows another form of pricing procedure that is appropriate for comparative analysis. Product price is based on amount of lumber footage (board feet) per pallet unit. Price of $0.50 per board foot in a pallet is taken as the average measure of its exchange

TABLE 31

AVERAGE PRICES IN TERMS OF PALLET SIZE

Price Ranges	Dominant Size
$ 2.00 - $ 5.00	36" x 40"
$ 5.00 - $ 7.00	40" x 48"
$ 7.00 - $11.00	48" x 72"
$11.00 & up	88" x 108"

SOURCE: Nies, Joseph. 1985. Bureau of Industrial Development, Michigan Technological University.

value to the consumer (Diaze, 1985). This is assumed to cover the costs of lumber including all operating expenses that go into manufacturing and delivering a pallet unit to the ultimate user. According to Mario Diaze, owner of a small average size pallet firm in Lansing, lumber costs $0.20 per board foot (bd. ft.). In terms of percentages of sale price per board foot ($0.50/bd. ft.); 75% is taken up by operating costs ($0.23/bd. ft.), 18% covers product loss (waste or residue) ($0.05/bd. ft.), and the remaining 7% is the profit margin left for the businessman ($0.02/bd. ft.).

Since there is no uniform pallet size or lumber content per pallet, "standard pallet" in this study would assume the findings of a study by Spelter and Phelps (1984) which used a national study to measure actual volumes of lumber input used per unit of pallet output between 1948 and 1980.

The findings were termed input-output coefficients or "use factors approach". Lumber consumption factor (lumber content per product) by end use was divided into softwoods and hardwoods. The study found that softwood pallet consumption (BF/pallet) had remained constant at 24 bd. ft./pallet between periods 1948-1981. On the other hand hardwood consumption per pallet decreased from 28 bd. ft./pallet in 1949 to 17 bd. ft. in 1981. In summary, when both species groups consumption patterns are added, it is realized that the weighted average lumber content of a pallet had fallen from 27 bd. ft. in 1949 to 19 bd. ft. in 1981. Table 32 indicates how pallet prices can be assessed on the basis of lumber content from the above study.

TABLE 32

STANDARDIZED PALLET PRICE ASSESSMENT

Board feet (total)	Total Price ($) ($0.50/bd. ft.)	Number of pallets (19 bd. ft./pallet)
19	9.50	1.00
100	50.00	5.26
500	250.00	26.32
1000	500.00	52.63
1500	750.00	78.95
2000	1000.00	105.26

ESTIMATING PALLET COST

Since pallets are low-value products, pallet manufacturers tend to locate within 100 to 150 miles of the industrialized market centers (Forest Products Laboratory, 1971). Pallets are also bulky and therefore expensive to ship. Thus they are generally sold to delivery points within a radius of 150 miles from a plant. The decision to locate a pallet plant on a particular site or area depends mostly on economic factors such as the cost of raw materials, labor and transporting the finished product to the market.

When dealing with pallet industry in Michigan, one finds that it is basically a small establishment industry. About 62 percent of pallet plants in the state employ less than 9 people (U.S. Department of Commerce, 1982). A typical pallet firm considered in this study can be characterized as a small pallet firm and includes all activity from supply of either cut-to-size lumber or cut cants/squared logs or round log through production process to the selling of finished pallets to customer. The major manufacturing process considered is that of cutting wood into pieces and nailing them into pallets. This is where the major labor costs arise. Certainly transportation cost is one of the major constraints in the production costs -- all along from stumpage sale to product delivery at the market.

RAW MATERIALS

Pallet parts generally come from the lower grades of either hardwood or softwood lumber. Purchased lumber is usually number 2 or 3 common grade except in low-value species, where all grades are used. Hence practically all commercial species may be used for pallets. In Michigan such abundant species such as maple, aspen, oak, etc. could all be used for pallet manufacture. Because lumber and nails comprise about 50 percent of the cost of a pallet, they form the major determinants in pallet price formulation (Figure 8).

The price of pallets at mills is usually quoted by the board foot. Though this is based on a valid principle (varying lumber requirements), this cost-figuring method does not properly compensate the mill for differences to the number of fastenings, handlings, labor, etc., involved in various sizes and types of pallets. The interview with the owner of the small pallet firm revealed that lumber cost is about $0.20 per board foot (BF). Processing wastes about 25% of the lumber. This then totals $0.25 per board foot delivered at the plant. Reliable cost estimates dictate accurate determination of nail or staple requirements. The same interview revealed that a typical small firm would spend about $0.075 per nail.

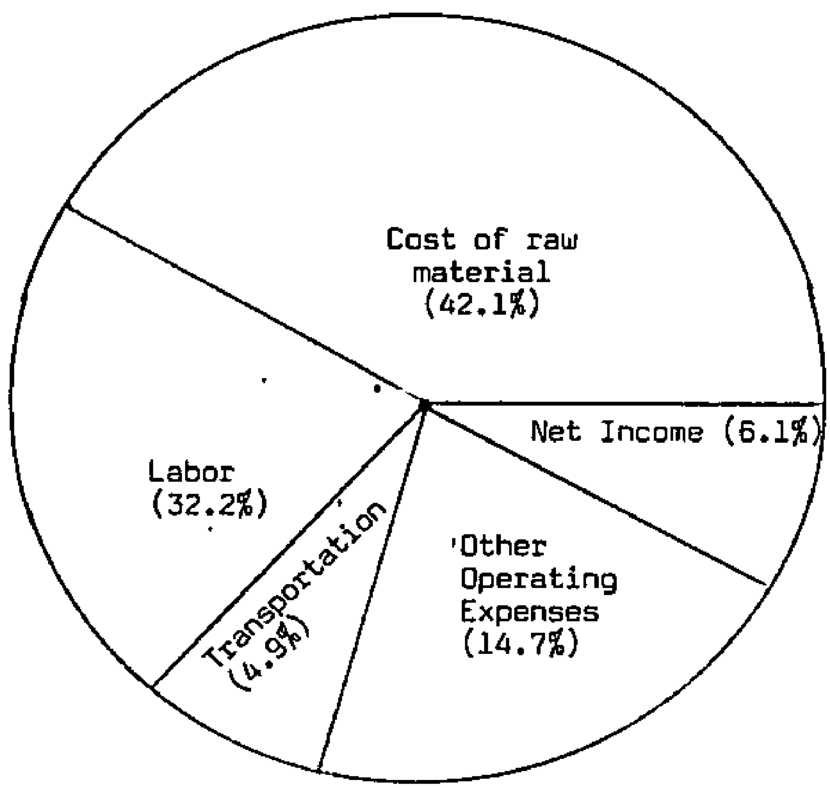


FIGURE 8 - BREAK-DOWN OF A TYPICAL PALLET COST IN MICHIGAN

SOURCE: Huber, Henry. 1982.

LABOR COST IN A PALLET FIRM

Apart from lumber cost or raw material cost, labor cost is the major operating expense in a pallet firm (Figure 8). In a study of 17 Michigan pallet manufactures, it was found that labor cost averaged 32.2% of every sales dollar (Huber, 1982).

In 1984 a wage and labor survey was undertaken by National Wooden Pallet and Container Association. Results in Table 33 feature nine common job categories of a pallet firm. The survey report indicated a 3.6% increase in average wages paid to production employees from $5.58 in 1983 to $5.78 in 1984. The assumption made here is that these are straight averages (no weighting). The averages are based on total cash compensations (including incentive pay). A figure of 2080 hours was used when computing the hourly wages of salaried employees.

If the labor/sales ratio (portion of a sales dollar attributed to labor cost) is high, it should be of concern to management. It may be the result of a high hourly rate or low production or lack of mechanization or any combination of the three (Huber, 1982). The Huber study further found that the range of labor cost to sales ratio for pallet manufacturers varies from 10.0% to 53.3%. This difference can be attributed to considerable variation in the amount of manufacturing labor performed by the 40 firms surveyed. Some used cut-to-size and length lumber and only nailed it

TABLE 33

SUMMARY OF THE 1984 SURVEY OF WAGES

	Central Region (includes MI)	National
	Averages (hourly rate)	
President/CEO	22.32	18.75
Headsaw Operator	7.22	7.01
Cut-off Saw Operator	6.10	5.66
Re-saw Operator	6.30	5.76
Planer Operator	6.49	5.60
Pneumatic Nail gun Operator	6.50	5.58
Nailing Machine Operator	6.65	5.56
Lift Truck Driver	6.32	5.88
Laborers (helpers, etc.)	5.26	4.92

SOURCE: National Wooden Pallet and Container Association. 1984. Mini Wage Survey.

into a pallet. Whereas others cut cants or squared logs into lumber and the rest cut thin pallet materials from round log. Certainly more labor is expended cutting round logs and this difference in type of pallet operation accounts at least in part for the wide variation in the range of ratios.

In the current input/output study of forest products industry in Michigan, the pallet sector was found to spend $0.2224 per dollar of expenditure on labor (Chappelle, et al., 1985).

At a more practical level (at a firm level) the Lansing pallet firm interviewed indicated that labor cost accounted for about 30% of pallet sale price.

Hence labor costs are a significant factor in total production cost of pallet industry. Direct labor costs are those resulting from salaries, wages, and piece-rate payments.

The labor/sales ratio also reflects labor productivity. Productivity of labor when "mixed" with capital inputs (technology) must be considered before comparison of labor costs are made between regions. Nature of labor force and consequently labor cost vary depending on technology used in the production process. Comparison between regions or plant locations is made difficult by the fact that labor costs per unit of output (pallet) is influenced by factors such as variation in the use of factors of production, types of products manufactured and institutional constraints (Blyth, 1964).

CALCULATION OF TRANSPORT COSTS

Because pallets are relatively low in cost, and relatively heavy, costs of transporting pallets controls to a significant degree the economic availability of existing raw materials for pallets. Location of forest resources as well as their characteristics are the primary determinants for assessing the future technology and market strategy for producing and supplying pallets (Wallin, 1977). Transport costs are costs of overcoming the barrier of distance between location of production and location of consumer. In a typical pallet manufacturing process timber or lumber is shipped from the supply region to the ultimate industrial consumer via the production plant site. This analysis assumes that most lumber or logs are hauled to the pallet firm by trucks since distances covered are mostly short. Even then most shipments of primary forest products in Michigan currently move by truck (DenUyl, et al., 1982). Rail which was extensively used in the past, has declined in importance because of abandonments, decreased reliability of service and rate increases relative to trucks. Nevertheless the forest products rail transport rate is less than that for trucks for long hauls when rail service is available.

MEASURING ROAD HAUL DISTANCES

Routes of travel are chosen to link supply regions to market locations via production sites. As it so happens in the pallet industry, the product has a low product price and at times the production point is in the same zone as the market place (market oriented good). Hence this accounts for overlapping of the production point and market areas in some places. In this analysis there are seven markets areas to be served with pallets 9 (Table 34). These are represented by the metropolitan areas of Jackson, Lansing, Grand Rapids, Detroit, Flint, Kalamazoo, Saginaw, and others mentioned.

Most timber supply regions are in Northern Lower Michigan. Pallet firms are located all throughout the state -

TABLE 34

AGGREGATION OF RAW MATERIALS, PRODUCTION AND MARKET LOCATIONS

INCLUDED COUNTIES IN A SUPPLY REGION	
1	Allegan-Barry-Kent
2	Otsego-Montgomery-Alpena
3	Crawford-Oscoda-Alcona
4	Roscommon-Ogemaw-Iosco
5	Clare-Gladwin-Midland
6	Osceola-Mecosta-Montcalm
7	Grand Traverse-Leelanau-Benzie
8	Manistee-Mason-Osceana-Muskegon
9	Charlevoix-Antrim-Kalkaska-Missaukee
INCLUDED COUNTIES IN A PRODUCTION ZONE	
1	Berrie-Van Buren-Cass
2	Muskegon-Ottawa-Kent
3	Oceana-Newygo-Montcalm-Mason
4	Oscoda-Alpena-Iosco-Arena-Ogemaw
5	Clare-Midland
6	Jackson-Ingham
7	St. Clair-Macomb-Oakland-Wayne
8	Monroe-Lenawee
9	Cheboygan-Otsego
INCLUDED CITIES IN A MARKET AREA	
1	Jackson
2	Lansing-East Lansing
3	Flint
4	Muskegon-Grand Rapids
5	Ann Arbor-Detroit-Toledo
6	Kalamazoo-Battle Creek
7	Midland-Bay City-Saginaw

clustered around the nine cited production zones. Each route extends from the market area to the edge of the supply area via a production point. The route then extends into the transportation network of the supply area (Osteen, 1976). Roads chosen are routes between points. Immediately after measuring the shortest straight-line distance (sd) for forest stand or supply region, transport distances by road quality class to a specific delivery/production point are then measured. These road haul distances can be stepped off on a map with a divider or for more exact results one can use a planimeter.

Regardless of where the production zones and market loci are located, there are usually different ways of getting there. In this analysis there would be 9x9x7 or 567 alternative routes (or shipment paths) between supply regions and market areas. The problem becomes that of locating routes that have minimum transportation costs (Davis, et al., 1972).

Hence the criteria established on this study measures the best route in terms of minimum distance. However, this would probably not be realistic because transport cost is a function of distance and road quality.

TRANSFER COSTS

Since only about 4.5% of every sales dollar ($0.045) for a pallet is used to pay transportation charges, it does not seem to be a major factor in determining pallet cost.

But considering the fact that pallets are low priced products, transportation costs account for the biggest share after raw material cost and labor cost (Huber, 1982). The principal factors determining these costs are (a) road quality, (b) truck capacity, and (c) hauling distance. Most haul cost information on lumber or timber assume that the species transported are the best commercial species for the product. Pallet firms tend to use lower grade lumber or lumber of low value species. Also many firms use cants or cut-to-size lumber as inputs.

Transfer or shipping costs were determined using the following two equations (DeUyl, 1982):

(i) shipping timber

$/CORD = 9.34 + 0.0579 (MILES)

(ii) shipping lumber

$/MBF (million board feet) = 10.25 + 0.14 (MILES)

The study assumed that the truck commonly used for hauling forest products (wood chips, timber and lumber) is a 40,000 pound tractor-trailer which carries about 20 cords of timber or 25 tons of wood chips or 7.5 mbf (thousand board feet) of lumber.

PLANT CAPACITIES

Since there are diverse sizes and technologies of pallet plants, pallet capacity values for all firms are difficult to estimate. The analytical model here requires that plant capacities be calculated and correlated to production costs. One would also have to know whether current plants are utilized at full potential at any given time in the year. These data are difficult to obtain. An assumption is made that plant capacities are never reached and hence would not impose cost constraints on the efficiency of a pallet firm. In other words, one may assume the variable away if it does not affect results. Maximum capacity of the model plant (small pallet establishment) would not exceed 500 units per 8-hour day, which requires 10,000 to 15,000 board feet of lumber supply. The plant of this size may employ about 16-18 people.

TOTAL OUTPUT

A strong industrial base and large forest inventory has resulted in Michigan as a state having the second largest number of pallet manufacturers in the country. Michigan had 198 pallet firms in the state in 1980 (Heinen and Ramm, 1983). The only other state with more was Ohio. Hence the state is a major area for industrial consumption of pallets. Annual production of pallets in 1981 in Michigan was found to be around 15 million units (Gray, et al., 1985). Econometric analysis of the forest products industry showed value of pallet output in Michigan to be about 120 million dollars in 1984 (Data Resources Inc., 1985). This is shown in Table 35. Forecasts for the future year 2000 estimate that there would be output of about 186 million dollars in the industry.

TABLE 35

FORECASTS FOR SECONDARY WOOD PROCESSING SECTORS (MICHIGAN): 1984-2000

(thousands of 1972 dollars)

Category	1984	2000
Wood pallets & skids (2448)		
Real Output	46448.67	70991.80
Interindustry demand	57605.81	86078.74
Inventories	0.40	0.19
Governments	17.67	25.94
Exports	8001.72	14370.51
Imports	19176.94	29483.58
Net Exports	-11175.22	-15113.07

SOURCE: Data Resources Inc. 1985.

The growth rate of the industry between the years 1984-2000 is expected to be about 8 percent (Table 36).

TABLE 36

PALLET INDUSTRY'S GROWTH RATE PERCENTAGES: 1984-1990

Category	1984-1990
Real Output	2.7
Interindustry Demand	2.5
Inventories	-4.4
Governments	2.4
Exports	3.7
Imports	2.7
Net Exports	-1.9

SOURCE: Data Resources Inc. 1985.

DATA SUMMARY

As formulated, the firm-location model consists of a single commodity - pallet (from different lumber species groups). The source of logs or lumber originate from nine specified supply regions which pass through nine production zones to ultimately seven specified market locations. This means that there are 9x9x7 or 567 possible routes or shipment paths by which a unit of output could pass through the network. The problem is to find the "paths" for locating new pallet firms through this spatial network in such a way as to maximize profit. Therefore the issue is that of locating routes that have minimum transportation costs and manufacturing costs. And if the pallet industry expansion took place these would be the best "spaces" to locate new plants.

CHAPTER VI

ANALYSIS AND RESULTS

This is the key chapter that portrays results of the firm-location model as it relates to the pallet industry in Lower Michigan. The chapter should resolve three issues at the core of this research; the indentification of surplus timber areas, potential locations for expansion of the pallet industry, expected economic impacts of the action on the state.

RESULTS AND INTERPRETATION OF COMPUTER RUNS

The firm-location model was written in Fortran language and is a modified version of one of Hoover's original Industry location programs tested with dummy data on an IBM 7090 at the University of Pittsburg in 1967. The firm-location program in this study was run on IBM XT microcomputer. The flexibility of the location program allowed one to study the effects of variations in model parameters. Insights into stability and sensitivity of solutions to changes in parameters. Insights into stability and sensitivity of solutions to changes in parameters was achieved by analyzing alternative runs of the location model. For instance, the importance of two key variables were tested to determine how they affected program results; (I) variations in plant capacities affecting program results, and (II) increases in demand (consumption) targest indicating magnitude of expansion of production locations. Initially, numerous runs were made to pretest and validate the location program. Once that was accomplished, four computer runs were made to arrive at the solutions. They were as follows:

(I) RUN-I. This can be referred to as "benchmark" run (Table 37). It has the following characteristics; (a) at any given time, it represents the average typical plant in the pallet industry in the study area consuming about 1.3 million of logs a year or about 6000 board feet of logs daily, (b) the plant's maximum capacity is about 250 units per 8 hour day or about 3.21 tons of products daily, (c) estimates of demand are derived from national econometric models reflecting the regional consumption patterns of the product. The rest of the parameters reflect production and distribution variables similar in all four computer runs.

(II) RUN-II. Same as RUN-I, except demand is doubled. See Table 38.

TABLE 37

RESULTS OF BENCHMARK SOLUTION (RUN-I)

Routes (N)	Profit (DMAX)	Supply Regions	Shipment Flows (tons/hour)	Production Locations	Shipment Flows (tons/hour)	Market (K)
565	55.04	CG	1	OA	1	DET
484	47.19	CG	1	CM	1	SAG
358	45.86	OM	1	MO	1	MUS
286	35.30	OM	1	OA	1	FLI
166	25.75	RO	2	JI	1	KAL
110	23.07	RO	2	JI	1	LAN
40	10.77	AB	1	ML	1	JAC

Definations:

N = number of eligible paths remaing.

