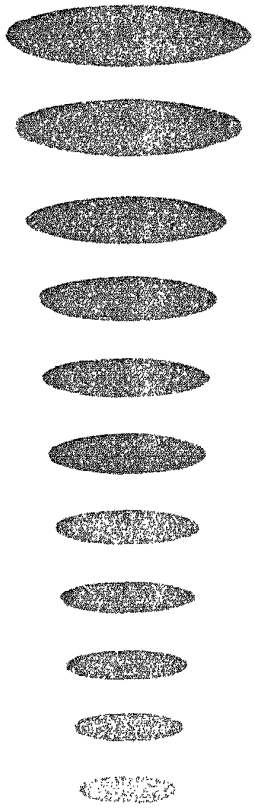
The Location Decision for Wood-Using Industries

In the Northern Appalachians

by

Perry R. Hagenstein



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Introduction

CHOOSING a site for an industrial plant requires a major decision, a decision in which many factors must be considered. In this decision-making process the economist can make a contribution. He can identify the most important factors to be considered; he can describe the decision-making process; and he can provide the kind of economic information that the decision-maker needs. He can help industrial firms and industrial development agencies to evaluate alternative locations for industrial plants; and he can suggest ways in which development agencies can facilitate and promote the establishment of new plants.

This economic-analysis approach was applied to the wood-using industries in a study made recently by the Northeastern Forest

Experiment Station. The purpose of the study was to provide a better understanding of the decision-making process, and a guide that can be used by selected wood-using industries in evaluating alternative mill locations.

Four wood-using industries were considered in the study: the lumber, particle-board, woodpulp, and furniture industries. Other wood-using industries were considered, but these four were chosen for study because they represent an interesting range of alternatives. Each uses a different type of raw wood material. The capital investment required for average size plants ranges from a modest amount in the lumber industry to a very large amount in the woodpulp industry. The range of alternatives covers a major part of the range of the whole wood-using industry.

Three of the industries chosen for study — lumber, particle-board, and woodpulp — are considered *primary* wood-using industries because they use round wood as their raw material. The fourth — the furniture industry — is considered a *secondary* wood-using industry because it uses lumber as its raw material.

Geographically, the study was restricted to the northern Appalachian region. This is an important hardwood-producing area. Furthermore, it is an underdeveloped area, in which the forest resources offer opportunities for increased economic development (Perloff and others 1960). The scope of the study was restricted to consideration of only the production side of the overall location decision.

A study of the likelihood of a specific type of industrial plant locating in a specific area requires more than an analysis of the availability of particular requirements in that area. It also requires an analysis of potential markets for the plant's output and a comparison of the area with all other possible locations — both important considerations, but beyond the scope of this study.

The material used in this report was obtained in a series of interviews with executives of firms in the industries under consideration. The interviews were directed at identifying factors that affect the location decision and at obtaining (1) estimates of the physical quantities of inputs required for plants of specified sizes and (2) comparisons of the costs of these inputs with those incurred by other plants in the region.

Within each industry, certain restrictions were placed on the scope of the study. The great preponderance of hardwoods in the Appalachian area limits the types of wood-using industry that can be considered. The hardwood resource restricts a sawmill to producing mostly hardwood lumber and a particle-board plant to producing a board made wholly or largely of hardwood particles. For a pulpmill, the hardwood resource limits the type of pulping processes that can be used satisfactorily. The neutral sulfite semi-chemical process was chosen as being well adapted to the pulping of Appalachian hardwoods.

Restrictions were also placed on the size of facilities selected for examination — a selection based on current construction in these industries. In the sawmill industry in the northern Appalachian area, modern sawmills are generally constructed to produce 10,000 to 50,000 board feet of lumber per day; and consideration here was directed at mills producing about 20,000 board feet. For particle-board plants, the size considered in this study is about 20,000,000 square feet (¾-inch base) of production per year, which is the minimum efficient size today for independent plants. For pulpmills, discussions with industry personnel suggested that the minimum efficient size of new mills is generally about 200 tons per day. And an average size for new wooden furniture plants appeared to be about $5,000,000 in annual sales.

The Location Decision

The decision to locate an industrial plant on a particular site or in a particular area depends on a number of factors. Some are economic, such as the cost of materials, labor, and transporting the finished product to market (Hoover 1948, Isard 1956, Greenhut 1956, and Lösch 1954). Other factors that affect the location decision apparently have no substantial economic basis; for example, the presence of churches, schools, recreation facilities, and other amenities (Thompson 1961, Mueller and others 1961). However, a common consideration about the factors affecting location is that the available quantities, the costs, or the decision-

maker's judgment concerning their suitability will vary among locations.

Demand aspects may also be important. First, demand for a product usually triggers the location decision. This is especially true in industries with expanding markets. However, it may also be true in industries where the total demand is constant but where changes are occurring in the location of markets. Second, there are often strategic considerations in locating to meet the demand for certain products (Hotelling 1929, Smithies 1941, Ackley 1942, and Stevens 1961). For example, direct contact with buyers and immediate delivery are important factors in some industries.

The location decision is often the most important single decision ever made by a firm. Because industrial plants are relatively immobile, the firm commits itself to a given location for a long time when it undertakes construction of a new plant. In addition, firms can and do affect their cost and profit structures strikingly in making the location decision because revenues, and especially costs, may vary substantially among locations.

The manner in which firms make the location decision varies; however, some useful generalizations can be made. A triggering mechanism is generally required; the scope of the choice must be brought down to manageable proportions; the costs and financial returns from the various possible locations must be considered; and the non-economic factors that affect location must be taken into account.

The nature of the location decision and the method of making it differ among the four wood-using industries considered in this study. These differences are important in that they affect the likelihood of plants being located in particular areas, and thus they may substantially affect the strategies employed by industrial-development agencies. Differences in the method of making the location decision are the result of differences in the size of plants in the various industries, in the competitive conditions within each industry, in the nature of the raw material that will be used, and in the nature of the markets that will be entered. Of these factors, size of plant is the most important. Two general types of location decision can be distinguished on the basis of plant size: the small plant and the large plant.

THE SMALL PLANT

Sawmills and those particle-board plants that are tied to specific sources of residues for raw materials fall into the small category. Some small furniture plants and other small wood-using plants not specifically studied (charcoal, pallets, handles) are also included in this class. Small wood-using plants are often developed by one or two local entrepreneurs who have some experience in or knowledge of a particular industry. Such entrepreneurial talent is often local in the sense that it is likely to be used in developing a hometown enterprise but is wholly unlikely to be used elsewhere.

