ECONOMIES OF SCALE AND TRENDS IN THE SIZE OF SOUTHERN FOREST INDUSTRIES

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Abstract

In each of the major southern forest industries, the trend has been toward achieving economies of scale, that is, to build larger production units to reduce unit costs. Current minimum efficient plant size estimated by survivor analysis is 1,000 tons per day capacity for sulfate pulping, 100 million square feet (3/8-inch basis) annual capacity for softwood plywood, and 20 million board feet annual output for softwood lumber. Estimates of efficient size by the survivor technique reflect a plant's ability to cope with the total economic environment. In fact, additions to capital investment required to meet social and technological changes have virtually forced increased scale of output to keep unit costs in line.

Introduction

Dramatic changes in the size of operations have accompanied the rapid expansion of southern forest industries. In the last decade, average pulpmill capacity rose 18 percent, average softwood plywood plant capacity climbed 61 percent, average sawmill output jumped 79 percent, and the average output for harvesting operations doubled.

These increases in average size indicate that positive measures have been taken to realize economies of scale. If so, what sizes or range of sizes appear to be the most efficient in processing southern timber? The comparative efficiency of operations of different sizes can be measured by examining trends in the number of establishments and their size distributions in each forest industry.

Economies of Scale

Economies of scale refer to the reduction in unit costs as output increases. Change in the scale of output within an industry is one of many factors that contribute to the efficiency with which outputs are produced. Therefore, it can be an important element in determining an industry's opportunity for growth.

Scale economies usually are considered most important in the context of manufacturing. As size increases at the plant level, for example, economies can result from division and specialization of labor, increased use of more efficient machines and advanced technology, and lower administrative costs per unit of output. Negative results occur when the scale of plant is expanded to the point where unit costs increase, due to management problems in controlling and combining inputs in the production process.

In the forest industries, however, factors outside the plant such as raw material availability, transportation facilities, and markets often weigh more heavily in determining mill size than the nature of production equipment available. Therefore, it is more difficult to determine the existence of plant-level economies of scale than in, say, the chemical process industries. Nevertheless, scale economies have been recognized among the forest industries--mainly in pulp and paper, but also to a degree in plywood and lumber (5).

Measurement of scale economies and efficient plant size in an industry is usually accomplished by comparing production costs of plants of different sizes. How much unit costs are reduced as plant size increases indicates the extent to which economies are achieved. Efficient plant sizes are identified as those having the lowest costs over the range of sizes examined. A major problem with this approach, however, is that accurate cost information is difficult to obtain and is seldom up-to-date. The effort to acquire satisfactory information of this sort is probably not justifiable unless one is actually planning to construct a plant.

Another approach for estimating size efficiency is called the survivor technique. Although not as precise as

the cost approach, it is more useful in indicating industry trends. By this method, plants in an industry are classified by size, and the share of industry capacity or output accounted for by each category is calculated for two or more time periods. Those size classes that increase their relative share over time are considered the most efficient. Estimates derived from such analyses reflect more than just costs internal to a plant. They reflect a plant's ability to survive all the problems a firm faces--labor relations, technological change, government regulations, market opportunities, and other factors. Since factors outside forest industry plants significantly affect size, this approach is suitable for examining industry trends.

Trends in Size

Pulp and Paper

From 1956 to 1976, the pulp and paper industry in the South[1] expanded from 68 mills with a combined capacity in excess of 38,000 tons per day (tpd) to 112 mills with a capacity of 98,000 tpd. Average mill size increased from 564 to 876 tpd.

To see how the expansion occurred, mills were classified by daily pulping capacity, in size increments of 250 tons, from 250 tons or less up to 2,000 tons or more for 1956, 1966, and 1976 (table 1). The percent of total capacity accounted for by each of the nine size classes was calculated for each year.

Over the 20-year period, mills in size categories above 1,000 tons have increased their relative share of total capacity (table 2). Meanwhile, the share for mills in the smaller categories--1,000 tons or less--has declined. According to the precepts of survivor analysis, therefore, the range of efficient size mills is 1,000 tpd or larger. It is notable, however, that mills above 1,750 tons have not increased their share as much as those in the range from 1,000 to 1,750 tons. This may indicate some diseconomies in the largest sizes, such as higher wood costs. But if engineering estimates continue to favor expansion of capacity at existing mills, these sizes may show greater growth in the future.

The mill capacity data used in the preceding analysis include all processes at a site and do not recognize the variations in products or proportions of pine and hardwood pulpwood consumed. It would be more accurate

[1] The South as discussed herein consists of the 12 most southern states, including Virginia.