DMAX = positive margin of pallet price over delivered cost in dollars ($).

BEST ROUTES = represented by the respective paths following the profit margins. Symbol descriptors for supply regions, production locations, and markets defined in Table F-1.

TABLE 38

RESULTS OF INCREASED DEMAND SOLUTION (RUN-II)

Routes (N)	Profit (DMAX)	Supply Regions	Shipment Flows (tons/hour)	Production Locations	Shipment Flows (tons/hour)	Markets
567	255.04	CG	1	OA	1	DET
567	247.18	CG	1	CM	1	SAG
504	245.86	OM	1	MO	2	MUS
504	235.30	OM	1	OA	1	FLI
392	225.75	RO	2	JI	1	KAL
392	223.07	RO	2	JI	1	LAN
294	210.77	AB	1	ML	1	JAC
294	150.39	CO	1	SM	1	DET
294	142.88	CO	1	CM	2	SAG
210	142.83	AB	1	MO	2	MUS
140	128.15	OM	1	SM	1	FLI
112	120.67	CA	2	BU	1	KAL
112	116.85	CO	1	ML	1	LAN
63	105.65	CA	2	BU	1	JAC
26	43.79	GL	2	ON	1	DET
22	37.72	GL	2	ON	1	MUS
4	33.29	MM	2	CO	1	SAG
3	23.55	MM	2	CO	1	FLI

Defination:

N = number of eligible paths remaing.
DMAX = positive margin of pallet price over deliver cost ($).
BEST ROUTES = represented by the respective paths following the profit margins. Symbol descriptors for supply regions, production locations, and markets defined in Table F-1.

(III) RUN-III. Same as RUN-I, except production capacity figures are increased to reflect full capacity value. See Table 39.

(IV) RUN-IV. Same as RUN-I, except the production capacity figures are low or minimal (25% and less). See Table 40.

Benchmark Solution (RUN-I)

According to the program results, there are four supply regions comprised of twelve counties that should be harvesting locations for pallet plants in Lower Michigan (Table 37). These are areas of surplus or excess timber inventory that could be used to satisfy raw material requirements of new pallet plants in case of expansion of the industry in the region. The solution indicates that logs in supply regions mentioned below can be transported economically (optimally) to pallet plants located in any of the following production zones:

Supply regions (counties)	TO	Production zone counties
Clare-Gladwin-Midland		Oscoda-Alpena-Iosco-Arean-Ogemaw
Clare-Gladwin-Midland		Clare-Midland
Osceola-Mecosta-Montcalm		Muskegon-Ottawa-Kent
Osceola-Mecosta-Montcalm	TO	Oscoda-Alpena-Iosco-Arena-Ogemaw
Roscommon-Ogemaw-Iosco		Jackson-Ingham
Roscommon-Ogemaw-Iosco		Jackson-Ingham
Allegan-Barry-Kent		Monroe-Lenawee

TABLE 39

RESULTS OF FULL CAPACITY SOLUTION (RUN-III)

Routes (N)	Profit (DMAX)	Supply Regions	Shipment Flows (tons/hour)	Production Locations	Shipment Flows (tons/hour)	Markets
565	55.04	CG	2	OA	1	DET
484	47.19	CG	1	CM	1	SAG
403	46.03	CG	1	ON	1	MUS
322	37.41	CG	2	OA	1	FLI
241	27.86	CG	2	JI	1	KAL
160	25.18	CG	2	JI	1	LAN
79	14.76	CG	1	ML	1	JAC

Definations:

N = number of eligible paths remaing.

DMAX = positive margin of pallet price over delivered cost in dollars ($).

BEST ROUTES = represented by the respective paths following the profit margins. Symbol descriptors for supply regions, production locations, and markets defined in Table F-1.

TABLE 40

RESULTS OF LOW-MINIMUM CAPACITY SOLUTION (RUN-IV)

Routes (N)	Profit (DMAX)	Supply Regions	Shipment Flows (tons/hour)	Production Locations	Shipment Flows (tons/hour)	Markets
565	55.04	CG	1	AO	1	DET
382	45.86	OM	1	MO	1	MUS
243	44.62	RO	1	CM	1	SAG
142	31.83	CO	1	JI	1	FLI
73	23.81	AB	1	BU	1	KAL
30	16.85	OM	1	ML	1	LAN
7	5.32	CA	1	ON	1	JAC

Definations:

N = number of eligible paths remaing.

DMAX = positive margin of pallet price over deliverd cost in dollars ($).

BEST ROUTES = represented by the respective paths following the profit margins. Symbol descriptors for supply regions, production locations, and markets defined in Table F-1.

In addition, the following markets could be supplied efficiently (optimally) from the plant in the stated group of counties. Pallet prices (per ton of sales) at the respective markets are also included:

Markets	Price per ton	Production zone counties
Jackson	106	Monroe-Lenawee
Lansing	116	Jackson-Ingham
Flint	128	Oscoda-Alpena-Iosco
Flint	128	Arenac-Ogemaw
Muskegon-Grand Rapids	138	Muskegon-Ottawa-Kent
Ann Arbor-Detroit-Toledo	147	Oscoda-Alpena-Iosco
Ann Arbor-Detroit-Toledo	147	Arenac-Ogemaw
Kalamazoo-Battle Creek	120	Jackson-Ingham
Midland-Bay City-Saginaw	137	Clare-Midland

The map (Figure 9) illustrates the locations of surplus timber, optimal plant locations, and markets. In a summary form, it portrays the locational patterns and flows of the pallet firm-location model. Thereby imparting to the observer the spatial relationships of the model results.

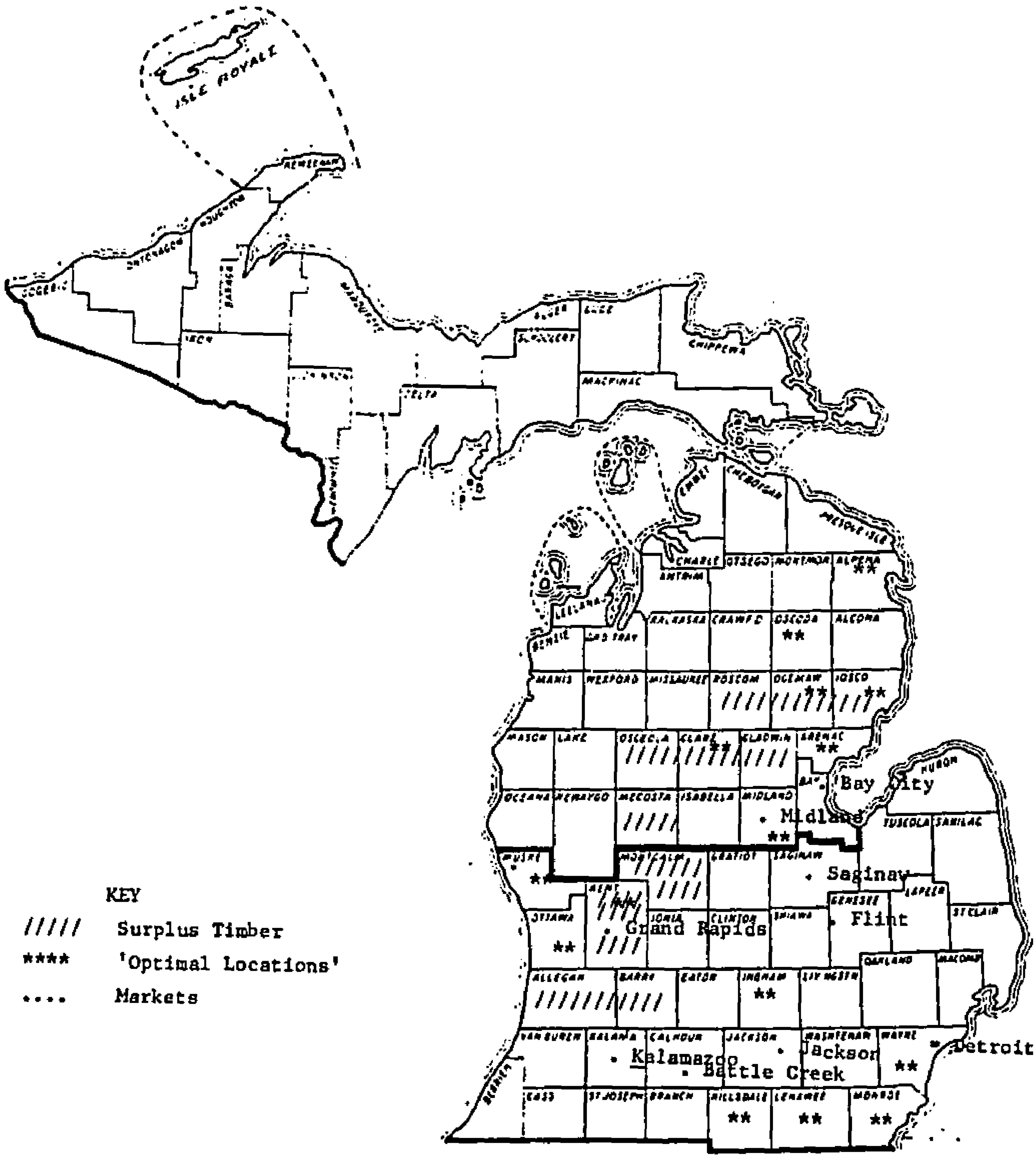


FIGURE 9. LOCATIONS OF SURPLUS TIMBER, OPTIMAL PLANT LOCATIONS, AND MARKETS.

Interpretation

With the pallet industry operating at the current capacity level (50 percent), these twelve counties were found to be most suitable as supply regions for pallet firms in the Lower Michigan area. These stumpage supply areas are prime sites that could enable the pallet industry to deliver pallets to the markets at minimum delivered cost. It is important to note that most of the counties supplying logs are located in the Northern Lower Peninsula. In fact eight counties are situated here; these are Roscommon, Ogemaw, Iosco, Mecosta, Midland, Osceola, Clare, and Gladwin. Only four counties are located in the Southern Lower Peninsula; these are Allegan, Kent, Montcalm, and Barry. Most of the stumpage supply counties form a ring around the Southern Lower Peninsula area.

Results also indicate that if pallet industrial expansion is to take place, half of the best locations for new firms are in the Northern Lower Peninsula. Coincidentally, they also happen to be heavily forested. These areas are basically rural and are in close proximity to manufacturing cities of Bay City, Saginaw, Flint, and Midland. The rest of the best areas for plant locations are near the urban centers of the Southern Lower Peninsula; these are Ingham, Jackson, Hillsdale, Muskegon, Ottawa, Monroe and Kent. Computer results heavily favor two counties, Ingham and Jackson, as central places conveniently located to serve industrial cities of Detroit, Lansing, Battle Creek, and Toledo.

As far as the results are concerned, the pallet industry would fetch the highest prices in the Detroit market. The lowest prices are offered in Jackson. Certainly, it can be inferred that heavy industrialization of Detroit and Toledo result in higher pallet demand, thereby contributing to the higher market prices for pallets in these urban areas.

Increased Demand Solution Run (RUN-II)

A higher demand function means that more pallet plants are brought into production as a result of increased output consumed in the market place. Given the same capacity level (about 50%) in the production process of the typical plants, increased production zones and distribution networks now come into action to satisfy increasing demand (Table 38).

Interpretation

If the pallet price is increased or even doubled (as in this program run) more forested counties would come under consideration as log supply counties. In fact, all 30 stumpage supply counties are at one point or the other efficient supply points for the pallet industry. There would be increasing utilization by pallet plants to satisfy the rising demand in the pallet markets. Based on the industry's current capacity rate, it appears that all nine production zones in 26 counties would be operational for pallet manufacturing purposes. However, should demand continue to rise faster than supply, few cities are deemed to compete effectively for production needs, these are: Detroit, Toledo, Muskegon, Flint, Grand Rapids, Bay City, Saginaw, and Midland. Incidentally, these are also the major pallet markets in Michigan since they are the centers for steel, manufacturing and automobile industries that consume most pallets.

Full Capacity Solution Run (RUN-III)

Again, based on the current capacity and demand levels, if pallet plants operated at maximum capacity and beyond it appears that only one resource supply region could satisfy all existing raw material needs (Table 39), a still fewer pallet plants could satisfy current product demand at the given seven markets.

Interpretation

If pallet plants were operating at full capacity, only three counties, instead of twelve counties at the current capacity (50%), would be sufficient enough to supply logs to sustain the current industry demand. These three counties are Clare, Gladwin, and Midland. These counties are located at the southeastern end of the Northern Lower Peninsula bordering manufacturing cities of Saginaw, Midland, and Bay

City. These forested areas are also located to efficiently supply the big pallet markets of Flint, Detroit and Toledo.

Low Capacity Solution Run (RUN-IV)

This solution is in reverse to the above statement. With low or minimum capacity it would take far more supply regions and production zones to even satisfy current demand, let alone maximum demand (Table 40). This result does not offer any practical solution for policy since there is a production limit beneath which a plant or industry cannot operate if it does not cover its overhead and production costs. In other words, a firm has to break even if it is to stay in business. At such a low capacity, costs might outweigh investment return margins.

ANALYSIS OF PALLET-FIRM LOCATION RESULTS

Results from the computer program can best be understood in the context of the study objective. This facilitates interpretations of the results in a more meaningful and realistic manner. To further add reality to the program solutions, output and capacity results in Table G-1 (calculated manually) can be used to compare and gauge the practicality of the computer results as far as the pallet industry is concerned in Lower Michigan. It is important to note that the 50% capacity is dependent on the assumptions made in modeling and does not represent a survey result of the pallet plants in the Lower Michigan region.

With respect to the computer model, the major solution it provides is that of defining the 'optimal' paths (I,J,K) out of a possible 567 paths (9 * 9 * 7) and designating the respective 'margins' (DMAX), i.e., sales profitability. For more information regarding the solution's significance, refer to the earlier formulation of the location model in Chapter IV. However as it relates to the research focus of the pallet industry, these 'optimum' paths represent the identification of ideal timber supply regions and production locations for the seven given major pallet markets in the region. Specifically two study goals are obtained simultaneously in these results;

(1) results indicate locational relationships and transportation flows between the surplus wood areas and current lcoations of pallet plants in the region. In other words, compare current plant locations in Figure 7 which show total number of plants in a county and potential plant locations in Figure 9 showing the optimal county locations.

(2) results convey the potential for expansion of pallet establishments in certain locations by defining the current correlation between timber supply, production capacity, and market demand in a given area; i.e., where should new pallet plants be located in the region. In the context of model results, this is shown as which

"paths" offer the largest profit margins and can withstand further introduction of new inputs or outputs into the system so as to arrive at an equilibrium in a given time. Two criteria are used to identify these best paths:

(a) positive margin of pallet demand price over its delivered cost.

(b) available capacity or capacity expansion cost.

The benchmark solution and sensitivity analyses conducted highlight three factors crucial in understanding the results of the location model:

I-Capacity Values

Capacity value is one of two key factors that imparts reality to the firm-location results. From the appearance of the benchmark solution (RUN-I), one would infer that more pallet plants need to be built in certain locations in the region (Table 37). In other words, there is an assumption of plants manufacturing pallets at full capacity in the Lower Michigan area. However, this is misleading, when it is realized that the optimal solution of the model is attained at a 50% capacity ratio. This is derived from practical data on the physical capacity of pallet plants in the region (see Table G-1). Therefore, it is important to note that there is underutilization of pallet plants in the region. Hence accurate measurement of capacity values appears to be crucial in the determination of model results.

II-Demand Function

Demand is the other key variable mentioned above. When demand is increased, as measured by increases in real price, more plants and routes are brought into production and operation respectively (Table 38). Higher consumption targets offer higher prices and hence more output sold at the seven markets in the Southern Lower Michigan area. This can be explained by the fact that the location model is demand driven.

III-Resource Supply Regions

Since the pallet industry in Lower Michigan appears to operate at about 50% capacity volume, it appears that with a scenario depicting a full or maximum capacity volume of the same number of plants, only one supply region would be able to fulfill the current output demand (Table 39). This portrays the magnitude of underutilization of timber resources in the area. However it would take a more detailed analysis to pinpoint exactly how much surplus timber is available specifically for the pallet industry. For apart from the pallet industry, other forest products industries compete for the same resource as raw materials. In this regard, it should be stated that the pallet industry is most directly competitive with the pulp and paper industry. Most often pallet plants process the least valuable quality of logs that other wood product firms might not consider as suitable raw materials.

To more clearly place the location model into perspective, one can also state that results are in the form of optimal points in space for specific resource management and production decisions. These spatial points represent the maximum range of distances between respective resource supplies, production locations and the markets for a given pallet establishment to operate and maintain a profitable economic activity.

When sensitivity analysis was conducted upon the results, it was found that most optimal routes (paths) did not exceed 150 miles from the point of origin to the destination. Indeed this is the normal economic distance radius at which a pallet industry operates profitably.

In view of the foregoing statement about distance, it is also worth noting that the northern most pallet plants did not appear in the solution for the southern markets. However if the same distance continuum is assumed to apply to the northern industries, it can be reasoned that pallets produced there are shipped economically to the Upper Peninsula. Or even depending upon cost differential of the industry and therefore its comparative advantage with respect to the Wisconsin pallet industry, these Michigan pallet plants could also export pallets to the other states.

DISCUSSION OF PROBLEMS DURING TESTING

Some problems were encountered when the first few runs of the model were undertaken. They dealt with the structure of the model as well as the nature of algorithm used in the programs.

Problems in Computer Model Structure

One of the major obstacles dealt with clarification of unit specification for input/output variables. The original unit specifications in the location model were in million board feet (MBF) of lumber or number of pallet units (19 board feet/unit). Yet the unit of analysis for the location computer program was on a per ton unit basis. Hence approximate conversions were necessary to reduce the unit of inputs from MBF to one-ton basis. Once this was done, all other related variables, especially production and consumption variables, had to be converted to the common denominator before program execution. The transport cost functions for inputs and outputs used in the study were different from the program transport cost computation techniques, i.e. different formula were used to compute transport cost rates. Some adjustments had to be made to approximate the two procedures. A transportation study of timber and lumber shipment on the Great Lakes provided the formulae used to derive the transportation cost values that served as inputs for the program (DenUyl, et al., 1982).

One major deviation of the model from program that inevitably affects results is capacity figures. The model had assumed away the impact of capacity constraints on results. Yet the program is structured in such a way that it cannot execute without capacity values at both source and production location. Therefore, the problem became that of defining the specific capacity values and their role in the computation of results. The computer program requires that the capacity values at raw material sources be higher than the values at production locations. This can be explained as follows: About 20%-25% of timber that goes into making pallets is wasted in the production process as residue, hence it could be said that one ton of logs (raw material) results in about three-quarters of a ton of lumber suitable for pallet manufacture. Therefore, the maximum capacity at the sawmill receiving raw materials would be higher than at the pallet plant receiving lumber processed from the same inputs. For instance, 6 tons of logs processed at the sawmill would produce about 4.5 tons of lumber for the pallet plant. Also, the extra cost of processing logs or lumber beyond full capacity was made too high to influence program results. The reasoning behind this is that by setting high costs for any output beyond the initial capacity limit, it means that the plant's physical capacity is non-expansible. This not only requires less data but also eliminates more complications relating to interpretation of results.