It can be argued that there is an economic basis for this so-called hometown preference: knowledge of the area and business contacts may be important to the economic well-being of the firm; and knowledge of a local raw-material supply in the area may be important to wood-using firms. Choice of location as a result of hometown preference can also be considered as an example of historical accident.[1] This appears to be true of many small plants.

In the first step of the location decision, the choice of location is made. The actual choice of the locality, and often even the site, for a new plant is made prior to the final decision to build a new plant. For an enterprise tied to a specific source of raw material, the location of the raw material determines the location of the plant. In other cases, the choice is a matter simply of the entrepreneur's preference — before even the decision as to whether or not a plant will actually be built has been made.

In the second step — after the *where* decision has been made — the decision-maker considers the type of product that can be produced. This is determined mainly by the raw materials that are available. Consideration is given next to the markets available for the various possible products. Estimated production costs and estimated returns for the various product and market alternatives are compared.

[1] Location by historical accident is not an uncommon occurrence in numerous industries. Although individual plants are resistant to change of location, in general it can be expected that the force of competition will lead to a reasonable location pattern. As Hoover pointed out (1948): "Competition, insofar as it prevails, will reward and encourage well-located enterprises and shorten the lives of poorly located ones."

In the final step, the decision to build or not to build a plant is made. The decision made in this step is an economic decision; profits are the major criterion. For small plants the actual choice of location is generally based on non-economic criteria; economic criteria are used only in deciding whether or not to build a plant.

THE LARGE PLANT

Pulpmills, medium and large furniture plants, and those particle-board plants that are not tied to specific sources of residues fall into the large category. The location decision for large wood-using plants approximates that presented in standard texts on economic location (Hoover 1948 and Isard 1956). Today most large plants are associated with large firms, which are not generally tied to particular localities. Thus the choice of location can be based on an evaluation of several alternative locations.

After the choice has been made, managerial talent can be transported to the location; and knowledge of the local area, if it is necessary, can be purchased. Thus in making the location decision the large firm is usually free of the constraints associated with hometown preference (Mueller and Morgan 1962). On the other hand — and this may be of special importance for wood-using industries — the large firm is generally faced with the prospect of moving managerial employees to the area of the new location. Considerations of this sort are often important enough to remove the location decision from the realm of pure and rational economics to that limbo where decisions are said to be *profit-satisficing*[8] rather than *profit maximizing*. In either event, the choice is made among alternative locations in the following manner.

The first consideration is markets. This factor is the one that usually triggers the initial investigation of the location decision. Several aspects of the markets may be important. The firm is likely to consider the location of the markets and the type of product that will compete best in the various markets. In addition, it will consider whether entry into or expansion in various

[8] *Profit-satisficing* means a willingness to settle for a profit that is satisfactory in the circumstances even though it may be less than the maximum possible. This concept is generally attributed to Herbert A. Simon (March and Simon 1958).

markets will enable the firm to meet particular goals such as maintenance of market shares and product diversification. Estimates are made of revenues likely to be obtained in the various markets.

The second consideration is the product itself, and the production process to be used. The firm often has some latitude in choice of process once the product has been determined.

The third consideration is the cost of production at alternative plant locations. Estimates are made of the availability and cost of the required inputs at various locations.

In the final consideration, the firm makes its choice among alternative locations, using profitability as the major criterion. But it is at this point that non-economic considerations may place certain constraints on the choice of location. If these considerations are important, it can be said that the firm is making a profit-satisficing decision rather than a profit-maximizing decision, as described by Hans H. Jenny (Boulding and Spivey 1960).

Factors that Affect the Decision

The four wood-using industries examined here differ considerably with respect to the location decision. They all require wood as a raw material, but the type and form of the wood each requires are different. Investment required ranges from small to very large. The four industries differ in the type of markets in which their products are sold. And they represent a range of opportunities for investment and for analysis.

Differences between the ways in which small and large firms make their location decisions have already been discussed. There are also differences among the industries — especially in the relative importance of the various factors that affect the location decision and in the amount of each input required for a plant. These differences, both in relative importance of location factors and in quantities of inputs required, have a substantial bearing on evaluations of particular locations by industrial-development agencies.

In evaluating various alternative locations, the individual firm has its own basis for making comparisons. The firm has considerable knowledge of its requirements; it can generally obtain the information it needs about the availability and cost of its requirements at alternative locations. On the other hand, simultaneous comparisons of alternative locations and alternative industries are usually made by outside organizations. Not only must these organizations be able to obtain information regarding requirements in various industries, but they must also have some common basis for evaluating locations.

ASSUMPTIONS

To provide comparable information on requirements for the four wood-using industries in the northern Appalachians, certain assumptions were made. The first assumption concerns the units in which location requirements will be expressed. The usual accounting practice of wood-using firms is to express cost items in dollars per sales unit: 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: electricity in kilowatt hours, labor in hourly or daily wages, wood in thousand board feet or cords, forest land in acres. For this study, requirements are expressed in the latter terms — the units by which these items are bought by the wood-using firm — because these are the terms that the author believes will be most useful in making evaluations of alternative locations.

For most location requirements, the quantity can be expressed in familiar terms. Thus there is no problem in saying what the quantity requirements are for a plant of a particular type and size. On the other hand, if the factors that affect location are to be evaluated in terms of their relative impact, some further assumptions are required to place these factors on a common basis. The general procedure used here is to convert requirements to a daily basis so that comparisons can be made.

Forest land and industrial sites are the two major location factors that generally require capital expenditures. The basic

Table 1.—*Assumptions about average plants in four wood-using industries*

Item	Lumber	Particle board	Woodpulp	Furniture
		OUTPUT		
1. Size of plant:	20,000 bd. ft. of lumber per day (5,000,000 bd. ft. per year)	20,000,000 sq. ft. (¾-inch basis) per year.	200 tons per day.	Annual sales of $5,000,000.
2. Type of output:	Rough, air-dry graded hardwood lumber.	Medium-quality flakeboard made largely of hardwood particles.	Neutral-sulfite semichemical pulp made largely from hardwoods.	Medium-quality wooden furniture (case goods).
		OPERATING RATES		
1. Days per year:	250	300	325	275
2. Hours per day:	8	22	24	8
		CAPITAL EXPENDITURES		
1. Forest land:	Forest land is assumed to be leased at an annual cost of $0.75 per acre, or 10 percent of the average selling price of forest land, excluding timber, in the northern Appalachians. This leasing cost covers annual property taxes of $0.30 per acre and allows for an alternative rate of return of 6 percent to the landowner. Forest land is not required for furniture plants.			
2. Industrial site:	Industrial sites are treated as though they are leased. The annual cost of leasing is assumed to be equal to 15 percent of the average selling price of industrial sites.			
3. Amount of loans available under local financial-assistance plans:	$10,000	$120,000	$350,000	$200,000
		SELLING PRICE		
Selling price per unit of product:	$90 per 1,000 bd. ft. of lumber.	$130 per 1,000 sq. ft. (¾-inch basis) of lumber.	$140 per ton of woodpulp.	No definable units.

assumption made in this study was that land and sites are leased instead of purchased outright. If it is assumed that they are leased, then the annual lease payments can be considered current costs and little violence is done to the evaluations of relative importance.

