ECONOMIES OF PLANT AND FIRM SIZE IN THE UNITED STATES PULP AND PAPER INDUSTRIES[1]

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(Received 19 June 1980)

ABSTRACT

Statistics from the United States Bureau of the Census, census of manufacturers of 1972 for the pulp and paper industries, were analyzed with respect to labor productivity and profitability for evidence of economies of scale. In the pulp industry, profitability and productivity appeared to decrease sharply for mills with more than 500 employees. For paper and paperboard, productivity and profitability tended to level off or decline only slightly in mills with more than 500 employees. Only in the small building paper and paperboard industry did the largest mills exhibit the highest productivity. Integrated paper mills appeared more profitable than nonintegrated mills, but even the former revealed a limit to productivity gains resulting from increases in size. Employees in large mills received significantly higher wages and worked fewer overtime hours. Survivor data for pulp mills indicated a strong increase in the relative frequency of plants with 250 to 500 employees, and a large decrease in plants with 100 to 250 employees. For paper mills, a small increase in the relative number of plants with more than 250 employees was apparent. Survivor data for other industries were inconclusive. For the three largest industries, there was no evidence of economies of scale at the firm level offsetting the stagnation or decline of productivity in large plants. Size of plants appeared to explain most of the variation in productivity among firms.

Keywords: Labor productivity, profitability, wages, survivor analysis.

INTRODUCTION

The view that there are considerable economies of scale in the manufacture of pulp and paper has a long history. Entrican (1950) argued that to achieve low average costs, production should be concentrated in as large plants as practicable. Sandwell (1960) asserted that except in extraordinary circumstances "small" mills cannot be as economic as "large" mills. More recently Sutton (1973) stated that plants are constantly being expanded to capture economies of scale. This general conclusion appears to be based on the belief that both capital and production costs per unit of output decline as the productive capacity of plants increases (FAO 1973; Gregory 1972; Guthrie 1972). Yet, a few dissenting opinions have also been expressed. Worrell (1959) contended that the most efficient plant size had already been reached. More recently, King (1977) has pleaded convincingly for the installation of small- to medium-size mills in developing countries. And Grant (1978) has, using Eklund and Kirjasniemi's (1969) data, reasoned that small mills can be economically viable even in industrialized countries.

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[1] The research leading to this paper was supported by the North Central Forest Experiment Station, USDA, Forest Service, Duluth, and by the School of Natural Resources, College of Agricultural and Life Sciences, University of Wisconsin, Madison. We are particularly indebted to Edwin Kallio and David Lothner of the North Central Forest Experiment Station for endorsing the idea of the project and for their constant support. The careful comments of Peter Ince and one anonymous reviewer are also gratefully acknowledged.

Wood and Fiber, 13(2), 1981, pp. 102–114

The extent of economies of scale in the pulp and paper industries is an important consideration in the formulation of public policy. These industries are generally quite concentrated, and have occasionally been characterized by noncompetitive behavior (Michaels 1979). Barriers to entry, which stem largely from the enormous capital required for new mills and the woodlands to supply them, while formidable at present, are predicted to increase in the future (Little 1977). Yet, if there exist large economies of scale, there may be significant social benefit from having only a few firms operate very large mills.

The objective of this paper is to examine the effect of plant and firm size on the economic efficiency of the pulp and paper industries. We plan to show that for the three major industries—pulp, paper, paperboard except building—although efficiency increases rapidly from small- to intermediate-size mills, it then levels off or even declines for very large mills. The same is true for integrated and nonintegrated paper mills, although integrated mills appear somewhat more efficient. Workers appear to fare better in large mills; they tend to work fewer hours and receive better wages. Nevertheless, there is no clear evidence that the relative number of small mills is declining. Analyses of profitability and productivity in firms of various size indicate that there are no economies of scale for firms that cannot be explained by the size of mills used.

METHODS AND DATA

The paucity of quantitative studies of economies of scale in the pulp and paper industry may be due to the difficulty of using econometric or engineering analysis in this context. Econometric estimation of economies of scale from cost functions requires data which, while available for some public utilities or railroads (Borts 1968; Christensen and Greene 1976), are not readily available for other industries. On the other hand, engineering studies are costly and often limited in scope.

In this study we have instead used simple comparisons of labor productivity and profitability, along the lines suggested by Miller (1978a, b). In addition we have sought additional evidence from survivor data (Saving 1961; Gorecki 1978).

All data were taken from the 1972 census of manufactures, except for the survivor analysis, which uses information gathered during the last six censuses. For the census of manufactures, the data are reported for each establishment (esentially a plant) on value of output, employment, payroll, and cost of materials used. These data are tabulated by size of plant, defined by number of employees; and by size of firm, defined by value of shipments. For the pulp and paper industries, data are available at the four digit Standard Industrial Classification level, comprising: Pulpmills (SIC 2611), Papermills except Building Paper (SIC 2621), Paperboard Mills (SIC 2631) and Building Paper and Board Mills (SIC 2661).