Computation Problems

With respect to the algorithm used in the program, it appears that it was written in the Fortran IV programming language which was popular in 1960s. Hence the language had to be modified in order to be compatible with the current language in use on microcomputers-Fortran 77. This revised standard was completed and issued for commercial use in 1977. The program was keypunched from a source code into a floppy disk using an IBM PC XT microcomputer. Conversion of the source code to machine code was accomplished through compilation and adjustment of the program to fit the MS-DOS operating system. MS-DOS provides commands for memory management, file management, input/output control and program control.

COSTS OF MODELING AND PROGRAMMING

Certainly the research costs entailed in attaining solutions to the study problem cannot be ignored. From the time of problem definition, it took about one year and a quarter to realize results of this effort. In terms of man-hour allocations explained below, this means that a full one man-year was spent to implement this model once conceptualized. The research costs can be assessed from three perspectives:

Data Collection

The nature of this task involved mainly secondary data collection because primary data collection would be very time consuming and costly. About seven months were spent in collecting and processing data. Around twenty hours per week were spent on the activity throughout this period. Library sources provided most data needed for the study. Other major sources for data were: Michigan State University research findings and publications, federal agencies - particularly USDA, Michigan Departments of Natural Resources and Commerce, and National Wooden and Pallet and Container Association (NWPCA).

Model Design

Formulation and construction of the model required about seven months to accomplish. One had to ensure that the model definition fit the study problem. This involved adjusting and improving upon the model structure. The result was appropriate flowcharts reflecting all the variables and analytical nature of the problem. The statements were then refined and translated into FORTRAN language. During the 5 months time period, about 30 hours per week were spent on this portion of research.

Costs of Programming

Considerable time and resources were used in computing the results. This program was run on an IBM PC XT microcomputer. Initially the original unmodified program was run on a mainframe computer at the University of Pittsburgh in late

1960s. The available source code was keypunched on the micro-computer. Once this was done several runs were completed to ensure model validity to get solutions. This also involved testing for sensitivity analysis. A programmer assisted in FORTRAN coding and programming operations (debugging). This task took about three months of about 40-hour weeks.

ADJUSTMENT OF THE MODEL AFTER TESTING

After several computer runs of the model, some adjustments were necessary to provide realistic solutions to the problem. The number of supply regions and production locations had to be either equal or less than ten. This is because the computer program structure necessitated up to ten spaces for each of the two inputs (supply regions and production locations). Hence though the original number of supply points in the model was eleven, a way had to be found to reduce or aggregate them to nine supply points. Statistically, one had to ensure that minimum loss of information occurred.

Data required in the model assumed constant production costs for all locations. Yet the computer program demanded constant manufacturing costs but varying processing costs, hence production costs differed at all the locations.

Another bottleneck to the program was definition of product increments i.e., additional amount of input after each iteration. Since the unit of input for the computer program was per ton basis, I decided to put minimum unit of increment, i.e. one ton for each successive iteration.

Since the location model is demand driven, demand function parameters do control the execution and results of the program. Hence an effort was made to research relevant and appropriate demand parameters for the pallet product at various markets. National data figures reflecting consumption patterns of the pallet products over the years were applied to the local market areas. The A(K) and B(K) parameters represent intercept and slope values respectively of demand curves of the pallet market.

In a context of programming techniques and efficiency, certain recommendations for improving the location program seem appropriate at this juncture:

(a) One of the weaknesses of this program is the output format. It should be improved upon in both its text and band structure. For instance, construction of output tables would be more demonstrative by showing shipments matrices from each origin to destination of each point. Unit measurements should be explicitly shown in real variables, not in integer form as shown in the current program output.

(b) The program should handle parameters interactively for all files each time a program is running. As it now functions, three operations take place sequentially during each program run; (a) access of files externally, (b) modification of program, and (c) stoppage and initialization of program. This laborious process involves stopping operations during each step back and forth. There should be no need to consult the external editor, as now required. This modification warrants establishment of a data management subroutine that would change files automatically and internally. This would be accomplished at the same time the operating system is running the program. Use of the external editor in the location program structure is inefficient in terms of time.

INCOME AND EMPLOYMENT IMPACTS FROM THE INPUT-OUTPUT MODEL

After gaining an understanding of location factors and patterns in the pallet industry, input-output analysis was used to evaluate economic impacts. The input-output model ascertains the significance of the pallet industry in increasing economic growth of Michigan. This analytical method develops multipliers which are vital when assessing impacts associated with the introduction of a pallet firm(s) in the local economy. Results are generally conveyed in terms of output, income, and employment multipliers. In a way, this discussion takes the location analysis to its logical conclusion - the regional impact of new pallet firms.

Assuming that production output was maximized (full capacity) in the industry, location analysis of pallet industry might suggest plant locations at major urban markets such as Detroit and Toledo, in the southeast and Muskegon and Grand Rapids in the southwest. The same scenario might depict that rural based firms in the northeast could compete effectively for nearby urban markets of Saginaw, Flint and Midland. These markets and others would be assumed to be capable of absorbing extra output if industry is expanded.

Once the rationale for expansion of the pallet industry in the state is established, it becomes necessary to take the analysis one step further and define the economic impact flowing from such an expansion. This is done before one appraises the potential impacts of pallet firms on cities or communities. On the basis of such factors as the projected industry's output growth rate of 7.7% up to the year 1990, forecast of increased output sales from $12 million in 1984 to $19 million in 2000 (Data Resources Inc., 1985), surplus timber inventory in the state, comparative advantage of the industry in relation to the neighboring states, major pallet markets and other factors, one can assume that the demand for pallet products is increasing and is likely to remain so in the future. Hence let's take a hypothetical example: suppose ten new pallet plants were to be constructed in the Lower Michigan area, what would be their economic impacts on the region. This can be measured on the basis of income and employment accruing from the action. However, it is important to note that according to this study there is no need to build new plants in the state in the foreseeable future because surplus capacity currently exists in the pallet industry.

Income Impacts Scenario

Impact is defined by a multiplier. In this instance, the income multiplier indicates value of income generated in the state for each additional dollar of final demand for the pallet sector's output. According to an input-output analysis of Michigan's forest products sectors, it was found that the wood pallets sectors had a Type I income multiplier of 1.917 and Type II income multiplier of 2.491 (Chappelle, et al., 1986). In this analysis, the Type II income multiplier is appropriate since the households sector is removed from final demand and considered an endogenous sector in order to capture the full local income multiplier effect (i.e., the induced effect). If ten new pallet plants are constructed in the region, total income accruing to the state would be $9.37 million. It is calculated in the following manner; in respect to the input-output analysis, wood pallets sector had total annual sales of $73.32 million in the state in 1980. A typical pallet plant in the study produces at full capacity of 500 units per 8-hour day. There are 198 plants in the state, most small in size. On an annual basis, this typical plant could manufacture 120,000 pallets (19 board feet each) or process about 2.3 million board feet of lumber. On average, a single plant's annual output is then $0.37 million ($73.32 million/198). Hence ten new pallet plants (assuming identical technology) would deliver annual sales of $3.7 million (10/198 * $73.32 million). Given Type II income multiplier of 2.491, total income generated for the state becomes $9.22 million ($3.7 million * 2.491).

Estimated New Employment

Employment multipliers indicate the number of jobs generated in the state for each additional dollar of final demand for the sector's output.

Given the ten additional pallet plants built in the region there should be 160 to 190 workers employed. This is because a typical plant in our study assumed employment of 16 to 19 workers. However given Type II employment of 2.069, total number of indirect and induced jobs for the state would be between 331 (2.069 * 160) and 393 (2.069 * 190).

CHAPTER VII

EVALUATION OF THE MODEL

CRITICISM OF THE IDEAL MODEL

The model used in this study is a revised and modified version of the basic Hoover's industry location model (Hoover, 1967). It is called a pallet firm-location model. However, it is important to note that the Hoover model is general and data sets were developed that apply to the pallet industry. The model gauges how the location pattern of the pallet industry can be affected by a variety of assumed changes in resource availability, input costs, transport costs, processing costs, or market locations as a direct or indirect result of project (plant) establishments.

As noted by Hoover (1967, p. 1):

> The (model) solutions describe the impact in terms of location shifts (including shifts in the patterns of material and product flows) and also provide information on the change in the overall "efficiency" of the industry's location pattern as measured by total output or average delivered cost of the product with a given pattern of demands at the various markets.

However as with any economic model, certain assumptions inherent in the formulation of the Industry Location model might not jibe with reality of given situations and cases in the real world. The model's major assumption that the solutions are "optimal" implies existence of perfect competition in an industry amongst other assumptions. That is, prevailing conditions guarantee a free impersonal market in which the market forces of demand and supply, or of revenue and cost determine the allocation of resources and the distribution of income.

In general, a purely competitive industry possesses the following four characteristics:

(I) Each firm in the industry is small relative to the market, i.e., it can exert no perceptible influence on price or produces only a very small fraction of the total output of the industry. If any single firm were to double its rate of output or cut its production, the impact on the total output of the industry would not be noticed.

(II) The second feature of perfect competition is that consumers, producers, and resource owners must possess perfect knowledge or be fully informed. In its fullest sense, perfect knowledge requires knowledge of the future as well as the present.

(III) It is assumed that there are no significant barriers to entry to a purely competitive industry. Capital costs required of prospective competitors are not so prohibitive that they are effectively barred from entering the industry. In short, free mobility of resources requires free and easy entry and exit of business firms into and out of an industry.

(IV) Finally, all firms in the industry produce a product that for all intents and purposes is homogeneous. The important point is that the product produced by each of the firms must be indistinguishable in the minds of the consumers, whether real or imagined.

Noting the assumptions and inherent characteristics above should automatically convince an observer that no market (for instance the pallet market dealt with in this study) has been or can be perfectly competitive. Though Hoover's industry location model makes an allowance for homogeneous product assumption, the model cannot meet the requirement for perfect knowledge in an industry under economic scrutiny or analysis.

Even though the pallet industry in Michigan tends to be dominated by relatively small firms, which is one of the preconditions for pure competition, one still finds monopolies abound here and there in certain areas of the state (especially in cases of vertically integrated firms). Finally the assumption of free mobility of resources is very difficult to realize particularly in a natural resource based industry such as the pallet industry where imperfect factor mobility constraints, imposed by such factors as land, biomass, capital, and technology plays an important role in location of the business firms.

Nevertheless, as indicated before, no industry, including the pallet industry, can pass all the tests for perfect competition. Economic models tend to be overly "abstract". Yet one should recognize that it is precisely this abstraction that makes the model a powerful analytical tool. Hence in this case, the location model provides a standard that measures how efficiently the pallet industry operates in providing the product to consumers at minimum delivered cost. This is especially important fact since much stumpage is in public ownership.

CRITICISM OF THE APPLIED MODEL

The applied model in this study has its origins in Hoover's Industry Location model which is a general model. It is important to reiterate that data sets used here only applies to the pallet industry. Hence it is labelled a firm-location model that deals with locational shifts within the pallet industry in Lower Michigan. This applied model has certain weaknesses in its characteristics and assumptions. It also differs in many respects from the original general model (Hoover, 1967).

Temporal Dimension

One of the major deviations is that this analysis deals with a natural resource based product (a pallet) which has physical, biological, and economic components to its utility. Timber which is the source of raw material for pallets, grows and matures over decades before it can be commercially utilized in the production process. Hence there is a temporal dimension with respect to varying stumpage productivity and supply over time as a consequence of biological processes and must be considered. The temporal dimension can also be applied to the manufacturing process of pallets since such factors as depreciation and rate of technological turnover do influence output of a physical plant over its physical life span which can be anywhere from a range of 20 to 40 years. However the applied model like the general model is static. Hence the temporal aspect of the problem involving time element is not captured in the model structure.

Aggregation Error

Another criticism of this study model has to do with delineation of regions, locales, or spaces for location analysis. Though this is a general problem in regional economics field, aggregation poses a particular concern in this research with regards to drawing boundaries of supply regions and production locations. Hence two complications ensue; first, the basis of aggregation of counties to form supply regions and production centers - this concerns finding focal points in space as origins of measurements to other points in space. Secondly, definition of routes of travel that link supply regions to the markets via production locations. Though a factor such as economies of concentration (agglomerative factor) tends to affect delineation of space and activity, the magnitude of aggregation error still cannot be under estimated. This particularly affects direction and outcome of project results.

Demand Function

Estimates of current (future) demand and price levels should be a major determinant of capital expansion in the pallet industry. In addition, estimates of demand can assist forest resource managers to evaluate current forest programs, establish timber growth objectives, and aid in structuring forest policies and programs. Most econometric models of pallet markets are national in scope, and hence the demand function data used in most regional studies including the location model applied in this study, have their origins from the same aggregate base. This makes for distorted values and results for a specific region such as Michigan or the Great Lakes. The current demand function parameters are not perhaps true with respect to the local consumption and price figures in Michigan. Therefore there is need to develop regional or state econometric models that would reflect demand functions for specific related markets. Furthermore, the pallet market can be segmented according to end-product markets such as the automobile industry market, the food pallet market, and the general industrial market. The resultant econometric models for each of these markets would provide significant information to pallet manufacturers in these markets.

Transport Cost-Configuration

In the applied location model, an assumption is made that the best route between points in space is measured in terms of minimum distance. Yet this is not necessarily true in the real world. This is because a transport (transfer) cost assessment is a function of both distance and road quality amongst other variables. Nevertheless these two factors play a crucial role in determining routes used for transportation. At the same time the exact "least cost" criterion is unrealistic due to complex mathematics, computation time, and costs involved to determine transport costs for every possible route. The pallet location model assumes that four-lane highways are the ones used. This may not always be true since other transport mediums such as waterways, railways, country side roads or freeways can be used to transfer timber or lumber. In addition, this model assumes that a tractor-trailer travelling at 45 m.p.h. might further distort the true time-distance picture of the situations in that it is major determinant of mileages between places and the one used to compute transfer costs in the model. If for example, a truck travels at a higher speed (say, 53 m.p.h.) the transport rates of lumber to sawmills, then from there to pallet plants might over estimate actual value paid by pallet manufacturers for hauling. The opposite would occur when trucks travel at a lower speed. The shipping cost formulae used in this analysis is not necessarily the optimal or "the best" one. Further, it does not specifically encompass all transportation problems and logistics of pallet industry for it is a general shipping cost formula that applies to any wood products industry. Hence it might not reflect the true transfer rates of pallet rates in the region. Unfortunately, there is a lack of transportation data specific for the pallet industry in Michigan. Errors caused by all the above mentioned factors in transport cost configuration have an important bearing on results of the pallet firm-location model. This is because transport cost is a major variable in the formulation and computation of industrial location analysis.

Pallet Unit Definition

To provide comparable information on requirements for wood pallet firms in Michigan, certain assumptions have to be made. The major assumption deals with the units in which location requirements will be expressed. The usual accounting practice of wood-using firms is to express cost items in dollar per sales unit, e.g. per thousand board feet of lumber, per thousand square feet of particle board, or per ton of pulp. On the other hand, in considering differences between locations, the figures available to the firm are normally expressed in terms of the units by which the inputs are sold: labor in daily or hourly wages, wood in thousand board feet or cords, forest land in acres. For the pallet firm-location model requirements are expressed in the latter terms - the units by which these items are bought by pallet firms. Hence wood is measured in thousand board feet (bd. ft.) - this is necessary if one is to make evaluations of alternative locations. A pallet unit (load) in the model is equal to a production output of a typical Michigan pallet plant or firm per year. Each plant processes 1.3 million board of lumber as inputs or manufactures 68,000 pallets (19 board feet per unit) outputs per year. Hence a quoted pallet plant capacity figures represents total amount of stumpage flow or output for a given path that sustains a typical pallet firm for a year in business. Production figures are totalled on a yearly basis depicting legitimate business expenditures such as transportation, labor, harvest and operating costs. Market prices are calculated for the whole pallet unit (load). These yearly figures are used to permit location factors to be evaluated on a common basis, hence assessing the magnitude of location factors and their relative impact on location analysis.

Supply and Demand

Implicit in the model is the assumption that supply equals demand: whatever the firm produces is consumed in the market. In the real world, this is rather difficult since there is erratic demand for a product at any given time. This is because the pallet market is strongly influenced by overall general economic activity (especially the prices pallet consumers receive for their products), while it is only weakly affected by activity (most significant being pallet prices) within the forest products markets (Luppold, et al., 1986). The business cycle (as influenced by the national economy) and state of the regional economy impact the nature of supply and demand for pallets in the markets. Hence various factors result in peaks or dips of demand for pallets and consequently their supply. This is because a pallet good is an industrial commodity in that it is a good whose demand is derived from demands for final consumer goods. Hence its demand fluctuates more than a typical consumer good given the linkages involved.

ASSESSMENT OF THE MODEL FOR POLICY ANALYSIS

The purpose of this section is to ascertain the suitability of this model for a policy objective, i.e. to analyze if there is potential for expansion of the pallet industry in Michigan. In other words, how does the model formulation relate to policy variables sought after in the study. There are political and economic issues that are not fully captured in the model structure. These issues are beyond the economic environment in which the industrial location model presumably operates, but nevertheless still play a key role in the long run. Hence when the pallet firm-location model is examined in terms of its relevance to policy problems, some pitfalls do emerge. They can be observed under the following headings:

Timber Supply

One limitation has to do with the nature of the product and its raw material supply patterns. The product (pallet) is a forest resource product, and hence the raw material supply pattern is a reflection of the regional timber supply pattern. Significance of location factors in the pallet industry cannot be appreciated without understanding the relations governing business decisions. These decisions not only involve business firms but also Government agencies. The forests as source of timber for pallets are owned by various institutions such as Federal, State, Local governments, and private industries/groups. Each ownership type pursues its own management objectives over the forest resources. the forest management programs executed by each group influences the availability and costs of timber for production processes of various wood products, including pallets. Most government units manage forest resources under the principle of multiple use. This means that a forest is managed for both resource conservation (non economic) and economic development purposes. Since government agencies own most of timber lands in Lower Michigan, it naturally implies that most of the timber market is controlled by those governmental bodies. Hence they possess monoplistic powers in the market place, thereby allowing the government to dictate price of raw materials or output produced. The industrial location model assumes that input or output costs are determined in the free market place. That ignores the reality when it comes to timber sales in the state. Government units influence raw material costs, which in turn affects product demand outcomes in the state at any given time.

Infrastructure

Raw material and product costs which play a major role in industrial location analysis are influenced indirectly by quality and efficiency of transport systems of the region under study. For example, when the State of Michigan undertakes to improve the transportation system, e.g., completion of a system of highways, building more railroad terminal facilities, port development, creation of waterways for vessels, etc. - these do have an impact on the relative advantages of a given area for industrial (firm) location. Construction of most projects are funded from tax revenues. Hence in areas such as Upper and Northern Lower Peninsula, which are well endowed with forests, transport improvement could tip the scales of locational advantage in their favor. Such an improvement might give the area an advantage over locations using inferior or high-cost materials which had existed because of nearness to markets. On the other hand in the southern region (Lower Michigan) which has densely populated market areas, transport improvement would cut costs of assembling raw materials there. Impacts of transportation policy is hardly built into the industry location model but it is sufficient to say that many questions of transportation policy can be analyzed using the model with different data sets.