Table 1. -- DISTRIBUTION OF PULPING CAPACITY OF MILLS USING PULPWOOD IN THE SOUTH IN 1956, 1966, AND 1976.[1]

Mill capacity[2]	1956			1966			1976		
	No. mills	Capacity		No. mills	Capacity		No. mills	Capacity	
		Total	Percent		Total	Percent		Total	Percent
Less than 250	20	2,442	6.4	19	2,541	3.9	16	2,153	2.2
250-499	13	4,770	12.4	15	5,680	8.9	17	6,382	6.5
500-749	17	10,175	26.5	12	7,738	12.0	20	11,430	11.6
750-999	9	7,530	19.6	16	13,718	21.2	12	10,295	10.5
1,000-1,249	3	3,575	9.3	9	9,500	14.7	16	17,604	18.0
1,250-1,499	2	2,870	7.5	9	12,215	18.9	11	15,295	15.6
1,500-1,749	2	3,100	8.1	4	6,325	9.8	16	25,810	26.3
1,750-1,999	1	1,870	4.9	1	1,879	2.9	1	1,950	2.0
2,000 or more	1	2,000	5.2	2	5,130	7.9	3	7,155	7.3
Total[3]	68	38,332	100.0	87	64,726	100.0	112	98,074	100.0

[1] Sources: 1956, (4); 1966, (17); 1976, (1).
[2] Tons per 24 hours.
[3] Percent totals may not equal 100 because of rounding.

Table 2. -- CHANGES IN PERCENTAGE SHARE OF PULPING CAPACITY IN THE SOUTH, BY MILL SIZE CATEGORY, 1956-1976.

Mill capacity	Change
Less than 250	- 4.2
250-499	- 5.9
500-749	- 14.9
750-999	- 9.1
1,000-1,249	+ 8.7
1,250-1,499	+ 8.1
1,500-1,749	+ 18.2
1,750-1,999	- 2.9
2,000 or more	+ 2.1

to make a comparative analysis based on the markets in which mills compete. Nonetheless, roofing mills are concentrated in the smallest size class. And sulfate pulping accounts for 80 percent of total capacity, with newsprint ranking next in importance. In effect then, the analysis indicates the range in size sulfate mills must achieve if they are going to successfully compete.

What do the trends tell us about future number of mills? The South's Third Forest report estimated pulpwood demand in the year 2000 as 112 million cords (15). This would require a regional capacity of 200,000 tpd, or roughly double that of 1976. The average capacity of mills within the efficient size range is 1,443 tpd. If we assume that average capacity for all mills in the year 2000 will equal the current average efficient size, the number of mills necessary to meet tonnage requirements will be 139. Taking replacements into account, that would indicate a net increase of 27 mills over the number found in 1976.

Softwood Plywood

The rapid growth of the pine plywood industry has been the most dramatic development in the southern forest economy in recent years. Since its beginning in late 1963, production had grown to an estimated seven billion square feet in 1977 (12).

Because of its relatively brief history and record of rapid growth, estimating relative size efficiency in the industry by survivor analysis may not be entirely valid. As one writer put it, in discussing application of the technique, "A period of rapid growth accompanied by high or increasing levels of profitability should be avoided because all but the completely inept would survive and prosper (13)." In the South, though, some plywood plants did fail, changed hands, or were destroyed by fire and subsequently rebuilt. Experience was being gained and applied in new plant construction. Thus, a look at the period from 1969, a point midway in the industry's regional development, to 1976 will not only show how most of the growth took place but point to probable efficient size.

During this period, the number of plants increased from 35 to 57, and total annual capacity grew from 2.9 to just over 7 billion sq. ft. Average plant capacity jumped from 83 to 124 million sq. ft. However, a distribution of plant capacity for each year shows that all of the growth occurred in size categories above 100 million sq. ft. (table 3), as plants below this level upped their capacity and new, larger ones came on stream. All size classes below 100 million sq. ft. registered declines, both in number of plants and capacity as well as their relative share of total capacity. Therefore, plants in the range from 100 to 225 million sq. ft. (the largest in 1976) appear to be relatively more efficient for producing sheathing grades of plywood, the dominant product at southern plants.

While the market outlook for southern pine plywood is attractive, future trends in plant size will be governed more by fragmented land ownership patterns and the availability of high quality timber. If these factors become limiting, however, there may be a trend toward supporting large plywood plants by building small, satellite, green veneer plants because it will probably be more economical to ship veneers rather than veneer bolts.