Some assumptions must also be made about the cost of borrowing funds, because financial-assistance plans are now commonly a part of the inducement package offered by industrial-development agencies. The market for borrowed funds in the United States is largely a national market; thus interest rates will tend to be similar among various locations because of the mobility of capital and the tendency for interest rates to equalize on loans of similar potential. However, there may be differences in interest rates among industries because of differences in size of firms and risk associated with investments in the various industries.

The one important exception to the general rule that interest rates do not vary with location is provided by the local financial-assistance plans. Two of these financial-assistance plans for states in the region with which this study is concerned provide for loans of public funds to cover one-half the cost of industrial sites and buildings for new industrial plants. As a practical matter, these loans do not run over $1,000,000 for the largest plants, and the interest rate presently being charged on these public loans is about 2 percent.

The assumptions concerning output, operating rates, capital expenditures, and product selling price are outlined in table 1.

LOCATION REQUIREMENTS

The location requirements considered in making an economic location decision are those inputs that vary in price among locations — raw materials, labor, power, and others. Major items that do not vary in price from location to location are selling expense, machinery costs, and general overhead.

There are also differences in the type of inputs and quantities required in the various industries. For example, operators of pulpmills require their wood in the form of pulpwood, but the furniture industry people want theirs in the form of lumber. In addi-

tion, within a given industry it is generally possible to substitute among inputs to some extent — for instance, materials-handling equipment and labor are substitutable to a degree.

The time when the location decision is made is also the time when there is the greatest degree of freedom in choosing a process or method of production. Once a plant or production line has been built, the cost of changing to allow for a more capital-intensive method of production is likely to be higher than at the time the location decision was made. As a result, firms exercise care in choosing the most efficient processes available at the time of the location decision.

There is general agreement in an industry at any point in time that a particular process is most efficient. This is true because information flows rather freely within these industries through personal contacts, trade journals, and technical assistance provided by machinery manufacturers, government agencies, and industry trade associations. Therefore, necessary inputs for any new plant in an industry are about the same from plant to plant. This is particularly true for a fixed output — that is, when plant size is held constant.

The location requirements considered in this study are for plants of a particular size and type. They are for average plants, based on current practices in the northern Appalachians. A change in the type of output or size of plant would necessarily involve a change in inputs. A change in the type of output would also probably require a moderate change in the type of inputs, but would involve little change in the quantity required. And a change in the quantity of output would probably require a nearly proportional change in the quantity of inputs.

The specific requirements for plants in all four industries are listed in a common table (table 2). The discussion of each industry, which follows, is limited to considerations not described in the table.

Lumber

Most of the new sawmills in the northern Appalachians are of moderate size (Simmons 1958, p. 26). Sawmills of this type are rather adaptable, and can be used to process a variety of log sizes.

Table 2.—*Factors that affect the location decision for four wood-using industries*

Item	Lumber	Particle board	Woodpulp	Furniture
		INDUSTRY STATUS		
1. Growth trend of industry:	1. Stable.	1. Rapid growth.	1. Moderate growth.	1. Moderate growth.
2. Factors triggering location decision:	1. Production cost squeeze at present location.	1. Expanding markets.	1. Expanding markets.	1. Production cost squeeze at present location.
	2. Unused resource or entrepreneurial talent.	2. Availability of unused wood residues from primary or secondary wood-using plant.		2. Expanding markets.
		STAGES IN MAKING THE LOCATION DECISION		
1. Stages:	1. Location determined largely on basis of home-town preference and local business ties in case of lumber, and on basis of location of raw materials for particle-board plants utilizing particular supplies of wood residues. 2. Type of product that can be produced determined largely by the nature of the available raw material. 3. Available markets considered. 4. Decision made to build a new plant. Size and type of production facilities determined.		1. Availability of expanding markets considered, markets chosen on basis of growth potential and strategic advantage to firm in maintaining or changing relative market shares. Typical for particle-board plants not tied to a specific supply of wood residues, for all woodpulp plants, and for moderate and large furniture plants. 2. Size and type of production facilities chosen to enable firm to compete in market determined in Step 1. 3. Availability and cost of necessary inputs at alternative locations determined.	

	INPUT REQUIREMENTS			
1. Inputs that vary in cost among locations:	1. Logs—20,000 board feet per day.	1. Wood (either residues or roundwood)—75 cords per day.	1. Pulpwood—280 cords per day.	1. Lumber—14,500 board feet per day.
	2. Labor— 3 skilled 5 semiskilled 4 unskilled	2. Labor— 35 skilled 35 semiskilled 30 unskilled	2. Labor— 32 skilled 16 semiskilled 16 unskilled	2. Labor— 75 skilled 150 semiskilled 75 unskilled
	3. Forest land—10,000 acres where competition for timber is strong; none where competition for timber is slight.	3. Forest land—10,000 acres in areas where competition for timber is strong; none where competition for timber is slight.	3. Forest land—30,000 acres where competition is strong or where a particular species is required; none where competition for pulpwood is slight.	3. Forest land—none.
	4. Electricity—750 kwh. per day.	4. Electricity—15,500 kwh. per day.	4. Electricity—55,000 kwh. per day.	4. Electricity—5,800 kwh. per day.
	5. Transportation—highway connections required.	5. Transportation—highway connections; rail connections for noncaptive plants.	5. Transportation—rail and highway connections required.	5. Transportation—rail and highway connections required.
	6. Industrial site—20 acres.	6. Industrial site—20 acres.	6. Industrial site—100 acres.	6. Industrial site—20 acres.
	7. Plant and equipment—$150,000.	7. Plant and equipment—$2,500,000.	7. Plant and equipment—$10,000,000.	7. Plant and equipment—$2,500,000.

(CONTINUED)

Table 2.—(Continued)

Item	Lumber	Particle board	Woodpulp	Furniture
			8. Water—8 million gallons per day required for production. Site on a river usually required for waste disposal; quantity of water required for disposal varies depending on regulation by water commissions and nature of streamflow.	8. Particle board—7300 square feet per day.
2. Inputs that do not vary in cost among locations:	—	Resin—16,800 pounds per day.	1. Sulfur—20 tons per day. 2. Soda ash—75 tons per day. 3. Chlorine—45 tons per day. 4. Caustic soda—18 tons per day.	