Production Functions

In an empirical location study, results seem to be influenced by nature of production functions within an industry. The production function can be defined as the physical relationship between various inputs (including transportation inputs) and output. In the pallet industry, just as in any other industry, it is necessary to know (a) raw material inputs per unit of output, (b) the utility and labor of inputs, (c) manner in which these inputs vary with the size of plant, and (d) the manner in which the capital investments vary with the plant size. Using another facet of location analysis, an examination of an industry's production functions and market areas could indicate a spatial framework of areas or regions which are suitable for plant location (Airov, 1959). The technology of pallet manufacture suggests that the most important types of variables include raw materials (lumber), nails, transportation, and labor. The pallet industry is continually using more high technology in their production processes. Also increasingly more firms (about 20%) are trying to upgrade the value and quality of pallets by binding wood and metal together to produce a pallet unit. This also allows entrepreneurs to compete with others in a larger market radius. Innovation has also resulted in a new production technology called palletech process (Nies, 1985). This is a patented method of manufacturing industrial grade, molded wood, material handling pallets. This is a technological advancement over conventional lumber-mailed units. As opposed to labor intensive operations prevalent in the traditional technology, the palletech process is heavily capital intensive, and can be sold beyond the usual 100-150 miles radius typical of wooden pallets. Actually palletech pallets can be sold profitably up to 500 miles market radius.

Agglomeration Economies

Both location theory and the economics of pallet manufacture suggest the importance of agglomeration economies in industrial plant location. In general the pallet industry is dominated by small scale production plants. Minimum capital is required to start a pallet firm, hence this results in lower capital costs per unit of capacity. Due to low market values, pallet firms tend to be market-oriented taking advantages of localization economies. They tend to be in close proximity to their industrial consumers such as Michigan automobile manufacturers. A typical pallet firm in this study is assumed to be composed of two production units. This makes for a vertically integrated industrial structure (integration economies). One is a sawmill that reduces roundwood or logs to lumber. Then a pallet plant takes over to process this lumber to pallet parts and is finally assembled for the consumers (for more details see Chapter III).

Assessment

Though the industrial location model attempts to offer optimal results, it nevertheless has imperfections hampering its ability to answer fully policy questions posed by decision makers. The model is equipped to effectively handle economic variables in a static setting. Yet the non quantifiable variables (e.g. policy stipulations, rules or laws) that might affect the nature in which the industry operates are not fully captured by the model. Production functions of pallet firms are affected indirectly by these non-economic forces. The legislative enactments, law and rules on such matters as harvest criteria, tax rates, transportaion systems, freight charges, regional/local economic development plans, etc. influence the workings of the market. More specifically the pallet industry's production costs, such as stumpage costs, labor costs, and transfer costs are influenced indirectly by nature of business climate in the state caused by various laws enacted by the state. For instance Federal and State harvest rules affect the amount and quality of stumpage available for sale to sawmill owners. Also, state or local government efforts at road constructions and improvements could indirectly affect business owner's location decision. The nature of economic incentives and tax structures do enter into a firm's location decision calculation. An owner of a pallet firm interviewed for this study emphasized that Michigan's worker's compensation act was the most important single factor that in the future would affect his decision to operate or expand his business in the state. As can be observed, these non economic forces appear to have substantial clout (in the long run) in influencing results of industrial location analysis. If these exogenous dynamic variables (policy issues) are not taken into account in the location model, validity of results would be questionable. Hence their role in business location decisions should be considered simultaneously with the usual economic variables in any economic analysis. The magnitude of many of these intangible variables could be reflected in the input data sets. For instance, using different stumpage or freight rates for the pallet industry and testing their impacts on firm location decisions.

CHAPTER VIII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

To reiterate, the purpose of this study was to analyze the potential for expansion of pallet industry in Lower Michigan: i.e., examining whether there is "space" for expansion and if positive, analyzing spatial distribution of pallet firms in relation to surplus wood areas so as to determine future sites (routes) for location of pallet firms. This is accomplished in the context of resource constraint analysis and its impact on the locational aspects of the industry in Lower Michigan area. Results of locational analysis are linked with input-output multipliers to ascertain potential economic impacts of pallet firms on the state, if expansion were to take place. This chapter summarizes research findings in three parts: (a) summary of results, (b) highlighting conclusions and policy recommendations, and (c) ideas for refining methodology and data.

SUMMARY OF RESULTS

The results can be better understood when viewed in relation to three major issues discussed and analyzed in the course of study. These are

(a) interpretation of final results when the capacity factor is considered;

(b) surplus wood areas in relation to current pallet production locations;

(c) potential economic impacts of pallet firms on the region.

The main conclusion is that the pallet industry in Lower Michigan is operating at about 50% capacity in the context of the assumptions and data of location model. Hence expansion of the industry by investment in new plants in the region is not necessary at this point in time. Only when this excess capacity in the pallet industry is utilized, should an alternative of building new plants in the region be considered. However, if new pallet plants that are to be introduced use new technologies, the decision to build new plants in the region may be worth reconsidering. If new plants are built they may compete away market share from existing plants. Ignoring possible new technologies, it now appears, however, that the low capacity factor appears to be a reflection of the vitality and productivity of the pallet industry in the Lower Michigan area. The capacity could be increased in one of two ways or both concurrently; first, increased demand for pallet products and/or secondly, increased product market share relative to substitute products.

With regards to surplus wood areas, except for four counties (Allegan, Barry, Kent, and Montcalm) in Southern Lower Michigan, all counties endowed with surplus timber stock are in the Northern Lower Peninsula. In total twelve counties serve as reservoirs for timber for production purposes, including the pallet industry in Lower Michigan. These counties form a rim around the industrial Southern Michigan region. They have enough excess timber inventory and productive timber growth to sustain new forest products firms, pallet plants included. It is important to note this fact since the same wood could be used for manufacture of other products such as paper, plywood, construction lumber, etc. Nevertheless, these areas are within economic distance of the industrial consumer markets of southern Michigan.

Going back to the beginning, this study is an offshoot of a project that analyzed economic impacts of forest products sectors in the State using an input/output model (Chappelle, et al., 1986). The analysis projected that the wood pallets sector had the highest income multiplier of all the major forest products sectors. Hence increased use of pallet plants (as a result of increased product demand) in the suitable production zones would also generate considerable income for the counties and cities involved. Most of the major pallet markets are also locations for major industries such as chemicals, steel, machinery, and transportation equipment supplying both local and national markets.

However summarizing again, the pallet industry in Lower Michigan has excess capacity and increased demand can be met from the current plants without necessarily building new pallet plants in the region. Hence there is no need for expansion of the industry at this particular time unless demand doubles or increases considerably. Or unless more efficient pallet plants come in and compete away current market shares.

CONCLUSIONS

Lower Michigan (composed of Northern Lower Peninsula and Southern Lower Peninsula) was the focus of study region. Inventory of natural resources, particularly forest biomass was reviewed. Other socio-economic resources of the region were also considered. All this information was essential to achieve the analytical and policy objectives of the study. Manufacturing industries of the region were also examined to assess significance of their production output and sales. Forest products industries, particularly the pallet sector were further scrutinized for their impacts on the regional economy. Also the general nature, structure, and technology of pallet firms in the industry were studied. Surplus wood areas were located mostly in the Northern Lower Peninsula. These areas were then made timber supply areas suitable for forest products processing, particularly pallet manufacture.

Resource and economic constraints that influence pallet supply and demand were analyzed. Such factors as type of timber species, competition, demand, and pallet price were found to influence pallet production. Pallet market structure was also studied to realize its impact on demand. Certainly the study of constraints cannot be complete without understanding the role of Michigan's comparative advantage for pallet manufacturing.

The crux of this research was spatial analysis of pallet plants vis-a-viz surplus wood areas and markets in the region; i.e. to determine whether expansion of pallet industry is likely to be profitable in the region and if affirmative, selection of potential locations for future pallet plants in the region. This was accomplished through the use of an analytical tool, the pallet firm-location model. However, the main finding from the analytical results is that the production capacity (as defined by the model) of the current pallet plants is not fully utilized. Hence there is still room for increased output without construction of new plants. However should potential new pallet plants use new technologies, the possible introduction of new plants into the region should be reconsidered. Nevertheless existing plants can handle any foreseen increased demand for product.

Nevertheless should there be a decision to expand pallet industry in Lower Michigan, half of the best locations for new pallet plants are in the Northern Lower Peninsula and the rest in the Southern Lower Peninsula. The best locations in Northern Lower Peninsula for new plants would be eight counties: Roscommon, Ogemaw, Iosco, Mecosta, Osceola, Gladwin, Clare, and Midland. These counties are located at the southeastern end of the Northern Lower Peninsula bordering manufacturing metropolitan areas of Bay City, Saginaw, and Midland.

These forested counties are basically rural and optimally located to efficiently supply the big pallet markets of Flint, Detroit, and Toledo. The rest of the best areas (counties) for plant locations are near the urban centers of the Southern Lower Peninsula: these are Ingham, Jackson, Hillsdale, Muskegon, Ottawa, Monroe, and Kent. The results indicate two counties, Ingham and Jackson, as central places to locate pallet plants - because there are conveniently located to serve industrial cities of Detroit, Flint, Lansing, Battle Creek, and Toledo.

However, apart from the plant site analysis conducted in this study, another key factor that influences plant-location is the tax climate in an area or region. The tax climate, as one element in the general business reputation of a State, influences plant location decisions. It influences some location decision making by causing firms to exclude certain states or urban areas from consideration. Apart from financial inducements in the form of tax concessions, others take the form of low interest loans at State and local levels. These inducement packages could be manipulated to attract wood products firms to the State. This would apply especially to large capital intensive industries. Intensive forest management can also be fostered by legislating proper forest taxation laws and incentives to keep private landowners reinvesting in their lands for increased timber yield.

With the apparent surplus of timber in the region, the pallet consumption pattern rate becomes a constraint in determining use of timber as raw material for the industry. Hence resource supply (timber) becomes a commodity for the pallet industry only when its market demand exists.

The recently published forest products industry input/output model of Michigan provided coefficients necessary to assess impact of pallet industry on the state (Chappelle, et al., 1986). The multiplier analysis indicated that if income maximization is the policy objective pursued, then wood pallets should be given priority. Therefore, should the product demand increase, higher production output in the pallet industry should result in good economic results for the region. The next topic below explores policy avenues that would facilitate utilization of timber resources for commercial purposes as well as for general economic development efforts.

RECOMMENDATIONS

Strategies for Economic Development

The motive behind the selection of this research topic was desire by professionals (policy makers, economists, resource managers, businessmen, and planners) to identify resource sectors that could foster economic development in the state of Michigan. The basis of this action was an attempt to diversify and revitalize the sluggish economy of the state in the early 1980s.

One resource base not fully utilized was the forest resources. Hence the wood pallet sector was chosen for investigation as a result of possessing the highest input/output income multipliers amongst all the wood products sectors in Michigan. It is in view of the foregoing statements that strategies for forest resource development are defined, particularly as it relates to the wood pallets sector:

(I) In the study region, the largest single owner of commercial forest land is the state of Michigan. This is administered by the State Department of Natural resources. One realizes that the state's forest management policy is not to maximize timber production as the sole goal, but rather to manage under the multiple use concept. This means that other than for timber, public forests are managed for non-commercial purposes such as recreation, hunting, wildlife, and so forth while protecting the environment. Though evidence indicates there is surplus timber in state forests, there is insufficient demand to justify further processing of timber for pallet manufacturing.

(II) One effective way to increase timber use by industry is to stimulate derived demand. In the case of the pallet industry, evidence indicates insufficient demand to utilize the current industrial capacity. Since demand level is set in the market place, only increased demand will result in increased use of plants, if not expansion of the industry. However, the state can assist in this process by mounting a campaign to promote use of pallets, such as encouraging palletization of handling systems. Promotion through either incentives or advertising could boost use of this industrial good. Overall the effort by the state to attract and keep major automobile and chemical industrial complexes in the state will go a long way towards fostering demand for pallet products.

(III) Accessibility to forested areas can be facilitated by investment in transportation systems. The state has regulatory or revenue power to help accomplish this goal. Most forest products are transported by truck on public roads. Hence regulations pertaining to truck weights and load size influence volume of transferred wood products and therefore cost of transporting materials and products between places. Maintenance of the rail transport system in major forested areas should be encouraged by state regulations. Other transport systems, such as water transport, should be explored by the state as a cost-cutting device for wood products firms.

SUGGESTIONS FOR FURTHER RESEARCH

Methods developed in this study appear to be effective for spatial timber supply analysis, which can help guide regional economic development. However, these methods do not resolve fully all the technical and policy questions posed in determining optimal locations of establishments in the pallet industry (or for that matter, any wood products industry). Much needs to be done to improve research methods. Some areas where improvements can be made are suggested below. The first two relate to alternative model designs that could also solve the industrial plant location problem. The remaining two areas for improvement pertain to improved data required for pallet industry analysis.

(a) The location analysis can also be approached from a different angle. This involves use of a spatial equilibrium technique. It could be applied to study the pallet industry in Lower Michigan. The specific objective would be to determine the probable spatial organization of the pallet industry under future economic conditions with special emphasis on identifying conditions under which production plants could be moved closer to market areas, away from raw material locations (supply regions). For a given industrial structure, a spatial equilibrium model can be formulated to determine locations of manufacturing that will minimize total costs of all manufacturing and transportation for the entire industry. Since cost minimization is the rational behavior of entrepreneurs in a perfectly competitive industry, the solutions are reasonable forecasts of probable future spatial organization of an industry. However one should realize that results would be for the sector as a whole not for the individual firm as in the location model.

(b) Further in-depth analysis could be undertaken using econometric techniques that would serve one or more of the following objectives; (a) ascertain forces associated with location of individual pallet firms, (b) project spatial distribution of pallet firms, and (c) offer policy guidelines to local development planners in evaluating employment prospects for their counties or cities. Regression analysis is a statistical technique to estimate from empirical data the relationships between two or more economic variables. These methods would permit analysis of changes in the location of firms or plants and determine the variables associated with these changes (for more details see work done by Spiegelman, 1968). With regards to location analysis, as in this study, the regression model would highlight the magnitude of three key impacts of external forces on plant location: (1) transportation costs, (2) production costs, and (3) agglomeration factors.

(c) Most econometric studies of pallet markets are national in scope, hence there is need for research that would segment the markets according to appropriate geographic markets or consumer centers. In this case Michigan econometric models could be constructed so as to obtain a more accurate information on demand and price projections for pallet products in the state.

(d) Further research is also needed on forest resources as raw materials for the pallet industry in the state. This would attempt to correlate specific timber species to a particular economic activity or production location at a given time. In the case of the pallet industry, this implies the amount of specific species (e.g., maple) consumed by a given manufacturing technology at a location at a given time. Essentially this would be a spatial-temporal model of resource analysis for production or consumption purposes. Also related to this issue would be an effort to structure a model to determine optimal allocation of timber to product lines given timber resource constraint analysis.

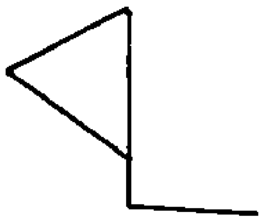
APPENDICES

APPENDIX A

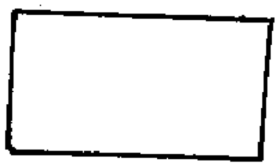
SYMBOLS FOR FLOWCHART

APPENDIX A - SYMBOLS FOR FLOWCHART

Beginning or ending of a program

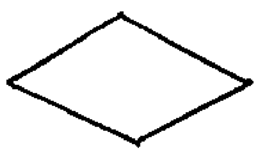


Start of Do Loop I
index j, Limits n, m.



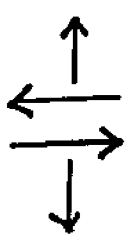
Process or Computation

Input or Output

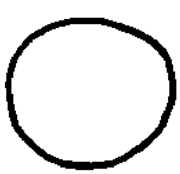


Decision

Print 'Information' or 'Results'



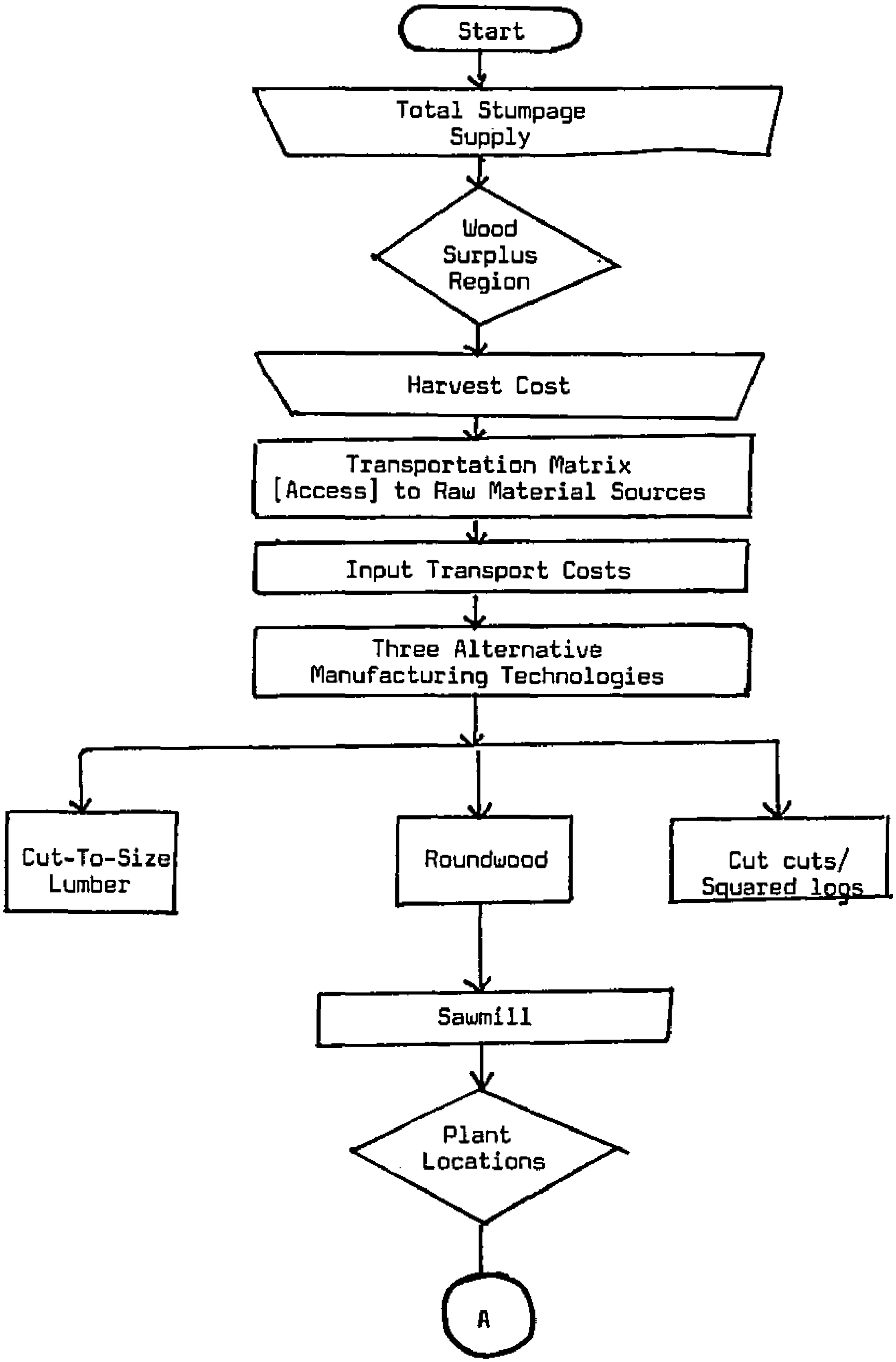
Operations sequence and
Dataflow direction