Lumber

In contrast to the rapid expansion that has characterized plywood and pulp and paper, recent growth in southern lumber production has been slow and intermittent. From a post World War II low of 9.1 billion board

Table 3. -- DISTRIBUTION OF SOFTWOOD PLYWOOD CAPACITY IN THE SOUTH IN 1969 AND 1976.[1]

Plant capacity[2]	1969 No. plants	1969 Capacity Total	1969 Capacity Percent	1976 No. plants	1976 Capacity Total	1976 Capacity Percent	Change in percentage share of total capacity
Less than 50	2	74	2.6	1	48	.7	- 1.9
50-74	13	766	26.4	7	419	5.9	- 20.5
75-99	9	765	26.3	8	662	9.4	- 16.9
100-124	7	750	25.8	18	1,928	27.3	+ 1.5
125-149	4	550	18.9	4	550	7.8	- 11.1
150-174	--	--	--	8	1,271	18.0	+ 18.0
175-199	--	--	--	4	726	10.3	+ 10.3
200 or more	--	--	--	7	1,463	20.7	+ 20.7
Total[3]	35	2,905	100.0	57	7,067	100.0	

[1]Sources: 1969, (7); 1976, (8).
[2]Million square feet per annum (3/8-inch basis).
[3]Percent totals may not equal 100 because of rounding.

feet in 1961, total output has reached over 11 billion in some years and was 10.4 billion bd. ft. in 1976 (table 4). Recent gains stem from rising softwood production, as hardwood lumber output continues to trend downward.

Underlying the gradual change in production levels, however, has been a major reorganization of industry structure. From almost 24,000 sawmills in 1947, only about 2,700 are in operation today (table 5). Indeed, if survival-ability is a valid measure of efficiency anywhere, it is in sawmilling.

Trends in sawmill size have largely reflected timber supply and market conditions. From the large, early mills necessary to handle the large-size virgin timber, average sawmill size declined when small, portable mills were more adaptable to second-growth timber and fluctuating lumber markets. In this environment, survival depended more on flexibility rather than efficiency. But as lumber markets stabilized and the improving timber supply situation attracted the pulp industry, the emphasis was changed. The need for a certain minimum size mill to economically utilize chipping facilities and rising labor costs mandated more efficient operations. With the resulting closure of many small mills, sawmill size began to turn upward. In the mid 1950's, mills producing 2-3 million bd. ft. annually were considered the most profitable size (2). By the early 1960s, optimum size was estimated in the 4-5 million range (18). Arrival of the pine plywood industry further intensified competitive pressures,

Table 4. -- LUMBER PRODUCTION IN THE SOUTH, SELECTED YEARS, 1956-1976.[1]

Year	Softwood	Hardwood	Total[2]
	- - -Billion board-feet- - -		
1956	8.2	4.5	12.7
1961	5.8	3.4	9.1
1966	6.7	4.1	10.8
1971	7.9	3.5	11.3
1976	7.4	3.0	10.4

[1]Source: (14).
[2]Data may not add to totals because of rounding.

Table 5. -- NUMBER OF SAWMILLS IN THE SOUTH, SELECTED YEARS, 1947-1976.[1]

Year	Number of sawmills
1947	23,810
1958	11,453
1963	8,561
1964-67	5,045
1973-76	2,707

[1]Sources: 1947-67, (15); 1973-76, Southern and Southeastern Forest Experiment Stations, State forest and industry reports.

and rising minimum wages continued to force mechanization. These influences, plus appearance of the chipping headrig, increased the mill size needed to operate efficiently.

An estimate of the current minimum efficient size mill can be made by examining a distribution of lumber production by sawmill size classes for 1966 and 1976. The mill sizes that have gained significantly in their relative shares of total output over this period are those producing 20 million bd. ft. or more annually (table 6). As one would expect, the largest decrease occurred for those mills turning out five million feet or less annually, where sawmill numbers were cut in half. Mills in the size categories between 10 and 20 million feet showed little change in their share of output. Although this would indicate that the minimum efficient size mill would be in this range, it should be noted that the distributions include all sawmills, both softwood, hardwood, and some that saw both species groups. Most hardwood lumber is produced in mills with less than 10 million feet of annual output; but in any case, production levels are lower for sawing hardwood compared to pine when both are jointly produced. So in terms of softwood production, 20 million feet annually on a one-shift basis would appear to be the minimum efficient size operation.