They can also be used for various types of output, such as lumber or dimension stock. Emphasis can also be placed on the production of large quantities of lumber — sacrificing quality — or on the production of high-quality lumber — sacrificing quantity. Because sawmills are adaptable, they are located in a wide variety of forest resource-conditions, ranging from heavily forested areas to primarily agricultural areas.

Once the tentative location for a sawmill has been chosen, the species and quality of the available timber are important considerations in determining the markets that will be entered. Species and grades that bring high prices can be shipped to more distant markets than those that bring low prices.

Markets for hardwood lumber for particular uses are to a large extent restricted geographically. In addition, particular uses often require certain species or grades of lumber. Thus, the High Point area of North Carolina, a major center for furniture manufacture, is a primary market for the better grades of cherry, birch, maple, walnut, and yellow-poplar. Oak of the lower grades is used extensively in the flooring and pallet industries, and nearly any species or grade of hardwood can be used for industrial purposes such as industrial blocking or dunnage. Flooring production is localized to some extent in the hardwood lumber-producing areas, but the major markets for pallets and industrial lumber are found in areas of concentrated manufacturing and shipping — in the Pittsburgh-Youngstown area or other nearby manufacturing cities, and in port cities.

Lumber producers in the northern Appalachians generally produce some mixture of high- and low-quality lumber. Producers who aim for low-quality markets usually find a ready market for the high-quality lumber that they produce almost as a byproduct. For them, markets for high-grade lumber are not of prime importance in determining a mill location. On the other hand, low-quality lumber produced as a byproduct by producers who aim for high-quality markets often presents a real problem. For them, markets for this low-quality byproduct may be very important in determining mill location.

By holding forest land, sawmill operators in some areas attempt to guarantee themselves a supply of raw material and to

obtain some control over timber prices. This is generally done in areas where there is considerable competition for timber. But in parts of the northern Appalachians where there is little competition and where agriculture is of some importance, this is not generally necessary. In such areas, it was found that single operators could exert monopsony power over stumpage prices without owning forest land.

The size of forest holdings desired by sawmill owners depends on the severity of competition for stumpage in the area of the sawmill. One respondent said he would like to own enough land to supply all of his raw material; however, he actually owns only 20 percent of the forest area necessary to meet all of his needs. Other respondents in areas where owning land is considered a requirement for operating a moderate-size sawmill suggested that enough land to supply one-third of the raw-material requirements would be sufficient. These respondents also had enough land to supply 20 percent of their needs.

The modern sawmill examined in this study is relatively efficient in terms of output per unit of labor. Labor productivity is considerably higher in the modern sawmill than in the average mill now located in the study area. Thus, to assess the impact on employment of expanded lumber production in an area, the use of current average labor-productivity rates in the area is likely to lead to overestimates.

Particle Board

There are two general types of particle-board plants: those that use roundwood as raw material and those that use wood residues. The type of raw material that is used has an important effect on both the type of particle board produced and the markets in which the board will compete. A brief description of both types follows.

For plants using wood residues, the type of board that is produced is determined to a large extent by the available residues. In general, both the cost of production and the quality of boards produced from residues are lower than those for boards produced from roundwood. The fact that there are no raw-material costs is an important factor in lowering costs. At worst, there may be a

replacement cost for the fuel required to replace residues formerly used for fuel.

The species composition of the available residues is usually the most important factor restricting the quality of this type of particle board. The high-quality boards are produced from light-weight and light-colored species. Much of the residues available in the northern Appalachians are heavy, and some produce a dark board of lower quality. Quality is also restricted to some extent by the form of the residues, although some of the technical problems of this nature are being overcome through advances in equipment design.

Largely because of the lower value of these boards — and partly because of the usually greater weight, which affects shipping costs — these boards normally sell in localized markets. Maximum shipping distances range from 150 to 250 miles. These boards tend to compete on a price basis rather than a quality basis, although minimum quality standards must be met.

Producers who are not tied to a source of waste for raw material have generally settled on the production of a homogeneous or three-layer flakeboard made of light-weight woods. Such boards are generally of high quality; they tend to compete with each other on a quality basis rather than on a price basis. They are distributed over a broad market area to shipping distances that may be 1,000 miles or more. Pine and soft hardwoods are the preferred species for production of this type of board. Wood is commonly purchased as pulpwood. A multi-platen press operation is generally employed by such producers.

The major market for particle board is the furniture and cabinet industry. Competition within the particle-board industry in recent years has resulted in a shift toward the production of a more finished product. Particle-board producers are competing for these markets by providing such services as cutting-to-size, prefinishing, and even laminating and veneering their product before it leaves the plant.

In the same way that sawmill owners like to own forest land in areas where competition for stumpage is strong, particle-board producers also require forest holdings capable of supplying probably one-third of the total requirements of the plant in areas

where competition for timber is strong. For a supply of hardwood, owning forest land is not considered an important factor in this region; however, if the particle board is to be made from pine or other softwoods, competition for raw material will be strong and forest-land holdings can be considered a requirement.

Resin costs make up an important part of the total cost of producing particle board. However, resin costs have little or no effect on the location decision for particle-board plants in the Northeast because resin prices are standardized among producers and are quoted on a delivered basis. Resin costs might be an important factor elsewhere and would undoubtedly become important if the pricing system for resin were to change.

Woodpulp

Location requirements for pulpmills generally are restrictive in the sense that large quantities of each input are required. Location requirements are also restrictive in the sense that a mill is generally planned for producing a specific product or products for a particular market. Of course, changes in output may be made after the mill is in operation; but in the planning stages, and in construction, design is generally predicated on a specific output.

In this study, we considered only factors that affect the location of pulpmills. However, most of the pulping facilities built in the United States today are built as part of an integrated pulp- and paper-making plant. This leads to a minor degree of confusion, particularly with respect to markets and transportation costs for woodpulp.

Clearly, the chief market for woodpulp produced in an integrated plant is the paper mill right next door, and the cost of transporting the pulp to the paper mill is slight. However, in choosing a location for an integrated facility, the transportation costs considered by the decision-maker will be those for transporting the paper to its markets. Because transportation requirements are an important location factor, it will be assumed that transportation requirements for paper are an accurate measure of the transportation requirements for woodpulp.

The markets in which paper is sold are national in scope. To a large extent they coincide with the pattern of population distribu-

tion, although markets for certain grades of paper may be restricted geographically. The probable markets for new paper mills in the northern Appalachians would be in the population centers of the Atlantic Seaboard and the North Central States. Mills are generally constructed to produce a relatively narrow range of products; such items as newsprint, book papers, and writing papers are normally produced in different mills. Some of the larger companies in the paper industry produce many of these items; other companies may concentrate on one or two particular items. Market considerations in the location decision depend on the type of paper to be produced.