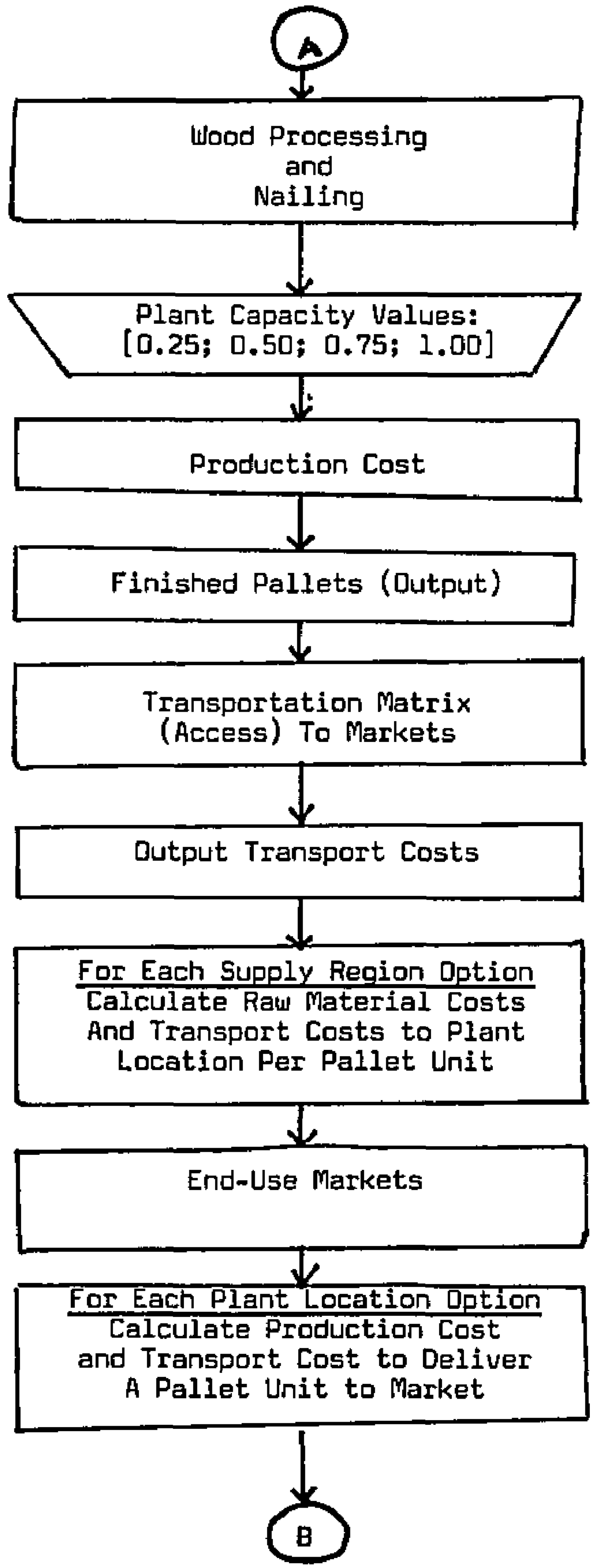


An entry form, or exit to another
part of the program flowchart

APPENDIX B

GROSS LOGICAL FLOWCHART


Start
Total Stumpage Supply
Wood Surplus Region
Harvest Cost
Transportation Matrix [Access] to Raw Material Sources
Input Transport Costs
Three Alternative Manufacturing Technologies
Cut-To-Size Lumber
Roundwood
Cut cuts/ Squared logs
Sawmill
Plant Locations
A


A
Wood Processing
and
Nailing
Plant Capacity Values:
[0.25; 0.50; 0.75; 1.00]
Production Cost
Finished Pallets (Output)
Transportation Matrix
(Access) To Markets
Output Transport Costs
For Each Supply Region Option
Calculate Raw Material Costs
And Transport Costs to Plant
Location Per Pallet Unit
End-Use Markets
For Each Plant Location Option
Calculate Production Cost
and Transport Cost to Deliver
A Pallet Unit to Market
B

B

Determine Delivered Cost

Totals for Each Pallet Unit

1. Raw material costs plus transport costs from each supply region to plant locations.

2. Production costs plus transport costs for each pallet unit from plant locations to markets.

3. Sum values; "2 + 3".

4. Shock the System: with alterna-capacity constraint values: [0.25, 0.50, 0.75, 1.00]

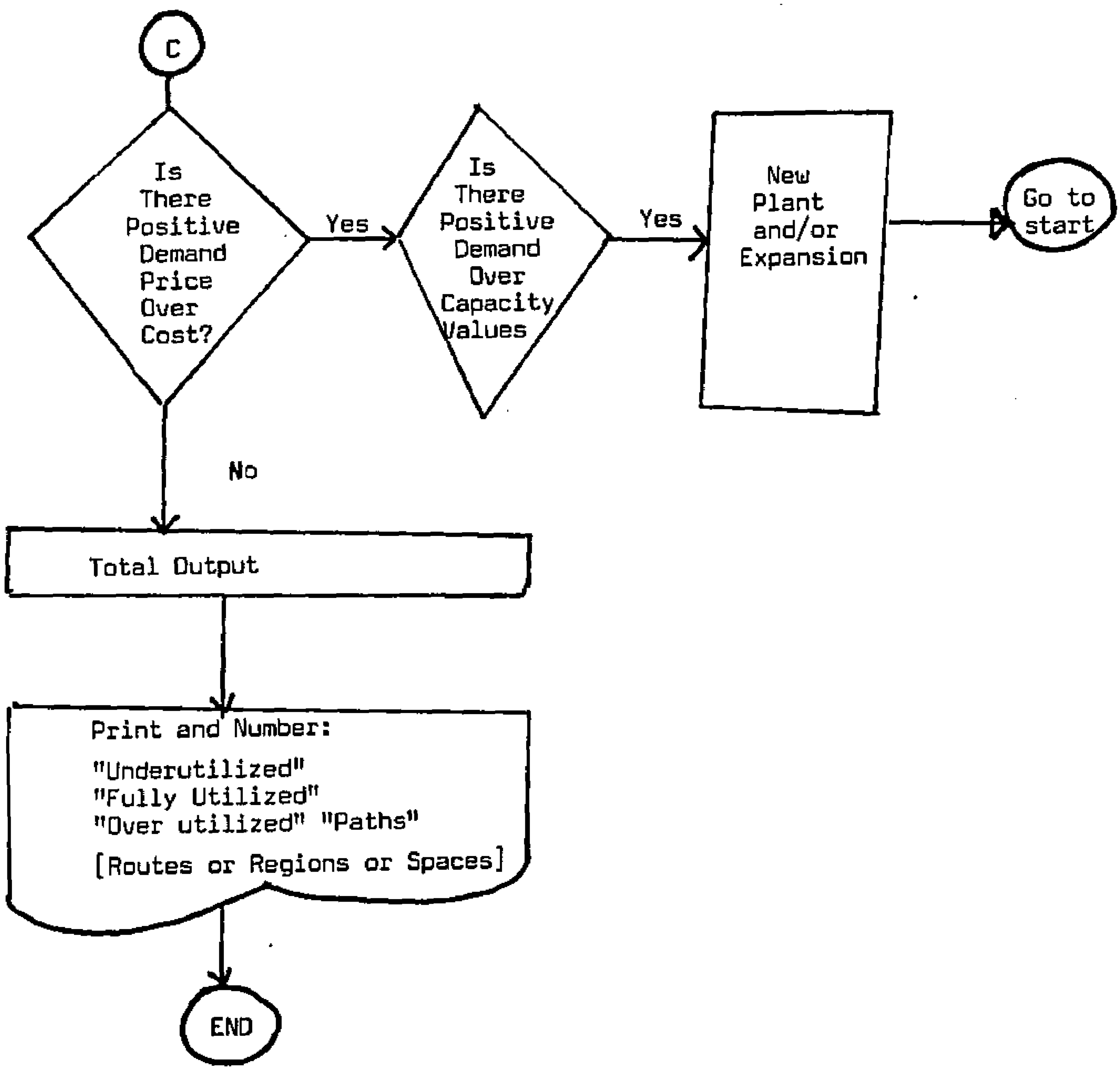
5. Calculate a delivered cost to markets. Total value: "2 + 3 + capacityvalues".

Print Table
With Pallet
Unit Prices at Markets

Unit Demand Price

Print Table With
Pallet Unit Prices
At Markets

C


C
Is There Positive Demand Price Over Cost?
Yes
Is There Positive Demand Over Capacity Values
Yes
New Plant and/or Expansion
Go to start
No
Total Output
Print and Number:
"Underutilized"
"Fully Utilized"
"Over utilized" "Paths"
[Routes or Regions or Spaces]
END

APPENDIX C

PROGRAM CODE NOTATION

APPENDIX C - PROGRAM CODE NOTATION

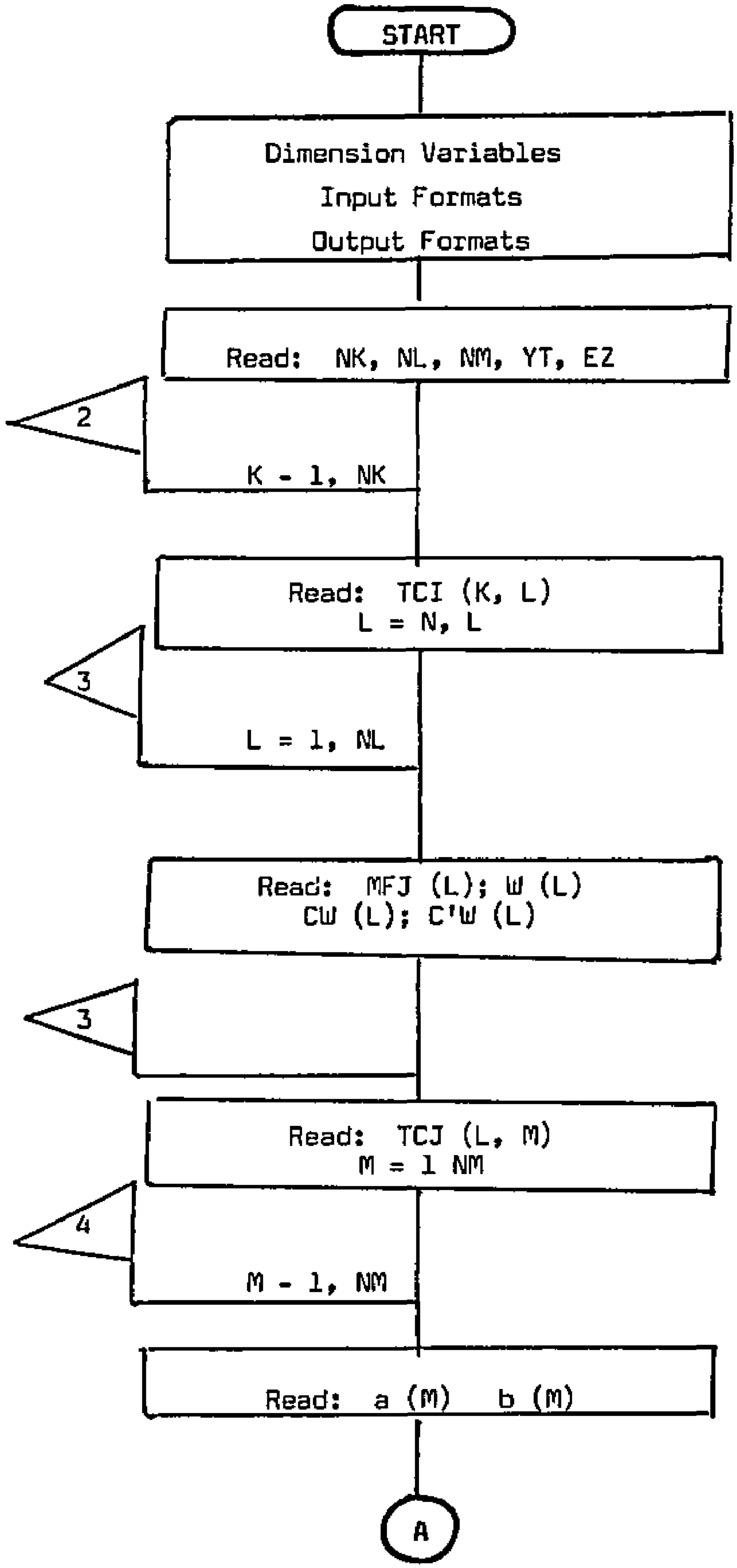
NK	= number of supply regions (K)
NL	= number of production locations (L)
NM	= number of markets (M)
YT	= timber yield in MBF (Y)
EZ	= stumpage supply in cords at each supply region K
TCI (K,L)	= transport cost of timber from source K to production point L
MFJ (L)	= manufacturing cost of pallet at a production point L
TCJ (L,M)	= transport cost of timber from production point L to market M
E	= total stumpage at each supply region K
F	= total output at each production point M
Y	= inventory of pallet units at plant location L
W	= capacity at plant location L
CW	= capacity constraint cost at plant location L
MR	= marginal revenue of a pallet unit
MC	= marginal revenue of a pallet unit
FD	= final demand for pallets at markets M
a (M); b (M)	= parameters of demand function set by market forces M
QJ (L)	= quantity of product shipped at production point L
QJ (L,M)	= quantity of product shipped from L to market M
y (M); w (M)	= parameters of demand function set at markets
N	= assignment of a valid path (N)

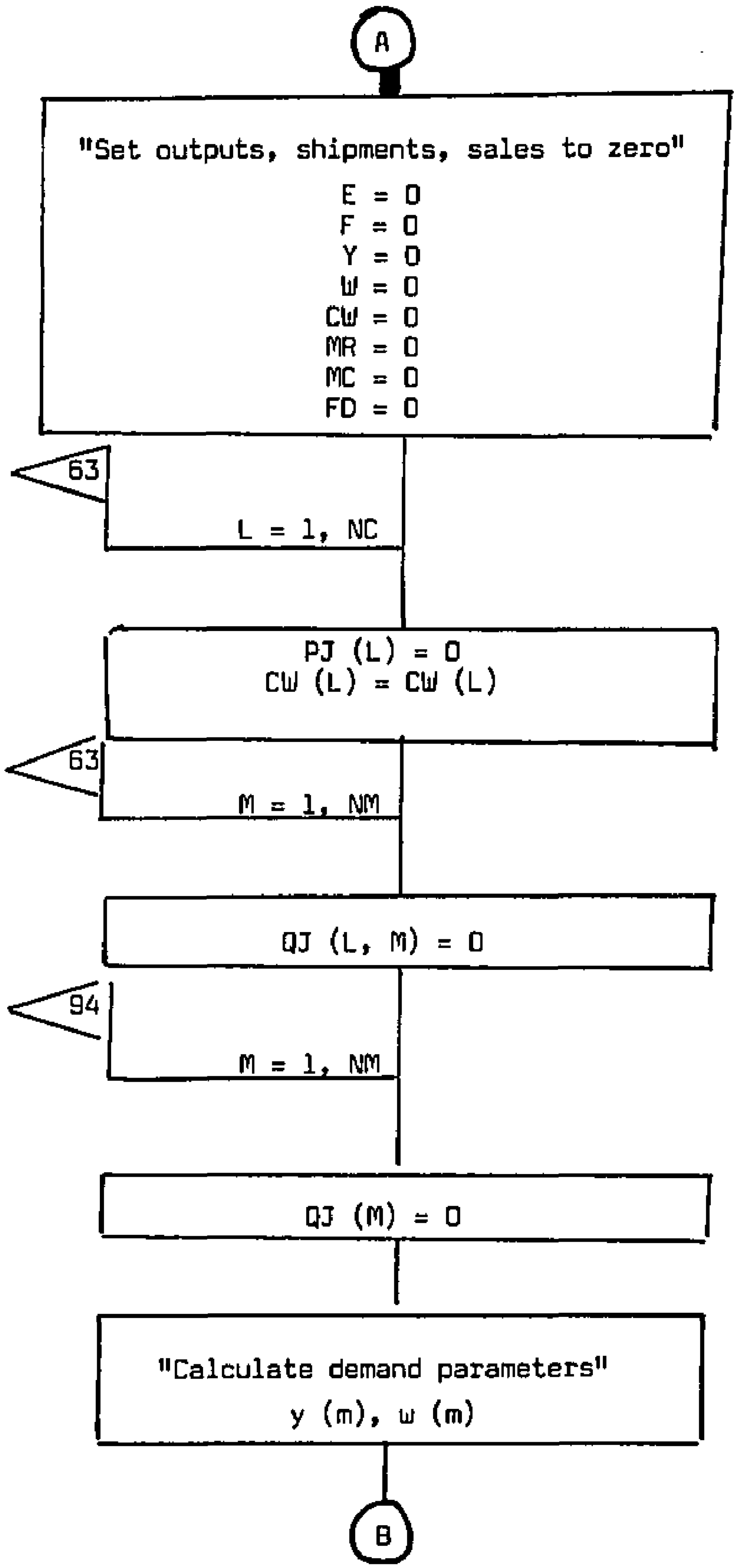
V	=	input/output ration (1)
A	=	raw material cost including harvest cost at supply region K
MF	=	manufacturing cost of pallets at plant location L
SC (K)	=	transaction costs including stumpage and transfer costs at K
SC (L)	=	transaction costs including processing and transfer costs at L
PJ (M)	=	pallet unit price at market M
CJ (L)	=	pallet unit cost at plant location L
WMAX	=	maximum capacity at plant location L
CW (L)	=	cost of capacity constraint at plant location L
NMAX	=	maximum number of valid paths
L	=	a route or path with the widest margin for extra input/output
W (L)	=	capacity potential of path L
CW	=	initial capacity constraint cost at plant location L
C'W	=	maximum capacity constraint cost at plant location L
M	=	invalid paths eliminated after an iteration
KMAX	=	exhaustion of supply regions K
LMAX	=	exhaustion of plant locations L
MO	=	set number of markets--where (MO = 7, 12, 17, 20)
DO	=	set volume of paths--where (DO = 567, 2352, 6137, 8000)
KO	=	set number of supply regions--where (KO = 9, 14, 19, 20)
KO	=	set number of production locations--where (KO = 9, 14, 19, 20)