Some further general observations are noteworthy from the 1976 data. Of the 2,700 mill total, 400 mills with an annual output above five million bd. ft. accounted for almost 80 percent of the total production. The 60 largest mills alone produced not only more than 30 percent of the total lumber output but nearly 50 percent of the softwood lumber.

A broad range of sawmill sizes occurs above the identified minimum efficient size--up to three mills producing over 100 million feet in 1976. However, no one single optimum size of mill exists in this range because firms do not have equal access to timber (or other resources such as capital and energy supplies). A recent cost study of sawmills in Alabama concluded that the optimum mill size was from 30 to 45 million bd. ft. per year (3), but several recent new mill announcements have been in the 50 to 60 million range. In short, the optimum size sawmill depends in large part on the assured timber supply and a firm's strategy in managing its present and future timber inventories.

Implications

Additions to capital investment required to meet social and technological changes have virtually forced increased scale of output to

Table 6. -- PERCENTAGE DISTRIBUTION OF LUMBER PRODUCTION IN THE SOUTH, BY MILL SIZE CLASS, 1966 AND 1976.[1]

Sawmill size [2]	1966		1976		Change in percentage share of total output
	No. mills	Percent of total output	No. mills	Percent of total output	
Less than 5.0	4,610 E	53.1	2,300	22.4	- 30.7
5.0-9.9	270 E	17.3	151	10.0	- 7.3
10.0-14.9	80 E	9.2	78	9.2	0.0
15.0-19.9	40 E	6.2	43	7.1	+ .9
20.0-29.9	18	4.0	54	12.9	+ 8.9
30.0-39.9	10	3.2	32	10.6	+ 7.4
40.0-49.9	5	2.0	17	7.3	+ 5.3
50.0 or more	9	5.0	32	20.5	+ 15.5
Total	5,042	100.0	2,707	100.0	

[1]Sources: 1966, (6), (15); 1976, (9), and Southern and Southeastern Forest Experiment Stations, State forest and industry reports.
[2]Annual production in millions of board feet.
E-Estimated.

keep unit costs in line. Pollution control regulations are a prime example. But this does not mean that all small producing units will disappear. Some operations always will continue to exist by providing specialized products and services. Beyond that, however, they will not be a serious factor in the total production picture.

Future developments in size in the individual forest industries will depend on the size, growth, and stability of product markets and other external forces as well as the efficiency with which the industry combines capital, labor, and available raw materials to produce and market these products. These factors will have varying effects in each industry. All sectors, however, face the common problem of procuring economical supplies of timber.

Where raw materials are a large component of total costs, as they are in the forest industries, it is most important to save on raw material cost to increase efficient production size. This can be done by increasing the yield of final product from a given amount of raw material input--such as computerized sawing, laminated lumber, and thermomechanical pulping; or by developing alternative process routes which utilize cheaper raw materials to produce the same product--for instance, whole tree chips and log allocation at wood processing complexes.

The development of integrated wood processing complexes in particular presents the opportunity not only to save on raw material costs but to expand product values. Complexes can allocate those portions of the tree to processes that maximize the net value per tree. Moreover, the output mix can be readily adjusted according to relative price changes in product markets.

The ability of complexes to process whole trees of all sizes offers other advantages. It enables more effective competition for open market timber than a nonintegrated, single product firm that can only use a limited portion of the resource. These complexes are also well suited to mechanized tree-length or full-tree logging and the economies that can be achieved from harvesting all trees in one operation. In effect, they offer the best opportunities for more complete tree utilization.

Complexes and other large installations, of course, require large volumes of raw material. The diseconomies associated with managing and harvesting small, fragmented forest tracts are often cited as a major obstacle to increasing southern wood supplies. However, it has been pointed out that most projected needs can be met by concentrating forest management efforts on 100 million acres of the best lands of the most responsive public and private owners (11). But a variety of programs will be needed for intensive forest management to be practiced on these lands. Some of the institutional arrangements designed for managing fragmented holdings are industrial leasing, tree farm families, consulting foresters, and incentive payment programs. Other approaches have also been suggested and will be needed (10, 16).

In conclusion, the ingredients for large-scale production with declining costs per unit include large-scale capital investment, the presence of skilled labor and modern technology, the availability of raw materials, the energy to operate, and sufficient market demand. While any of these factors may at times be an operative constraint affecting future trends in size, prospective timber supplies are the most important for the long run. A future picture of the South presents an image of comparative advantage enjoyed by large vertically integrated producing units as a result of economies of scale in the region's forest resources. But if prospects are to become reality, continuing intensification of forest land management is a must.

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