The choice of the pulping process and the qualities desired in the pulp and the resulting paper determine the selection of tree species that will be used. In considering the Appalachian hardwood region, any pulpmill must plan on using a high percentage of hardwoods and must choose a hardwood pulping process. Today only a few minor hardwood species are considered wholly unsuitable for pulping. However, most papers contain a softwood pulp component—about 20 percent or more of the total—and, as a result, either softwood trees for pulping or softwood market pulp to provide this component is a requirement for most mills.

The desire and need to hold forest land is stronger among pulp producers than among lumber or particle-board producers. Interruptions in the supply of wood to sawmills and particle-board plants are inconvenient. But for the pulpmill, which has a high operating rate necessary to maintain profit levels, an interruption in wood supply can be critical. Holding forest land provides some guarantee of a future wood supply and provides for some monopsony control over pulpwood prices. Having company-owned timber may enable a pulp company to withstand collusion on the part of pulpwood producers.

Most respondents in this study said that their companies would like to be able to supply one-third to one-half of their total wood requirements from company lands. However, in the Eastern hardwood region, the growth of hardwoods meeting pulpwood specifications far exceeds the present drain, and companies locating pulpmills generally are aware of this. Respondents in this study said that the question of forest-land ownership would not be

crucial in most hardwood areas, especially where their wood-procurement areas would not seriously overlap those of other pulpmills.

A pulpmill must have good highway and rail connections. Much of the pulpwood in the Eastern region is hauled by trucks, but many pulpmills also rely on rail shipments for some pulpwood. Where a particular species is needed, such as a softwood component for the pulp, location on rail lines that will allow one-line or two-line hauls from the pulpwood supply area is of importance. This is the case in much of the eastern hardwood region. Rail and highway connections are also important in shipping the final product. Ideally, the pulpmill should be located so that as much of the final product as possible can go to market on one-line or two-line hauls. This may mean locating on major railroad systems and may mean locating so that the mill would be served directly by two or more lines.

Large quantities of water are required in pulp manufacture; and for most types of woodpulp production even larger quantities of water are required for diluting waste material. In some places, water-supply and waste-disposal problems have assumed top priority in determining pulpmill locations. The quality of water required for production of neutral-sulfite semichemical pulp depends on whether or not the pulp is to be bleached. If unbleached pulp is to be used, the requirements are not very restrictive; and many of the rivers in the East have water that is suitable for unbleached pulp manufacture after passing through a settling basin. On the other hand, if the pulp is to be bleached, requirements are much more restrictive; and filter plants, which may cost up to a million dollars, may be required.

In the semichemical pulping processes, no fully satisfactory means of reclaiming chemicals has been developed; consequently, disposal of large quantities of waste liquor is necessary. And to complicate the problem, public pressure to do something about water pollution has become increasingly urgent, and in recent years has resulted in numerous state laws, interstate regulations, and commissions that forbid or penalize water pollution of certain degrees or varieties.

Requirements for industrial sites suitable for a pulpmill are

more restrictive than requirements for sawmills or particle-board plants. Because of the water-supply and waste-disposal problem, the location must be on a river with sufficient low-water flows to meet water-supply and disposal needs. The site must be reasonably level and large enough to provide for good storage and future expansion and have suitable transportation and power facilities. A 50-acre site would be adequate for a 200-tons-per-day mill, but would not be large enough to allow for much expansion; nor would it provide the buffer zone that might be considered necessary under crowded conditions. A 200-acre site would probably be more suitable.

As resin does for particle-board plants, chemicals for pulpmills make up an important part of the total raw material costs; yet these costs do not vary substantially among locations. Prices for the standard chemicals used in woodpulp production appear to be equalized among the various chemical-producing companies. In addition, freight is equalized up to certain amounts for a number of producing and shipping points in the Northeast. Thus, in effect, the chemical producers absorb differences in freight costs; the extent to which freight costs are equalized enables most locations in the Northeast to compete on almost even footing with regard to the cost of chemicals—with the exception of sulfur.

Sulfur is produced along the Gulf Coast in Texas and Louisiana, and prices quoted by sulfur-producing companies in this area are standard. However, freight rates to Eastern users vary somewhat by location. The other three chemicals used by Eastern pulpmills —soda ash, chlorine, and caustic soda—are produced mainly in Michigan and Ohio. Prices on these are equalized, as are most freight rates. Thus chemical costs have only a slight effect on the location decision.

Wooden Furniture

The wooden furniture — "case goods" — industry differs considerably from the three primary wood-using industries discussed. The furniture industry is a *secondary* wood-using industry: it produces consumer goods rather than industrial goods. In fact, of all the major wood-using industries, the furniture industry is perhaps the most strongly oriented toward the consumer. Some

of the other secondary wood-using industries—such as the flooring, pallet, and wooden-container industries — fall in between those that are strongly oriented toward the consumer and those that are strongly oriented toward raw materials. Thus the furniture industry is almost in a class by itself.

The concept of the "average" plant is more elusive for the furniture industry than for the other industries that have been considered. There are two reasons for this: first, there is more variation in types and sizes of plants; second, there is no standard unit of production such as there is in each of the other three industries.

Furniture is purchased at the retail level through a large number of furniture stores, department stores, and mail-order houses. Contact between the retail seller of furniture and the producer is made to a large extent at the furniture "markets," where furniture is exhibited either semi-annually or quarterly. The most important market exhibit for manufacturers in the Appalachian region is held at High Point, North Carolina. Here each producer exhibits a number of style lines. The retailer chooses among these and places orders. The producer then uses the orders in scheduling production runs (Davis 1957). The market provides an opportunity for the producer to keep up with changes in style, production methods, and marketing. Thus it helps him to decide on style lines.

The impact of style and style changes on the location and structure of the furniture industry is important. Because tooling costs are low, styles can be changed readily. Style changes are frequent, and the producer that does not respond readily to these changes may suffer a loss in sales. The ease of making style changes and the frequency with which they are made have had important effects on the industry. No manufacturer can hope to capture a market for very long simply on the basis of style; successful styles can be copied and manufactured readily. One important result is that contact with other manufacturers is necessary so that a firm can keep up with changes. This has led to spatial concentration of the industry.

Entry into the industry is relatively unrestricted, because capital investment in a new plant can be rather small. As a result, the

case-goods industry is fragmented into a large number of firms. There are some cost advantages associated with large-scale production, but manufacturing-cost advantages to be obtained through large-scale production are limited to a large extent by the frequency of style changes (Davis 1957).