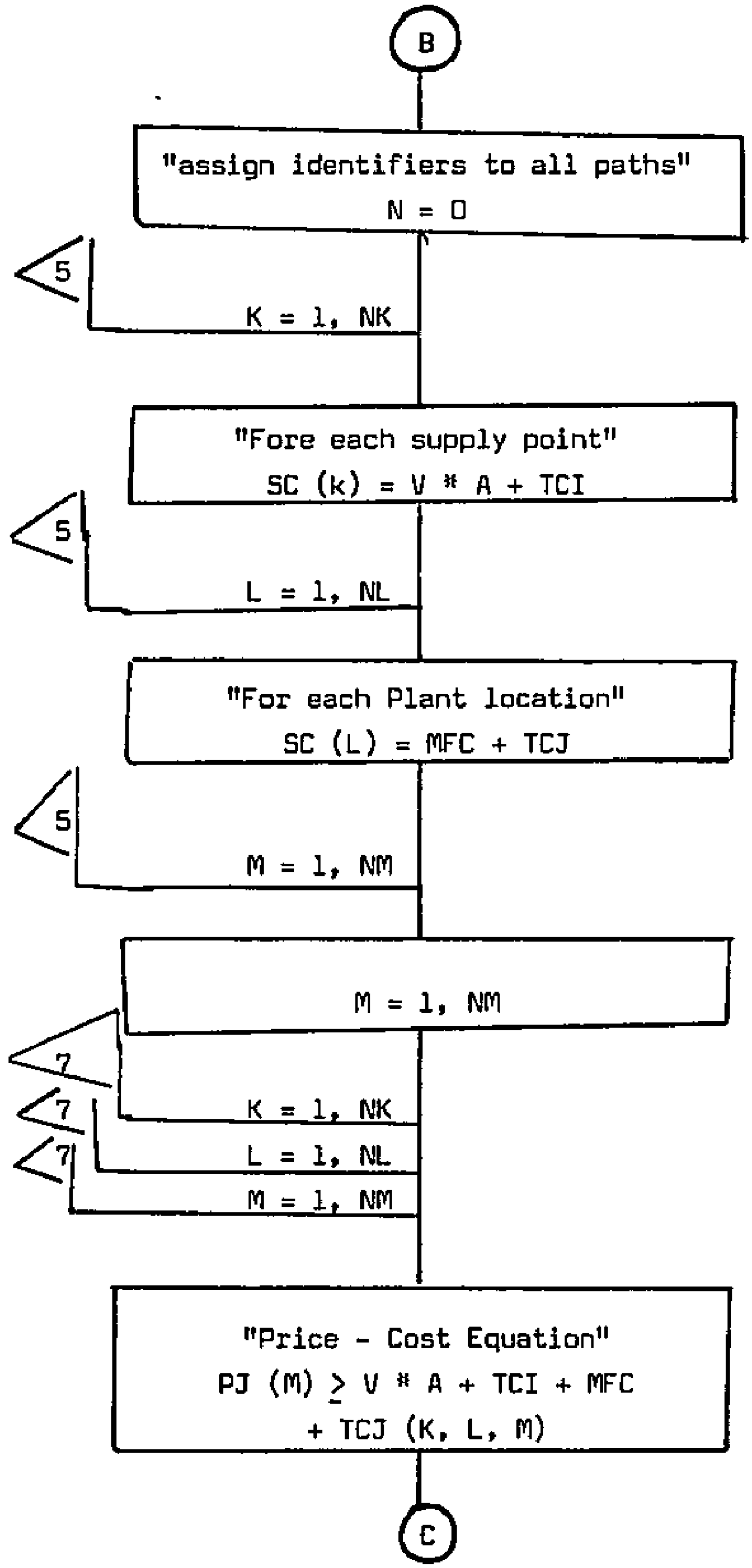
M - MO	= deviation of given number markets M from exogenously set number of markets M; M = MO
D - DO	= deviation of given volumes of paths D from exogenously set volume of paths DO
K - KO	= deviation of given supply regions K from exogenously set number of supply regions KO; K = KO
L - LO	= deviation of given production locations from exogenously set number of production locations LO; L = LO

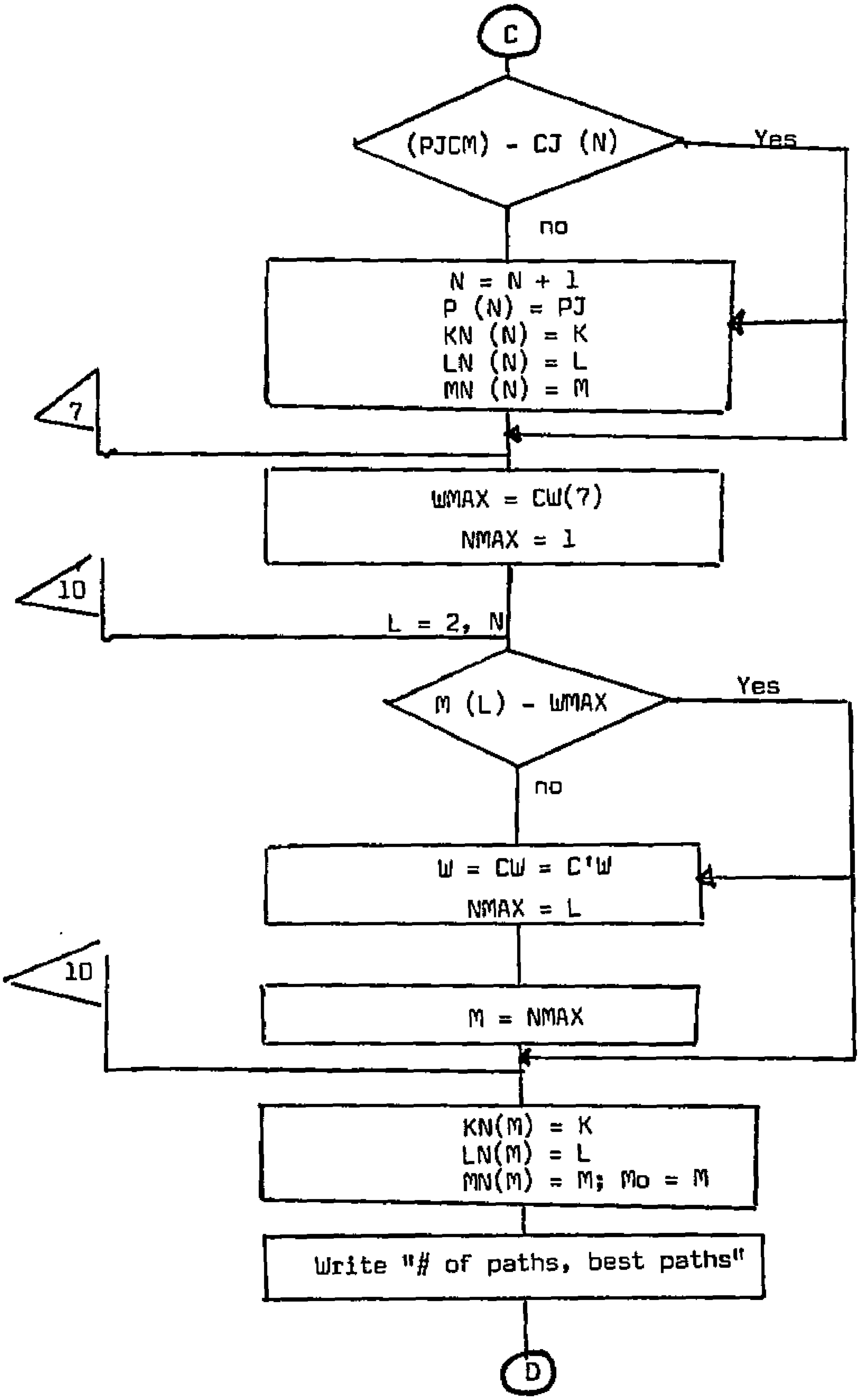
APPENDIX D

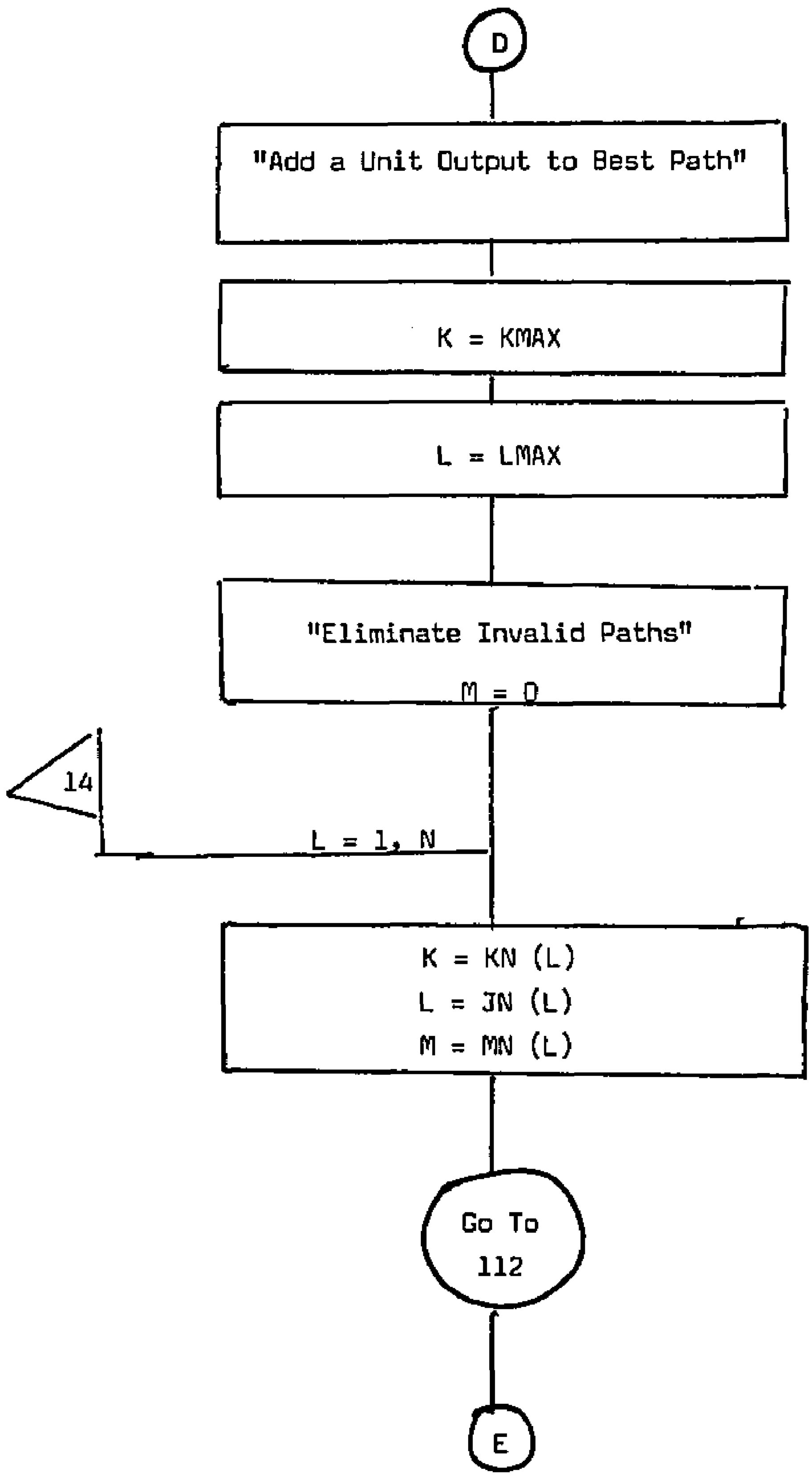
DETAILED FLOWCHART

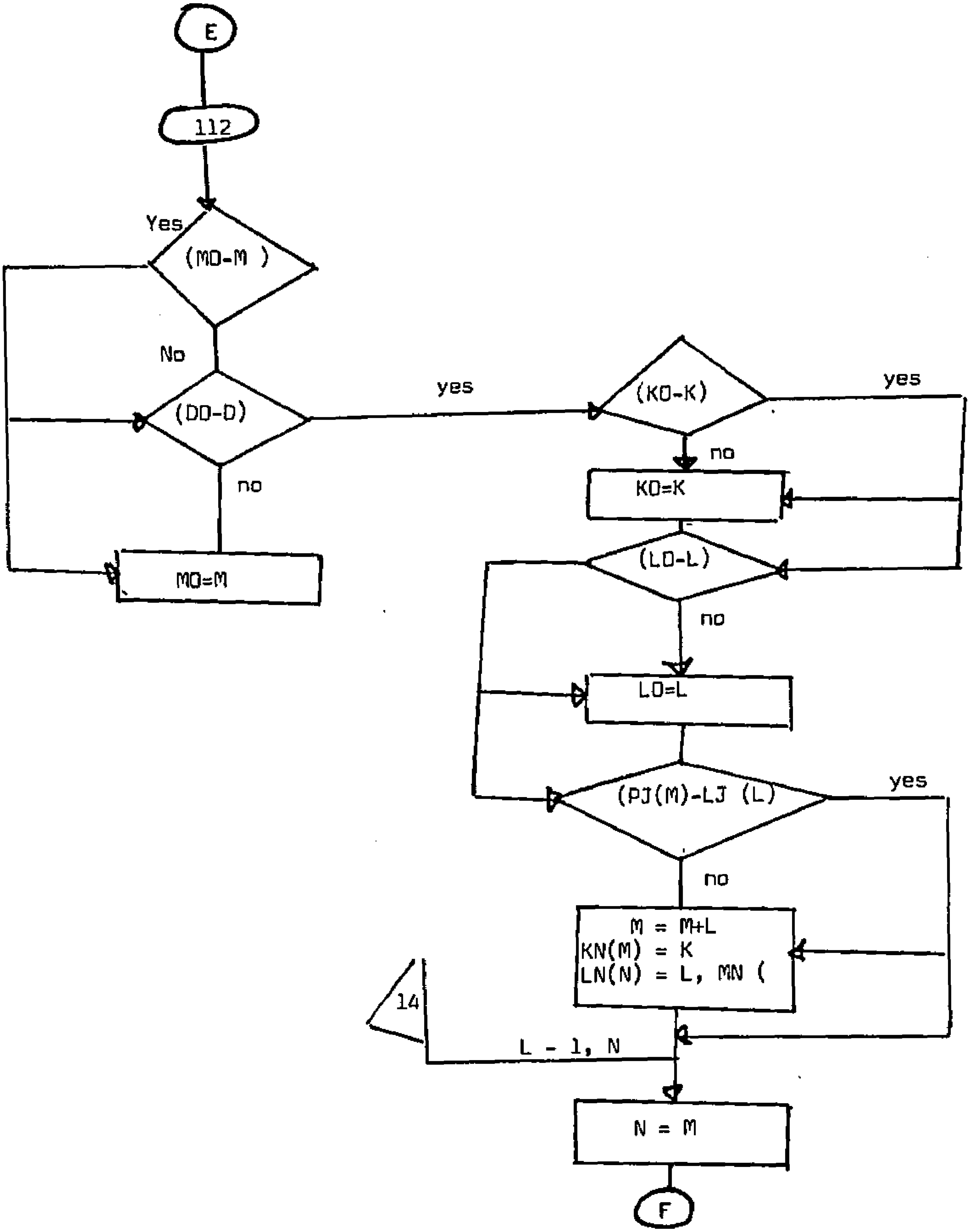

START
Dimension Variables
Input Formats
Output Formats
Read: NK, NL, NM, YT, EZ
2
K - 1, NK
Read: TCI (K, L)
L = N, L
3
L = 1, NL
Read: MFJ (L); W (L)
CW (L); C'W (L)
3
Read: TCJ (L, M)
M = 1 NM
4
M - 1, NM
Read: a (M) b (M)
A

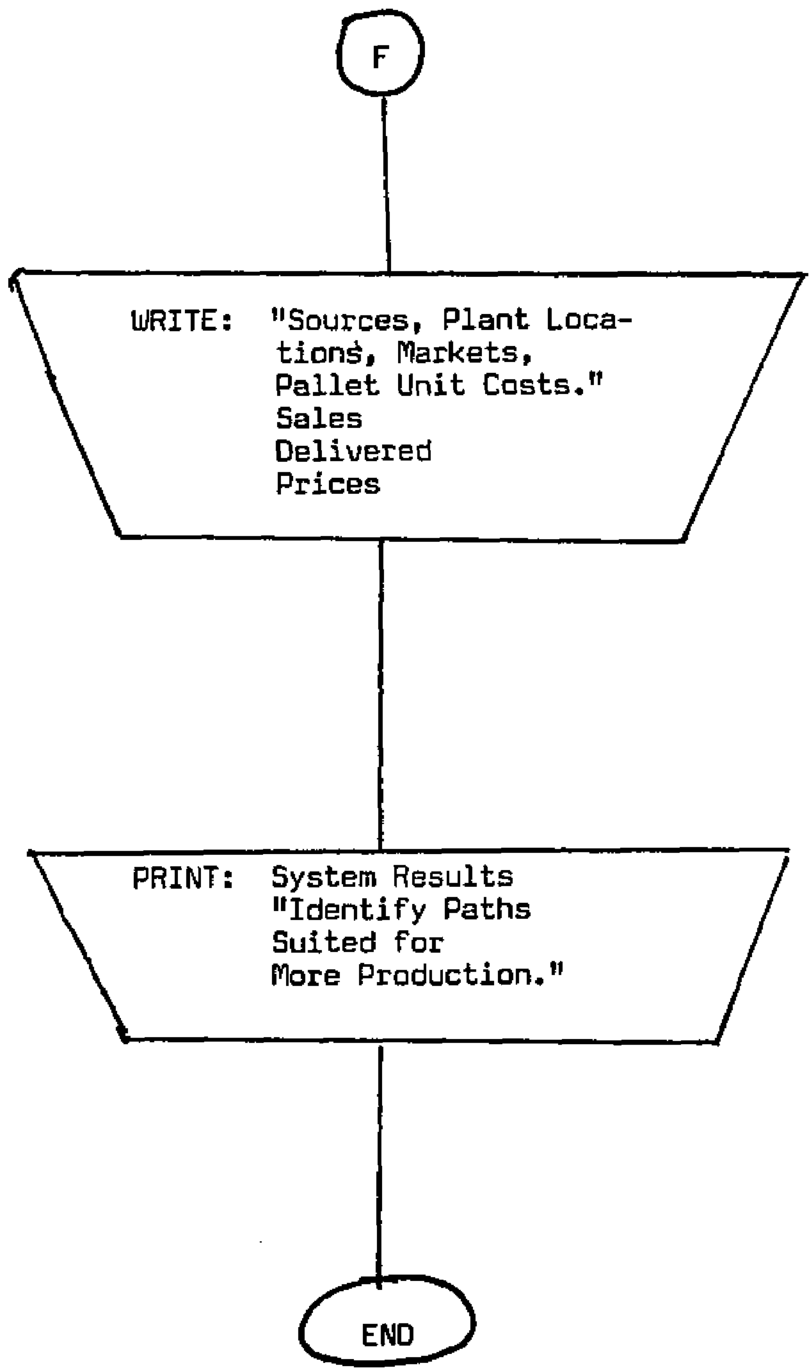

A
"Set outputs, shipments, sales to zero"
E = 0
F = 0
Y = 0
W = 0
CW = 0
MR = 0
MC = 0
FD = 0
63
L = 1, NC
PJ (L) = 0
CW (L) = CW (L)
63
M = 1, NM
QJ (L, M) = 0
94
M = 1, NM
QJ (M) = 0
"Calculate demand parameters"
y (m), w (m)
B