Furniture plants vary considerably in size. Small plants, which are essentially craft shops, may employ fewer than 10 production workers and have sales of less than $100,000 annually. The largest plants in the industry have more than 1,000 production workers and sales may run over $50,000,000 annually. There is no minimum profitable size, but small plants are generally less profitable.

In 1960, after-tax profits — as a percent of sales for the industry — varied from a loss of about 2 percent for a sales volume of less than $500,000 to a profit of about 2 percent for a sales volume of $5,000,000 to $10,000,000 and to a profit of about 4 percent for a sales volume over $25,000,000. Based on the above figures, it seems likely that annual sales of $3,000,000 to $5,000,000 would be required to give a reasonable chance for making suitable profits. Capital requirements for furniture plants average about one-half of annual sales.

The quality of furniture that is produced depends primarily on two factors — labor and wood. Labor costs, as a percent of total manufacturer's price, are higher for high-quality furniture than for low-quality furniture. Wood costs per unit of furniture are also higher for high-quality furniture; better species and higher quality lumber are required. Species such as walnut, mahogany, and cherry are generally associated with high-quality furniture, although hidden parts are commonly made of yellow-poplar, gum, or other relatively inexpensive woods.

Because of the variety of wood species used in furniture manufacture, the source of wood is geographically broad. Cherry comes primarily from Pennsylvania, walnut from Indiana, yellow-poplar from the Appalachian region, gum from the Mississippi Delta, and mahogany from overseas. A good deal of substitution is possible among species; for example, yellow-poplar and gum or tupelo are substitutes in some uses. For some species and at particular times, however, style may necessitate use of a certain

species, especially for visible parts. One result of changes in style and substitutability of species is that furniture producers are not strongly tied to a particular geographic source of wood.

Higher labor costs for better quality furniture are a reflection both of more time spent in the manufacturing process and higher levels of skill. Furniture requires more hand labor than many other products. Up to 50 percent of the labor in a plant may be classed as skilled if the quality of the product is high, and nearly all plants require at least 25 percent skilled labor.

Labor skilled in the manufacture of furniture is not necessarily skilled in other manufacturing processes. As a result, the use of standard skill classifications to judge the suitability of a labor supply may be misleading. Skilled labor for the furniture industry is generally found in areas where furniture manufacturing is concentrated. Some say that the best location for a new plant is next to a competitor's plant, in order to attract some of his labor. Skills can be developed, but training takes 6 months to a year or more. And the cost of obtaining skilled labor, or training all labor, may be prohibitive for firms moving into an area where there are no furniture plants.

Relative Importance of Requirements

Some location requirements are more important than others in that a relative shortage of one input may preclude further consideration of some areas. For example, stringent waste-disposal regulations have precluded the location of pulpmills in many areas. And lack of certain timber species or labor skills have prohibited the location of plants in some places. But often it is not readily apparent which requirements weigh most heavily in the location decision.

It was pointed out earlier that the methods of production at a given time are generally taken as being constant, and firms do not generally consider substitution among the factors of production. On the other hand, they do consider *interactions* among the costs of these factors, and this is the crux of economic-location

theory. It is possible to analyze these cost interactions and to determine, in turn, the relative importance of the various factors. This consideration will be referred to as "cost substitution."

For instance, suppose a sawmill that produces 20,000 board feet of lumber per day requires 20,000 board feet of sawlogs per day and 10 laborers working 8 hours per day. Each cost dollar per 1,000 board feet of sawlogs is equivalent to 25 cents per hour in labor costs. Hence, if the sawmill operator decides that he can operate efficiently with a sawlog cost of $60 per 1,000 board feet and a labor wage rate of $1 per hour, he can operate just as efficiently if sawlogs cost $59 per 1,000 board feet and the labor wage rate is $1.25 per hour; the total cost of producing 1,000 board feet of lumber will not change. Therefore the costs can be substituted.

The rate of cost substitution can be expressed as the change in the cost of one factor that is equivalent to an equal but opposite change in the cost of another factor. Such rates can be expressed for simple cost factors for which quantity requirements and average costs have been determined. Only factors that have been considered to be important in the location decision (that is, factors for which costs might vary among locations) are considered here.

The rate of cost substitution is defined as the change in cost that is equivalent to 10-percent changes in the cost of wood, using average costs as a base. For the lumber industry, for example (table 3), a 10-percent change in the cost of wood delivered at the plant is equivalent to a 61-percent change in labor wage rates, or to a 578-percent change in the average cost of electricity. And a 10-percent change in the cost of wood is equivalent to greater percentage changes in the cost of all other factors. This suggests that wood costs are the most important factor governing plant location in the lumber industry. That is, the smaller the percentage change that is equivalent to a 10-percent change in wood costs, the greater is the importance of the factor represented by this change.

To illustrate this point: a 10-percent change in wood costs for the lumber industry represents a change of $5 in the cost of

Table 3.—*Rates of cost substitution among inputs, in percent*[1]

Inputs	Lumber	Particle board	Wood-pulp	Furniture
Wood	10	10	10	10
Labor	61	9	36	5
Transportation	25	14	20	14
Electricity	578	35	44	155
Forest land	333	480	647	—
State and local taxes	222	55	64	40
Industrial site	2,100	2,500	2,400	4,100
Local financial assistance	6,250	750	1,050	620
Particle board	—	—	—	18

[1]Percent change in cost of inputs equivalent to a 10 percent change in the cost of the wood input.

producing 1,000 board feet of lumber, while a 10-percent change in the cost of electricity represents a change of only 9 cents in the cost of producing 1,000 board feet of lumber. Thus wood costs are considerably more important than electricity costs for sawmills, and comparisons made on the basis of cost substitution can be used to rank location factors in order of their importance.

Changes in cost greater than 100 percent are unlikely for most factors, and downward shifts greater than 100 percent are impossible. Thus, while it is quite possible that a 10-percent difference in wood costs can be found among locations, it is much less likely that a difference in labor costs of 61 percent can be found; and it is quite unlikely that a difference in electricity costs of 578 percent can be found among locations that are otherwise comparable.

Average costs for location requirements in the northern Appalachians are shown in table 4. These estimates, which were obtained from respondents interviewed in this study, were used as a base for estimating rates of cost substitution. In addition, they can be used for comparing the suitability of particular locations with the northern Appalachian average.

Rates of cost substitution for all four industries are shown in table 3. The rates are converted by dividing into the rate for the

Table 4.—*Average costs for inputs for average plants in the northern Appalachians*

Location Factors	Lumber	Particle Board	Woodpulp	Furniture
	FACTORS WHOSE COSTS VARY WITH LOCATION			
1. Wood:	Sawlogs $50 per 1,000 bd. ft. delivered to the sawmill.	Roundwood $16 per standard cord delivered to the plant.	Pulpwood $16 per standard cord delivered to the mill.	Lumber $120 per 1,000 board feet delivered to the plant.
2. Labor, per hour:	Skilled $2.25, semiskilled 1.75, unskilled 1.25.	Skilled $2.00, semiskilled 1.60, unskilled 1.25.	Skilled $2.70, semiskilled 2.45, unskilled 2.00.	Skilled $1.70, semiskilled 1.35, unskilled 1.20.
3. Forest land:	$7.50 per acre, excluding timber.	$7.50 per acre, excluding timber.	$7.50 per acre, excluding timber.	—
4. Electricity:	$0.023 per kwh.	$0.020 per kwh.	$0.018 per kwh.	$0.020 per kwh.
5. Transportation to major markets:	$20 per 1,000 bd. ft.	$13 per 1,000 sq. ft.	$11 per ton	8% of manufacturing costs (not including transportation costs).
6. Industrial sites:	$400 per acre	$400 per acre	$500 per acre	$400 per acre
7. Investment in plant and equipment:	6%	6%	6%	6%
8. State and local taxes:	2½% of sales dollar.	2½% of sales dollar.	2½% of sales dollar.	2½% of sales dollar.
9. Particle board:	—	—	—	$135 per 1,000 sq. ft.
	FACTORS WHOSE COSTS DO NOT VARY WITH LOCATIONS			
1. Resin:	—	$0.08 per lb.	—	—
2. Chemicals, per ton:	—	—	Sulfur $25, soda ash $34, chlorine $75, caustic soda $62.	

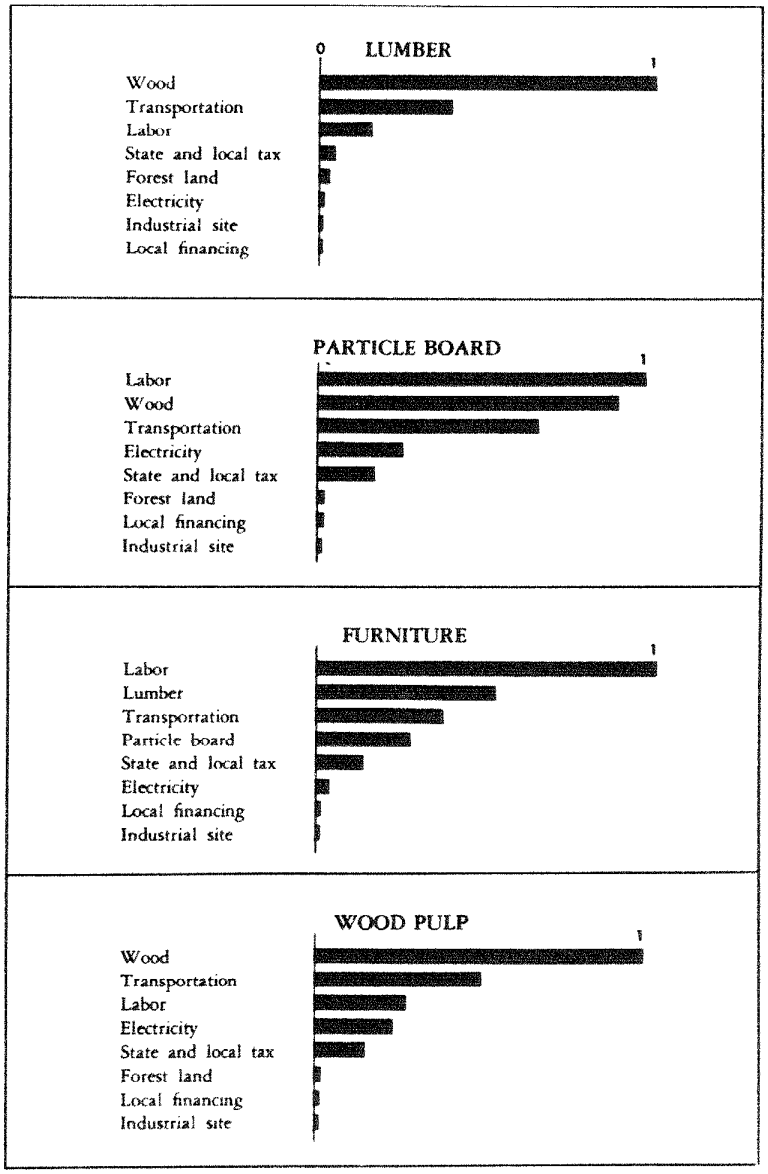

Figure 1.—Importance of selected location factors relative to the most important factor (top bar in each case). The ratios were determined by dividing rate of cost substitution (table 3) of the most important factor by the rate of cost substitution of the selected factor.

most important factor to show the relative importance of each factor. Figure 1 indicates these comparisons for each industry. Some comments regarding these rankings are in order.

First, for all four industries, the most important factors are wood, transportation, and labor. For the three primary wood-using industries, wood is at the top of the list, or very close to the top. For the furniture industry, labor is substantially more important than wood, although wood and particle board taken together are of substantial importance. Thus all four industries are raw-material-oriented (Fuchs 1962, Perloff and others 1960), although this orientation is much less strong in the furniture industry.

Second, differences in labor productivity may have some impact on the location decision. If wage rates are held constant, labor appears to be a more important factor relative to wood where labor productivity is low. However, increased labor productivity is generally associated with increased wage levels, and to a large extent this probably holds the impact of labor nearly constant on the location decision. This, of course, is aside from the question of particular labor skills or other factors, such as degree of unionization, that may affect the evaluations made by the decision-maker.

Third, the low rank of state and local taxes, and particularly industrial site and local financial assistance, suggest that industrial-development agencies are relatively ineffective in providing economic assistance to new wood-using firms through lowering taxes and providing financial assistance. This point is not wholly unexpected. Others have suggested that taxes are of little real importance in the location decision (Survey Research Center 1950). The fact that the financial-assistance plans used in this study provided help only with industrial-site land and buildings suggests that these plans would be of little real help to most wood-using firms, for which land and building requirements are not large. However, these agencies may be more important as promotional organizations and as compilers of basic information (Mueller and others 1961).

Although these rankings have been developed only for certain types and sizes of plants in the four industries, some comments

vary their approach depending on the particular industry they hope to attract.

They might also choose industries for their potential effects upon the region or community. Plants in some industries obviously employ more people than plants in other industries. Wage rates are likely to be higher in some industries. Additions to the taxable real estate base and increases in subsidiary industries may also differ. Though this study was not directed at analyzing the impact on the community of new plants in the various industries, it does indicate that there are substantial differences among plants.