B
"assign identifiers to all paths"
N = O
5
K = 1, NK
"Fore each supply point"
SC (k) = V * A + TCI
5
L = 1, NL
"For each Plant location"
SC (L) = MFC + TCJ
5
M = 1, NM
M = 1, NM
7
K = 1, NK
7
L = 1, NL
7
M = 1, NM
"Price - Cost Equation"
PJ (M) ≥ V * A + TCI + MFC
+ TCJ (K, L, M)
C


C
(PJCM) - CJ (N)
Yes
no
N = N + 1
P (N) = PJ
KN (N) = K
LN (N) = L
MN (N) = M
7
WMAX = CW(7)
NMAX = 1
10
L = 2, N
M (L) - WMAX
Yes
no
W = CW = C'W
NMAX = L
10
M = NMAX
KN(M) = K
LN(M) = L
MN(M) = M; Mo = M
Write "# of paths, best paths"
D


D
"Add a Unit Output to Best Path"
K = KMAX
L = LMAX
"Eliminate Invalid Paths"
M = 0
14
L = 1, N
K = KN (L)
L = JN (L)
M = MN (L)
Go To
112
E


E
112
Yes
(MO-M)
No
(DD-D)
yes
no
MO=M
(KO-K)
yes
no
KO=K
(LO-L)
no
LO=L
(PJ(M)-LJ (L)
yes
no
M = M+L
KN(M) = K
LN(N) = L, MN (
14
L - 1, N
N = M
F


F
WRITE: "Sources, Plant Locations, Markets, Pallet Unit Costs." Sales Delivered Prices
PRINT: System Results "Identify Paths Suited for More Production."
END

APPENDIX E

SOURCE CODE LISTING

APPENDIX E - SOURCE CODE LISTING

```
      PROGRAM LOCATION
C
C     FIRM - LOCATION PROGRAM
C     PALLET INDUSTRY STUDY
C     AUGUST, 1986
C     ORIGINAL LOCATION PROGRAM NO. 6 BY EDGAR HOOVER, 1966
C     REVISED VERSION BY ALEX OBIYA AND NILSON AMARAL: 1986
C     NK          =  NUMBER OF MARKETS
C     NI,NJ       =  NUMBER OF SOURCES OR PROD. LOCS.
C     I,J,K       =  SUBSCRIPTS INDENTIFYING SOURCES, PROD. LOCS., MARKETS
C     TM          =  TRANSPORTATION COST ON MATERIALS FROM SOURCE, PER TON
C     TP          =  TRANSPORTATION COST OF PRODUCT TO MARKET, PER TON
C     AMI         =  TONS OF MATERIAL PER TON OF PRODUCT
C     CP          =  COST OF PROCESSING, PER TON (CONSTANT)
C     CAPM, CAPP = CAPACITY AT SOURCE OR PROD. LOC.
C     U = SIZE OF PRODUCT INCREMENT, IN TONS
C     A,B,W,Y = PARAMETERS OF DEMAND FUNCTION
C         Q = A - BP   OR   P = W - YQ
C     EXM, EXP = EXTRA COST OF PRODUCING BEYOND INITIAL CAPACITY
C
      DIMENSION CM(10),CAPM(10),QM(10),TM(10,10),SM(10,10),CP(10),
     1          CAPP(10),QP(10),TP(10,10),SP(10,10),Q(10),W(10),
     2          Y(10),D(1000),IN(1000),JN(1000),KN(1000),A(10),B(10),
     3          P(10),EXM(10),EXP(10),CAPME(10),CAPPE(10)
C
C     READ DATA
C
      OPEN(2,FILE='DATALOC')
      READ(2,*)NI,NJ,NK,U,AMI
      DO 2 I  =  1,NI
         READ(2,*)CM(I),EXM(I),CAPM(I)
2     CONTINUE
      DO  20001  I  =  1,NI
          READ(2,*)(TM(I,J),J=1,NJ)
20001 CONTINUE
      DO 5 J  =  1,NJ
         READ(2,*)CP(J),EXP(J),CAPP(J)
5     CONTINUE
      DO  50001  J  =  1,NJ
          READ(2,*)(TP(J,K), K=1,NK)
50001 CONTINUE
      DO 7 K  =  1,NK
         READ(2,*)A(K),B(K)
7     CONTINUE
C-----------------------------------------------------------------------C
C         SET OUTPUTS, SHIPMENTS, AND SALES TO ZERO                     C
C-----------------------------------------------------------------------C
      SQ     =   0.
      SV     =   0.
      SQM    =   0.
      CMXT   =   0.
      CAPMT  =   0.
      CPXT   =   0.
      CAPPT  =   0.
      IA     =   0
```

```
      JA     =   0
      DO   75   I=  1,NI
           QM(I)     =   O.
           CAPME(I) =   CAPM (I)
           DO 75     J  =  1,NJ
           SM (I,J)     =  O.
75    CONTINUE
      DO 97   J   =   1,NJ
         QP(J)    =   O.
         CAPPE(J) =   CAPP(J)
         DO 97   K   =   1,NK
            SP(J,K)  =   O.
97    CONTINUE
      DO 112 K = 1,NK
         Q (K) = O.
C----------------------------------------------------------------------C
C          COMPUTE DEMAND PARAMETERS W AND Y                           C
C----------------------------------------------------------------------C
         Y(K) = 1./B(K)
         W(K) = A(K)/B(K)
112   CONTINUE
      WRITE(0,67)
67    FORMAT ('     ASSIGNMENT OF OUTPUT INCREMENTS',//)
      WRITE(0,68)
68    FORMAT(23X,'N',4X,' DMAX',9X,'I J K',/)
C----------------------------------------------------------------------C
C     COMPUTE INITIAL MARGINS FOR ALL VALID PATHS, ASSIGN NUMBERS      C
C----------------------------------------------------------------------C
      N = 0
      DO 15   I   =   1,NI
         DO 15   J   =   1,NJ
            DO 15    K   =   1,NK
               DT=W(K)-Y(K)*(Q(K)+U)-TP(J,K)-CP(J)-AMI*(TM(I,J)+CM(I))
               IF(DT)15,12,12
12             N = N+1
              D(N) = DT
             IN(N) = I
             JN(N) = J
             KN(N) = K
15    CONTINUE
C----------------------------------------------------------------------C
C        IDENTIFY BEST PATH                                            C
C----------------------------------------------------------------------C
10    DMAX = D(1)
      NMAX = 1
      DO    16   L  =  2,N
           IF(D(L)-DMAX)16,16,18
18         DMAX = D(L)
           NMAX = L
16    CONTINUE
      M  =  NMAX
17    I  =  IN(M)
      J  =  JN(M)
      K  =  KN(M)
      KA =  K
```

```
C-----------------------------------------------------------------------C
C          PRINT NUMBER OF PATHS, BEST PATH, MARGIN                     C
C-----------------------------------------------------------------------C
      WRITE(0,69)N,DMAX,I,J,K
69    FORMAT(10X,I5,2X,F10.2,2X,I5,2X,I5,2X,I5)
C-----------------------------------------------------------------------C
C          ASSIGN OUTPUT TO BEST PATH                                   C
C-----------------------------------------------------------------------C
      QM(I) = QM(I) + AMI*U
      IF(QM(I)+U*AMI-CAPME(I))22,22,21
21    IA     =  I
22    QP(J)  = QP(J)+U
      IF(QP(J)+U-CAPPE(J))19,19,23
23    JA    =    J
19    SM(I,J) = SM(I,J)+AMI*U
      Q(K)    = Q(K)+U
      SP(J,K) = SP(J,K)+U
C-----------------------------------------------------------------------C
C          REDUCE MARGINS, ELIMINATE INVALID PATHS                      C
C-----------------------------------------------------------------------C
      M = 0
      DO 20   L   =   1,N
         I    =    IN(L)
         J    =    JN(L)
         K    =    KN(L)
         IF(K-KA)76,77,76
77       DT   =    D(L)-Y(K)*U
         GO TO 50
76       DT =      D(L)
50       IF(I-IA)401,402,401
402      DT = DT - AMI*EXM(I)
401      IF (J - JA) 124,403,124
403      DT = DT - EXP(J)
124      IF (DT) 20,51,51
C-----------------------------------------------------------------------C
C             COUNT VALID PATHS, RENUMBER                               C
C-----------------------------------------------------------------------C
51       M = M + 1
         D(M) = DT
         IN(M) = I
         JN(M) = J
         KN(M) = K
20    CONTINUE
      N = M
C-----------------------------------------------------------------------C
C            RELEASE CAPACITY CONSTRAINTS                               C
C-----------------------------------------------------------------------C
      IF (IA) 500,500,501
501   CAPME(IA) = 100.*CAPME(IA)
      IA = 0
500   IF (JA) 502,502,503
503   CAPPE(JA) = 100.*CAPPE(JA)
      JA = 0
C-----------------------------------------------------------------------C
C          WHEN ONE PATH REMAINS, ASSIGN FINAL OUTPUT INCREMENT         C
```

```
C---------------------------------------------------------------------C
502   IF(N-1)44,17,10
C---------------------------------------------------------------------C
C          OUTPUT ASSIGNMENTS FINISHED, PRINT RESULTS                 C
C---------------------------------------------------------------------C
44     DO 30 I = 1,NI
C---------------------------------------------------------------------C
C          PRINT RESULTS FOR SOURCES AND MATERIAL SHIPMENT            C
C---------------------------------------------------------------------C
           WRITE(O,24)I
24         FORMAT('* SOURCE*',I2,/)
           WRITE(O,25)CAPM(I)
25         FORMAT (5X,' INITIAL CAPACITY     =',F8.0)
           WRITE(O,26)QM (I)
26         FORMAT(5X,' OUTPUT               =',F8.0,/)
           SQM = SQM + QM(I)
           CAPMT = CAPMT + CAPM(I)
           CMX = CAPM(I) - QM(I)
           IF(CMX)81,82,80
80         CMXT = CMXT + CMX
           WRITE(O,83)CMX
83         FORMAT (7X,' NO EXPANSION, IDLE CAPACITY IS =',F8.0)
           GO TO 130
82    -    WRITE(O,84)
84         FORMAT (7X,' INITIAL CAPACITY FULLY USED')
           GO TO 130
81         WRITE(O,84)
           GROW = -CMX
           WRITE(O,85)GROW
85         FORMAT (7X,' CAPACITY EXPANSION FULLY USED IS =',F4.0)
130        IF(QM(I))30,30,331
331        WRITE(O,86)
86         FORMAT (1HO)
           DO 3030 J = 1,NJ
              IF(SM(I,J))3030,3030,28
28            WRITE(O,29)J,SM(I,J)
29            FORMAT(5X,' SHIPMENTS TO P.L. = ',I2,F9.0)
3030       CONTINUE
30     CONTINUE
       DO   31   J   =   1,NJ
C
C          PRINT RESULTS FOR PROD.LOCS. AND PRODUCT SHIPMENT)
C
            WRITE(O,32)J
32          FORMAT (' ',//,' PRODUCTION LOCATION = ', I2,/)
            WRITE(O,25)CAPP(J)
            WRITE(O,26)QP(J)
            SQ    =    SQ + QP(J)
            CAPPT = CAPPT + CAPP(J)
            CPX = CAPP(J) - QP(J)
            IF (CPX) 181,182,180
180         CPXT = CPXT + CPX
            WRITE(O,83)CPX
            GO TO 230
182         WRITE(O,84)
```

```
          GO TO 230
181       WRITE(0,84)
          GROW = -CPX
          WRITE(0,85)GROW
230       IF (QP(J)) 31,31,332
332       WRITE(0,86)
          DO 3131 K = 1,NK
             IF(SP(J,K))3131,3131,128
128          WRITE(0,129)K,SP(J,K)
129          FORMAT(5X, ' SHIPMENT TO MKT. = ',I2, F9.0)
3131      CONTINUE
31     CONTINUE
       EXCM = CMXT + SQM
       EXCP = CPXT + SQ
       POO  = EXCM/AMI
       DO   36   K  =  1,NK
            P(K)   =   W(K)-Y(K)*Q(K)
            SV     =   SV + P(K)*Q(K)
C
C         PRINT RESULTS FOR SALES AND DELIVERED PRICES
C
          WRITE(0,37)K
37        FORMAT (' ',4(/),15X, ' MARKET = ',I2,/)
          WRITE(0,38)Q(K)
38        FORMAT (20X,' SALES, TONS          =',F8.0)
          WRITE(00,39)P(K)
36     CONTINUE
39     FORMAT(20X,' PRICE PER TON        =',F8.2,//)
       Z         =      SV/SQ
C
C           PRINT SYSTEM RESULTS
C
       WRITE(0,150)
150    FORMAT (' ',10X,' TOTALS FOR SYSTEM',///)
       WRITE(0,151)
151    FORMAT (15X,' SOURCE CAPACITY')
       WRITE(0,158)CAPMT
158    FORMAT (10X,' INITIAL      =',F8.0)
       WRITE(0,159)EXCM
159    FORMAT (16X,' EXPANDED     =',F8.0)
       WRITE(0,160)POO
160    FORMAT (23X,' (ENOUGH FOR',F8.0, ' TONS OF PRODUCT)',/)
       WRITE(0,152)SQM
152    FORMAT(15X,' SOURCE OUTPUT          =',F8.0,/)
       WRITE(0,153)CMXT
153    FORMAT (15X,' CAPACITY UNUSED      =',F6.0,5(/))
       WRITE(0,154)
154    FORMAT (15X,' PROCESSING CAPACITY')
       WRITE(0,158)CAPPT
       WRITE(0,159)EXCP
       WRITE(0,155)SQ
155    FORMAT (/15X,' PROCESSING CAPACITY  =',F6.0,/)
       WRITE(0,153)CPXT
       WRITE(0,156)SQ
156    FORMAT (15X,' TOTAL SALES            =',F6.0)
```

```
      WRITE(0,157)Z
157   FORMAT (15X,' AVE. DEL. PRICE        =',F8.2)
C------------------------------------------------------------------------C
C          CALCULATION OF TOTAL COSTS AND RENTS                          C
C------------------------------------------------------------------------C
      COST = 0
      DO  170   I   =  1,NI
          COST = COST + CM(I) * QM(I)
          IF(QM(I)-CAPM(I))172,172,171
171       COST = COST+EXM(I)*(QM(I)-CAPM(I))
172       DO  170   J   =   1,NJ
          COST = COST + TM(I,J)*SM(I,J)
170   CONTINUE
      DO 173   J   =   1,NJ
         COST = COST + CP(J)*QP(J)
         IF(QP(J)-CAPP(J))175,175,174
174      COST = COST+EXP(J)*(QP(J) - CAPP(J))
175      DO 173 K= 1,NK
         COST = COST + TP(J,K)*SP(J,K)
173   CONTINUE
      RENT = SV - COST
      RENTP  = 100.*RENT/SV
      WRITE(0,46)SV
      WRITE(0,47)COST
      WRITE(0,48)RENT
      WRITE(0,49)RENTP
46    FORMAT (' ',5(/),' VALUE OF OUTPUT              =',F8.2)
47    FORMAT (' ',' TOTAL COST                    =',F8.2)
48    FORMAT (' ',' RENT                          =',F8.2)
49    FORMAT (3X,'( ', F8.2,' PERCENT OF OUTPUT VALUE)')
      END
```

APPENDIX F

COMPILED DATA FOR THE MODEL

APPENDIX F - COMPILED DATA FOR THE MODEL

The supply and production locations are represented by identifiers (two-letter variables). Whereas markets are spelt out by name. There are 9 supply regions, 9 production centers, and 7 major market centers (see Table F-1). In a matrix format these add to 567 possible routes that one pallet capacity unit (load) could travel through in a given year from raw material source to a given market to satisfy equivalent capacity unit demand.

To reiterate, the basic purpose of the firm-location model is to determine which routes (spaces) need extra production plant or whether the production output could be expanded to meet capacity potential of each firm (plant).

For each path (space), the total costs of manufacturing and delivering a pallet unit are compared with market price when sales in that unit are just one unit:

$$V * A + TC + MF = D$$

V = raw material/product

A = cost of raw material (harvest cost)

MF = manufacturing/production cost including labor cost and normal profit margin

D = demand price of pallet unit at market

TC = transport cost--access to raw material plus movement to markets

A pallet capacity unit (load) in this model is equivalent to production output of a typical Michigan pallet plant (198 firms) which manufactures 68,000 pallets (19 board feet each) or processes about 1.3 million board feet of lumber as raw material in a given year. Hence a cited pallet capacity unit represents the minimum amount of output or raw material flow in a given route that can sustain a typical pallet firm in business for a year (capacity unit/route/year). Production figures are summarized on a yearly basis detailing business expenditures for every essential item such as transportation, harvest, labor costs, etc. Market prices too are calculated (for convenience) for the whole capacity unit. In order to serve as inputs for the computer program, these figures are further broken down to a per ton basis, e.g. price of input or output per ton per route. As a result of this, the time frame is also comparatively reduced from a yearly basis to a working hourly basis e.g. price of input/output per route per hour (ton/route/hour).

D-PRODUCTION COSTS AT PLANT (FIRM) LOCATIONS

The equation below shows how production cost is arrived at by adding raw material cost (A) and manufacturing cost (MF). One should notice that these costs are assumed constant throughout the study area.

On per capacity unit basis:

A	+	B	=	PROD. COST
\$260,000	+	\$325,000	=	\$585,000/capacity unit/route/year

On per ton basis:

A	+	B	=	PROD. COST
\$ 37.00	+	\$ 46.25	=	\$ 83.25/ton/route/hour

E-TRANSFER (SHIPMENT) COSTS - Matrix computation formula

Transport costs are estimated for the entire network, i.e. from supply regions through the production zones ultimately to the markets. Final figures are shown in Tables F-2, F-3, F-4, and F-5.

(i) supply region to production location

\$/one capacity unit (cord)/route/year:

9.34 + 0.0579 (miles)

For example, shipping timber or logs from Montcalm County to a production plant in Ingham County:

9.34 + 0.0579 (60 miles * 1371 cords = \$17571.90

On per ton basis:

This is equivalent to \$ 2.50/ton/route/hour

(ii) production location to market

pallet transfer--allowing for 20% waste in transformation process.

\$/one capacity unit (mbf)/route/year:

10.25 + 0.14 (miles)

e.g., transporting pallets from St. Clair County to Detroit:

10.25 + 0.14 (56 miles) * 1.3MBF = \$ 18,813.6

On per ton basis:

This is equivalent to \$3.34/ton/route/hour

F-DEMAND PRICE AT MARKETS - constant figure

Pallet price is assessed at 0.50/board foot based on earlier stipulations in Chapter V.

Based on the basis of one capacity unit that a typical plant would sell in a given market, market price becomes:

1.3 MBF * 0.50/board foot = $650,000/capacity unit

On per ton basis:

This is equivalent to $92.50/ton

G-CAPACITY ALTERNATIVES

Plant capacity is one key variable that affects program results. The capacity value can be expressed in different terms; either in physical units (weight or volume) of output processed at a given time period (hour, day, week, month or year). The maximum capacity of the small pallet plant applicable to this model does not exceed 500 units per 8-hour day in a 5 day-work week. As a reminder, 1 pallet unit contains 19 board feet of wood and 185 board feet is approximately equal to 1 ton of lumber. However the results are tested under varying capacity estimates i.e. shocking the computer program exogenously with different capacity values:

A - 25%

B - 50%

C - 75%

D - 100%

Capacity value estimates (units or weights) for different time periods are shown in Table G-1.