And this study does provide a means for development agencies to choose among industries on the basis of availability and cost of location requirements. In addition, our understanding of the location decision for the four industries considered in this report can be used to guide the actions of development agencies in attempting to attract new wood-using industries. Each industry will be considered separately.

Lumber. — Entrepreneurial talent for the average new sawmill generally develops from within the area in which the sawmill will be located. The location decision does not ordinarily involve a choice among possible sites; instead it involves a decision whether to build or not build in a given area. The entrepreneur's decision to build a sawmill depends on his evaluation of the raw material available and of the markets that are available for the projected lumber output.

Development agencies interested in increasing the lumber output in their areas can direct their activities toward developing the interest of latent entrepreneurial talent in the area and of suppliers of local capital. This could be done by providing information and by identifying opportunities in terms of available timber and potential markets.

To be more specific, the nature of the raw-material supply determines in part the type of markets that can be entered. The location of the markets for hardwood lumber is important in determining the profitability of new sawmills. Development agencies could direct their attention at matching timber supplies

with the most profitable market opportunities and at providing this information to interested parties within the area.

Particle board. — Several possible locations are generally considered for new particle-board plants. The most important considerations are the availability of a suitable raw-material supply, low labor costs, and low transportation costs to the available markets. Other economic considerations are of relatively little importance.

Industrial-development agencies could direct their efforts toward assembling information to describe the raw-material supply and labor situation within their area, and information about market outlets and transportation costs to these markets. This information could then be provided to firms that might be interested in building new particle-board plants. Particle-board plants have usually been constructed by firms already in the wood products field — plywood producers, lumber producers, and pulp and paper producers. Firms in these fields would be potential customers for information about particle-board production possibilities.

The identification of areas that contain species suitable for particle-board manufacture — principally the pines and some of the soft-textured and light-colored hardwoods — is particularly important. Woodpulp firms compete keenly for these species in some areas. However, the quantity of wood required for an average particle-board plant is substantially less than that required for an average pulpmill. As a result, pockets in which the raw-material supply is sufficient and in which competition is negligible could be particularly attractive to new particle-board plants.

Information about prevailing labor wage rates could be provided for the standard skill classes in the area. Unemployment levels might also be of interest. Important market information would include both the types of markets available and transportation rates to these markets.

Woodpulp. — The decision to construct new pulping capacity involves the consideration of many potential locations. Generally the decision is made by a firm already in the business of producing pulp and paper. Development agencies interested in

attracting such facilities could take two types of action. First, they could provide information about the important cost factors: wood supply, transportation to markets, and utility costs. Second, they could take direct action to make industrial sites available and to ease waste-disposal requirements.

Both the cost of obtaining wood and the availability of particular species may be important in locating a pulpmill. In the hardwood region, the availability of some softwood either in the area of the potential mill site or accessible through a one-line railroad haul is generally significant. Softwood equivalent to 10 or 20 percent of the mill's total requirements would probably be sufficient. As with particle-board plants, competition from other users for limited supplies of the important species might be a limiting factor — especially considering that the quantities of wood required by a pulpmill are large.

In the long run, sources of softwood pulpwood could be developed through planting programs. However, in the space of a few years, development of a wholly new supply is not feasible. The short-run emphasis of the development agencies might be placed on identifying the location of existing supplies, and determining their availability; and, if there are some existing supplies, promoting softwood planting programs to meet the needs of potential mills when the present supplies are exhausted.

Although the cost of industrial sites is unimportant, suitable sites in the Appalachian region may be hard to find. Development agencies might identify sites that have the necessary physical requirements (water, rail sidings, and power connections in particular); and, if necessary, they might consolidate ownership of such sites so that pulpmill firms could obtain the whole site free from encumbrances.

Obtaining sites where water-supply and waste-disposal requirements can be met is difficult. Water-supply requirements are rigid for a given pulpmill, but there is little problem in judging the suitability of a particular supply. On the other hand, the impact of waste disposal on a particular stream is not easy to specify; in addition, requirements of water authorities are commonly incompletely specified. This leads to uncertainties over what waste-disposal facilities the pulpmill will have to install.

Development agencies might be able to reduce these uncertainties. One approach would be to develop a rigid set of standards that would have to be met by any mill. Allowable levels of pollution and the specific facilities that would be required to meet these levels would have to be carefully defined. This approach might discourage some new plants, but it also might attract others capable of easily meeting the standards.

A second approach would be to develop, in conjunction with the regulating commission, a flexible set of standards that would allow for negotiation between the development agency and the pulp firm. This might reduce uncertainties enough to attract a new plant. In this way, communities might modify pollution controls advantageously. Or perhaps they might provide for staged development of pollution controls in return for a promise of increased employment and payrolls (Ciriacy-Wantrup 1961).

Furniture. — Labor, both in terms of wage rates and skills, is clearly the most important factor determining the location of wooden furniture plants. This is true if the location decision is made internally by persons in the area, which is likely for small plants. It is also true if the decision is made externally, which is likely for medium and large plants.

The skills needed in furniture plants are not reflected in the standard skill classifications used by most labor census bureaus. As a result, industrial-development organizations might find it necessary to conduct special canvasses of labor skills if they are to judge satisfactorily the suitability of the area for furniture plants. Where the quantity of skilled woodworking labor is negligible, efforts could be directed at training people in woodworking skills. In areas that have any shortcomings in labor skills for furniture plants, efforts of the development agency might be better directed at attracting plants to make relatively low-quality furniture rather than plants to make high-quality furniture.

Lumber costs are second to labor costs in importance. Species requirements are usually broad in terms of geographical origin, and appear to change rather frequently. Therefore, the impact on the location decision of the lumber supply in a particular area may be slight.

There seems to be a tendency for furniture plants to concentrate in certain areas. Development agencies should consider this as a factor in determining the suitability of an area and in choosing among potential locations. They could do this either by emphasizing locations close to centers of current furniture production or, more ambitiously, by working toward the development of a concentrated area of furniture production. In the latter case, concentrating labor-training programs in one area and negotiating with several firms for contiguous locations might prove to be successful.

Summary

An improved understanding of the location decision is important to industrial-development agencies attempting to attract new plants to their areas. This study was directed at improving our knowledge of the location decision in four wood-using industries — lumber, particle board, woodpulp, and furniture. The cost of wood, labor, and transportation were found to be the most important factors that affect choice of location in all four industries, but the relative importance of these factors differs among the industries. Some factors — state and local taxes, local financial assistance, and the cost of industrial sites, which in the past have been stressed by development agencies — were found to be of relatively little importance for the wood-using industries. It is suggested that development agencies intent on attracting these industries should concentrate on providing potential firms with information organized in terms of the requirements of each industry.

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