H-SENSITIVITY ANALYSIS

Further testing and verification of the model takes the form of testing sensitivity to spatial and temporal dimensions.

(i) varying timber supply sources and timber productivity in periods between 1980 and 2010. (periods 1980, 1985, 1995 and 2010 as inputs)

(ii) rate of capital and technological turnover (0 - 40 years)

(iii) general sensitivity analysis (response to changes in parameters)

Table G-1 also represents mathematically calculated solutions which can be compared for consistency and practicality to the computer results of the firm-location model.

TABLE F-1

SYMBOL DESCRIPTORS FOR SUPPLY, PRODUCTION AND MARKET LOCATION

INCLUDED COUNTIES IN A SUPPLY REGION	SYMBOLS (model-program)	
Allegan-barry-Kent	AB	1
Otsego-Montgomery-Alpena	OM	2
Crawford-Oscoda-Alcona	CO	3
Roscommon-Ogemaw-Iosco	RO	4
Clare-Gladwin-Midland	CG	5
Osceola-Mecosta-Montcalm	OM	6
Grand Traverse-Leelanau-Benzie	GL	7
Manistee-Mason-Osceana-Muskegon	MM	8
Charlevoix-Antrim-Kalkaska-Missaukee	CA	9

INCLUDED COUNTIES IN A PRODUCTION ZONE	SYMBOLS (model-program)	
Berrien-Van Buren-Cass	BV	1
Muskegon-Ottawa-Kent	MO	2
Oceana-Newygo-Montcalm-Mason	ON	3
Oscoda-Alpena-Iosco-Arena-Ogemaw	OA	4
Clare-Midland	CM	5
Jackson-Ingham	JI	6
St. Clair-Macomb-Oakland-Wayne	SM	7
Monroe-Lenawee	ML	8
Cheboygan-Otsego	CO	9

INCLUDED CITIES IN A MARKET LOCUS	SYMBOLS (model-program)	
Jackson	JAC	1
Lansing-East Lansing	LAN	2
Flint	FLI	3
Muskegon-Grand Rapids	MUS	4
Ann Arbor-Detroit-Toledo	DET	5
Kalamazoo-Battle Creek	KAL	6
Midland-Bay City-Saginaw	SAG	7

TABLE F-2

DISTANCES IN MILES BETWEEN SUPPLY SOURCES AND PRODUCTION LOCATIONS

PRODUCTION LOCATIONS		1 BU	2 MO	3 ON	4 OA	5 CM	6 JI	7 SM	8 ML	9 CO
SUPPLY SOURCES										
1	AB	55	29	83	148	165	89	186	83	271
2	OM	267	227	158	146	89	181	228	214	75
3	CO	252	212	143	94	71	162	176	192	59
4	RO	185	145	76	57	36	97	137	134	115
5	CG	217	178	108	58	32	125	140	155	98
6	OZ	123	80	68	119	141	134	224	168	222
7	GL	146	103	77	135	92	158	218	191	194
8	MM	235	195	125	149	92	183	231	216	113
9	CA	100	56	59	141	140	112	208	145	245

SOURCE: Michigan Department of State Highways and Transportation. 1980.

TABLE F-3

DISTANCES IN MILES BETWEEN PRODUCTION LOCATIONS AND MARKETS

MARKETS		1 JACKSON	2 LANSING	3 FLINT	4 MUSKEGON/ GD. RAPIDS	5 ANN ARBOR/ DETROIT/ TOLEDO	6 KALAMAZOO/ BT. CREEK	7 MIDLAND/ BAY CITY/ SAGINAW
PRODUCTION LOCATIONS								
1	BV	97	104	148	78	160	58	177
2	MO	106	80	123	32	153	63	184
3	ON	132	99	130	59	172	100	141
4	OA	99	68	33	124	86	122	91
5	CM	138	105	107	142	161	157	17
6	JI	37	5	47	74	77	56	78
7	SM	116	100	56	170	56	154	106
8	ML	5	37	77	108	71	50	117
9	CO	221	190	152	247	206	244	124

SOURCE: Michigan Department of State Highways and Transportation. 1980.

TABLE F-4

TRANSPORTATION COSTS ($) PER TON OF PALLETS
FROM SUPPLY SOURCES TO PRODUCTION LOCATIONS

PRODUCTION LOCATIONS		1 BU	2 MO	3 ON	4 OA	5 CM	6 JI	7 SM	8 ML	9 CO
SUPPLY SOURCES										
1	AB	2.44	2.15	2.76	3.49	3.69	2.83	3.92	2.76	4.88
2	OM	4.88	4.39	3.61	3.47	2.87	3.87	4.40	4.24	2.67
3	CO	4.67	4.22	3.44	2.88	2.62	3.65	3.81	3.99	2.49
4	RO	3.91	3.46	2.68	2.45	2.23	2.92	3.37	3.34	3.12
5	CG	4.27	3.83	3.04	2.47	2.18	3.23	3.40	3.57	2.92
6	OZ	3.21	2.73	2.59	3.16	3.41	3.34	4.35	3.72	4.33
7	GL	3.47	2.99	2.69	3.35	2.86	3.61	4.28	3.98	4.01
8	MM	4.48	4.03	3.23	3.51	2.86	3.89	4.43	4.26	3.10
9	CA	2.95	2.45	2.49	3.41	3.40	3.09	4.17	3.46	4.69

SOURCE: DenUyl, R. B. and Associates. 1982.

TABLE F-5

TRANSPORTATION COSTS ($) PER TON OF PALLETS FROM PRODUCTION LOCATIONS TO MARKETS

MARKETS		1 JACKSON	2 LANSING	3 FLINT	4 MUSKEGON/ GD. RAPIDS	5 ANN ARBOR/ DETROIT/ TOLEDO	6 KALAMAZOO/ BT. CREEK	7 MIDLAND/ BAY CITY/ SAGINAW
PRODUCTION LOCATIONS								
1	BV	4.41	4.59	5.73	3.80	6.04	3.39	6.48
2	MO	4.64	3.97	5.08	2.73	5.86	3.53	6.65
3	ON	5.32	4.46	5.26	3.42	6.35	4.47	5.56
4	OA	4.41	3.66	2.75	5.10	4.12	5.06	4.24
5	CM	5.47	4.62	4.67	5.56	6.07	5.97	2.34
6	JI	2.85	2.03	3.11	3.81	3.89	3.35	3.93
7	SM	4.90	4.49	3.35	6.30	3.35	5.89	4.63
8	ML	2.03	2.85	3.89	4.68	3.74	3.19	4.93
9	CO	7.62	6.82	5.83	8.23	7.23	8.22	5.08

SOURCE: DenUyl, R. B. and Associates. 1982.

TABLE G-1

PRODUCTION OUTPUT ESTIMATES UNDER DIFFERENT PHYSICAL CAPACITY VALUES FOR A TYPICAL PALLET PLANT AT A GIVEN TIME PERIOD

	CAPACITY VALUE (PERCENTAGES)			
	25	50	75	100
HOUR				
units (pallets)	16	31	47	63
weights (tons)	1.61	3.21	4.82	6.42
board feet	297.85	593.85	891.70	1187.70
DAY				
units (pallets)	125	250	375	500
Weights (tons)	12.84	25.68	38.52	51.36
board feet	2375.4	4750.80	7126.20	9501.60
WEEK				
units (pallets)	625	1250	1875	2588
weights (tons)	64.20	128.40	192.60	256.80
board feet	11,877.00	23,754.00	35,631.00	49.173.00
MONTH				
units (pallets)	2500	5000	7501	10,001
weights (tons)	256.80	513.60	770.40	1027.20
board feet	48,508.00	95,016.00	142,524.00	190,032.00
YEAR				
units (pallets)	30,005	60,010	90,015	120,020
weights (tons)	3081.60	6163.20	9244.80	12,326.40
board feet	570,096.00	1,140,192.00	1,710,288.00	2,280,384.00

LITERATURE CITED

LITERATURE CITED

Airov, Joseph. 1959. The Location of the Synthetic-Fiber Industry: A case study in regional analysis. MIT Press and John Wiley and Sons, New York. 203 pp.

Blyth, James E. 1964. The Labor Resource for Expanding Wood Using Industries in Northern Minnesota. USDA For. Serv. Lake States For. Exp. Sta. Res. Pap. LS-2. St. Paul, MN. 27 pp.

Bradley, Dennis P. 1972. Improve Forest Inventory with Access Data - measure transport distance and cost to market. USDA For. Serv. North Central For. Exp. Sta. Res. Pap. NC-82. 21 pp.

Brindley, E. D. Jr. 1982. A Pallet - an Industrial Good. Pallet Enterprise. Vol. 1. Number 3.

Bureau of Economic Analysis. 1982. Regional Economic Information System. Washington, D.C.

Chappelle, D. E.; S. E. Suzanne; L. M. James; K. M. Kittleson and D. D. Olson. 1985. Economic Impacts of Michigan Forest Industries: A partially survey based input-output study. Res. Rep. #472, Michigan State Univ. Agr. Exp. Sta. 17 pp.

Chatterji, Manas. 1983. Management and Regional Science for Economic Development. Kluwer-Nijhoff Pub.: Boston-The Hague-London. 255 pp.

Data Resources Inc. 1985. Secondary wood/processing/remanufacturing demand analysis and forecast: Final report. Submitted to the Office of Business and Community Development, Michigan Department of Commerce. 167 pp.

Davis, Lawrence S.; E. F. Lyons and H. E. Burkhart. 1972. Analysis of the Southern Appalachian Hardwood Lumber Using Industry. For. Sci. 18(3): 247-260.

DenUyl, R. B. and Associates. 1982. Great Lakes Shipping, Transportation, and Markets for Michigan's Forest Products: A preliminary economic inquiry. Michigan State University. Coop. Ext. Serv. Mich-sg-82-500, East Lansing, MI. 25 pp.

Diamond, Jospeh P. 1977. Some Impacts on Resource Use by the Woodpulp Industry in Manistee County. Unpublished Ph.D. Dissertation, Michigan State University, East Lansing, MI.

Eichler, John. 1976. Wood Pallet Manufacturing Practices. Eichler Assoc., Cape Coral, Florida. 168 pp.

Grey, J.; Paul Elefson and D. C. Lothner. 1985. Timber Supply and Demand: A Lake States Regional Perspective. USDA, Forest. Serv., North Central For. Exp. Sta. Res. Rep. St. Paul, MN. 65 pp.

Heinen, S. E. and K. S. Ramm. 1983. Michigan Directory of Forest Product Manufactures. Michigan State Univ. Coop. Ext. Serv., For. Dept. East Lansing, MI. 136 pp.

Hoover, Edgar. 1967. Some Programmed Models of Industry Location. Land Econ. 43(3): 303-311.

Huber, Henry. 1982. Forest Wood Products Firms - The use of financial indicators. Michigan State Univ. Coop. Ext. Serv. Ext. Bull. E-770. East Lansing, MI. 7 pp.

Jakes, Pamela and W. B. Smith. 1983. Michigan's Predicted Timber Yields 1981-2010. USDA North Central For. Exp. Sta. Res. Pap. NC-243. St. Paul, MN. 98 pp.

James, L. M.; S. E. Heinen; D. Olson and D. E. Chappelle. 1982. Timber Products Economy of Michigan. Michigan State University. Agr. Exp. Sta. Res. Rep. No. 446, East Lansing, MI. 23 pp.

Luppold, W. G. and R. B. Anderson. 1986. A Regional Analysis of Pallet Supply and Demand. USDA, For. Serv., Northeastern For. Exp. Sta., Res. Pap. NE-580. Broomal, PA. 8 pp.

Michigan Agricultural Reporting Service. 1982. Michigan Agricultural Statistics.

Michigan Department of Natural Resources. 1982. Michigan Mineral Producers. Lansing, Michigan.

Michigan Department of Natural Resources - Forest Management Division. 1982. Apparent Annual Timber Surpluses for the Northern Two-Thirds of Michigan. Lansing, Michigan.

Michigan Department of State Highways and Transportation. 1980. Statewide Transportation Analysis and Research (STAR). Lansing, Michigan. 549 pp.

Michigan Employment Security Commission. 1983. Bureau of Research and Statistics, special release.

Moore, F. T. and J. W. Peterson. 1955. Regional Analysis: An Interindustry Model of Utah. Review of Economics and Statistics, 37 (4):368-383.

National Wooden Pallet and Container Association. 1981. Annual Report. Washington, D. C.

National Wooden Pallet and Container Association. 1982. NWPCA Logo-Mark: Hardwood Pallet Standards. Washington, D.C.

National Wooden Pallet and Container Association. 1984. Annual Report. Washington, D.C.

National Wooden Pallet and Container association. 1984. Mini-Wage Survey Report. Washington, D.C.

Nies, Joseph. 1985. The Palletech Process for Molded Wood Pallets. Bureau of Industrial Dev., Michigan Technological Univ., Houghton, Michigan. Unpubl. Rep. 106 pp.

Osteen, Craig P. 1977. Applications of a Linear Programming Model to Spatial Planning of Forest Resources in the Kalamazoo River Basin of Michigan. Unpublished Ph.D. dissertation. Michigan State Univ., East Lansing.

Pepke, E. K., H. Huber and A. Silker. 1977. Pallet Lumber Makes Furniture Parts. Mich. State Univ. Dept. of Forestry Paper. East Lansing, MI.

Pleeter, Saul. (ed).). 1979. Economic Impact Analysis: Methodology and Application. Martinuf and Nijhof: Boston-The Hague-London. 196 pp.

Raile, G. K. and W. B. Smith. 1983. Michigan Forest Statistics. USDA For. Exp. Sta. Res. Bull. NC-67. St. Paul, MN. 101 pp.

Richardson, H. W. 1972. Input-Output and Regional Economics. Weidenfeld and Nicolson: London. 294 pp.

Sardo, William H. 1982. Wooden Pallet Basics - Design, Applications and Material facts. National Wooden Pallet and Container Association Report. Washington, D. C.

Schuller, A. and W. Wallin. 1979. An Econometric Model of the U.S. Pallet Markets. USDA Forest Service. Res. Pap. NE-449. Broomal, PA. 11 pp.

Schuller, A. and W. Wallin. 1980. Report on an Econometric Model for Domestic Pallet Markets. Forest Prod. Journ. 30(7): 27-29.

Schuller, A. and W. Wallin. 1983. A Revised Econometrics Model of the Domestic Pallet Market. USDA For. Serv. Res. Pap. NE-522. Broomal, PA. 5 pp.

Spelter, Henry and R. B. Phelps. 1984. Changes in Post-War Lumber Consumption Patterns. Forest Prod. Journ. 34(2): 35-41.

Spencer, John. 1983. Michigan's Fourth Forest Inventory: Area. USDA For. Serv. North Central For. Exp. Sta. Res. Bull. NC-68. St. Paul, MN. 39 pp.

Spencer, John and J. T. Hahn. 1984. Michigan's Fourth Forest Inventory: Timber volumes and projections of timber supply. USDA North Central For. Exp. Sta. Res. Bull. NC-72. St. Paul, MN. 95 pp.

United States Bureau of the Census. 1977. Census of Manufactures. U.S. Department of Commerce. Washington, D.C.

United States Bureau of the Census. 1980. U.S. Census of Population: Number of Inhabitants, Michigan. Washington, D.C.

United States Bureau of the Census. 1981. Census of Manufactures. U.S. Department of Commerce. Washington, D.C.

United States Bureau of the Census. 1982. Census of Manufactures. U.S. Department of Commerce. Washington, D.C.

United States Bureau of the Census. 1983. Census of Manufactures. U.S. Department of Commerce. Washington, D.C.

United States Bureau of the Census. 1982. County Business Patterns. U.S. Government Printing Office, Washington, D.C.

United States Bureau of Labor Statistics. 1982. Employment and earnings. Washington, D.C.

United States Department of Commerce. 1976. Income by States Since 1929. Washington, D.C.

United States Forest Products Laboratory. 1971. Wood Pallet Manufacturing. USDA For. Serv. Res. Note. FPL-0213. Madison, WI. 37 pp.

Wallin, Walter B. 1977. Characteristics of the U.S. Pallet Industry. USDA For. Serv. Res. Pap. NE-1977. Upper Darby, PA. 74 pp.

GENERAL REFERENCES

GENERAL REFERENCES

Atkinson, Lloyd C. 1982. Economics - The Science of Choice. Richard D. Irwin, Inc., Homewood, IL. 723 pp.

Chappelle, D. E.; R. C. Miley and R. Gustafson. 1982. Land Use Models. In David W. Countryman and D. M. Sofransko. Guiding Land Use Decisions: Planning and Management for Forests and Recreation. The John Hopkins Univ. Press. Baltimore. pp. 11-49.

Ferguson, C. E. and S. C. Maurice. 1978. Economic Analysis - theory and Applications. Richard D. Irwin, Inc. Homeward, IL. 520 pp.

Greenhut, Melvin L. 1956. Plant Location in Theory and Practice. North Carolina University Press. 275 pp.

Hagenstein, Perry R. 1964. The Location Decision for Wood Using Industries in the Northern Appalachians. USDA For. Serv. Northeastern For. Exp. Sta., Res. Paper NE-16.

Hoover, Edgar. 1948. The Location of Economic Activity. McGraw Hill Book Co., New York. 310 pp.

Hoover, Edgar. 1971. An Introduction to Regional Economics. Alfred A. Knopf, New York. 396 pp.

Isard, Walter. 1956. Location and Space Economy. Massachusetts Institute of Technology and John Wiley and Sons, New York. 350 pp.

Isard, Walter. 1960. Methods of Regional Analysis. Massachusetts Institute of Technology and John Wiley and Sons, New York. 784 pp.

Karaska, G. J. and D. F. Bramall (eds.). 1969. Locational Analysis for Manufacturing: A Selection of Readings. MIT Press: Cambridge and London. 515 pp.

Lansing State Journal. 1983. Update: Various aspects of forestry provide strong potential for development. pp. 24-25 (Sun., Feb. 13).

Losch, August. 1954. The Economics of Location. Yale University Press. New Haven, CT. 520 pp.

Nicholson, Walter. 1979. Intermediate Microeconomics and Its Applications. The Dreyden Press, NY. 614 pp.

Obiya, A.; D. E. Chappelle and C. Schallau. 1986. Spatial and Regional Analysis Methods in Forestry Economics. USDA, Forest Serv., Pacific Northwest Res. Sta., Gen. Tech. PNW-190. Portland, OR. 32 pp.

Spielgman, Robert G. 1968. A Study of Industry Location Using Multiple Regression Techniques. USDA, Economic Res. Serv., Agr. Econ. Rep. No. 140. Washington, D.C. 66 pp.

Spielgman, R. F.; El. L. Baum and L. E. Talbert. 1965. Application of Activity Analysis to Regional Development Planning: A case of study of economic planning in rural south central Kentucky. U.S.D.A. Tech. Bull. No. 1339. Washington, D.C. 81 pp.

Weber, Alfred. 1965. Theory of the location of industries. The University of Chicago Press: Chicago and London. 256 pp.