INFLUENCE OF PLANT SIZE ON LABOR PRODUCTIVITY

Labor productivity will be used here as an indicator of the efficiency of pulp and paper plants of various sizes. Although this may be challenged on theoretical grounds (Kaiser 1971; Dempsey 1973), no practical alternative is available. In particular, over-all productivity cannot be computed because of the absence of data on capital input. However, several measures of labor input are available. These include total number of employees, total payroll, number of production

TABLE 1. *Labor productivity in pulp and paper plants of various size, based on value added per man-hour of production worker in 1972.*

Plant size					
Class	Number of employees	Pulp mills	Paper mills	Paperboard mills	Building paper and board mills
			(Dollars/hr)		
I	20–49	10.4	11.4	10.6	7.6
		(7)	(31)	(24)	(29)
II	50–99	12.6	11.6	11.0	8.2
		(6)	(33)	(66)	(19)
III	100–249	21.5*	12.6	11.7	12.0
		(5)	(80)	(80)	(16)
IV	250–499	19.7	13.3*	19.7*	10.7
		(10)	(56)	(43)	(5)
V	500–999	15.9[b]	12.9	18.8	13.3[b]*
		(7)	(68)	(20)	(5)
VI	1,000+		12.9	17.5	
			(27)	(15)	

Notes: Numbers in parentheses refer to the number of mills in that size class. * indicates the maximum labor productivity. The superscript b indicates that some larger mills were included.

workers, number of production worker man-hours, and total wages of production workers. We have chosen man-hours of production workers as the measure of physical labor input mainly because it is a relatively homogeneous and well-defined quantity.

The simplest measure of output is the value of shipments. However, Census Bureau data also provide an estimate of value added by manufacture. Value added is derived by subtracting the total cost of materials from the value of shipments, and adjusting the resulting amount by the net change in finished products and work-in-process inventories between the beginning and end of the year. Thus defined, value added is widely accepted as a measure of output. Value added, in conjunction with the number of man-hours of production workers, forms the basis of the labor productivity index used here.

Value added per man-hour has been computed for the four industries of interest, for each size class of plant as defined by the total number of employees, for which census data are reported. According to this size classification, number of employees doubles between each successive class. Roman numerals have been used to identify these size classes in Tables 1 to 6. They will be used throughout the text for brevity in referring to a given size class. It should be noted that there is a much larger absolute difference in number of employees between size classes V and VI than between size classes I and II (Table 1).

As indicated in Table 1, labor productivity in pulp mills increases rapidly with size of plant up to plants with 100 to 250 employees. Value added per man-hour in pulp mills of size class III was double that of size class I. However, labor productivity measured in this manner was slightly lower for the next largest size class, and considerably lower (by about $5 per man-hour) for the seven mills with more than 500 employees.

For paper mills, value added per hour also increased with size of plant up to

a point. The increase in productivity is much smaller than for pulp mills; the difference is only about $2 per man-hour between mills employing fewer than 50 persons and mills ten times larger. Labor productivity peaks in mills with 250 to 500 employees and declines slightly in larger mills.

For paperboard mills there appears to be little increase in labor productivity between size classes I and III. But, in contrast with paper mills, value added per hour is much higher for plants in size class IV, i.e., 250 to 500 employees. Productivity tends to decline for larger mills.

The pattern is less systematic for building paper and board mills. Value added per man-hour of production worker increases steadily from size class I to III, declines for size class IV but reaches its maximum in size class V. This is the only industry in which the largest mills exhibit the highest labor productivity. However, the productivity difference between size classes III and V is not very large. Furthermore, it must be kept in mind that value added originating from building paper and board mills represented only some 5% of the value added for the entire pulp and paper industry, in 1972. The situation in this small sector therefore cannot be considered typical of what occurs in all pulp and paper industries.

In summary, the evidence provided by value added and employment data tends to indicate that although there is generally a substantial increase in labor productivity as size of plant increases, there is a limit to this phenomenon. For paper and paperboard, giant mills are no more productive than mills with 250 to 500 employees, whereas pulp mills with 100 to 250 employees appear much more productive than mills that are two to four times as large.

EFFECT OF PLANT SIZE ON PROFITABILITY

To get some indication of how profitability may vary according to mill size, we used the profitability index adopted by Miller (1978a). Total profit or, more accurately, "gross rent" is defined as value added minus payroll—that is, value of shipments, minus value of materials, minus payroll. Gross rent is not comparable across mills, however, because of large differences in mill size. Miller adjusted for mill size by dividing gross rent by number of employees. We chose instead to use number of man-hours for production workers as our standard in order to obtain a measure of profitability similar to the productivity measure used above. The resulting profitability index (gross rent per man-hour of production worker) is in effect a combination of economic profit, return to capital, depreciation, nonplant costs, purchased services, and payment for proprietor's labor (Miller 1978a). Since the pulp and paper industries are capital-intensive, one might expect return to capital and depreciation to be of major importance.

The results are reported in Table 2. The pattern observed for labor productivity is repeated by the profitability index—rising profitability up to medium-size mills, then stagnant or declining profitability over a wide range of sizes, with the exception of the building paper and paperboard industry, in which the largest mills appear most profitable.

EFFECT OF VERTICAL INTEGRATION AND SIZE ON PRODUCTIVITY AND PROFITABILITY OF PAPER MILLS

There appears to be an increasing tendency for pulp and paper firms to integrate vertically, for example for pulp mills to acquire a paper mill or vice-versa. There-

TABLE 2. *Profitability of pulp and paper plants of various sizes, based on gross rent per man-hour of production worker in 1972.*

Plant size					
Class	Number of employees	Pulp mills	Paper mills	Paperboard mills	Building paper and board mills
			(Dollars/hr)		
I	20–49	6.2	6.5	5.3	3.4
		(7)	(31)	(24)	(29)
II	50–99	6.3	6.1	5.6	3.1
		(6)	(33)	(66)	(19)
III	100–249	14.9*	6.4	6.1	6.8
		(5)	(80)	(80)	(16)
IV	250–499	12.2	6.9*	12.9*	4.9
		(10)	(56)	(43)	(5)
V	500–999	8.7[b]	6.6	12.2	8.0[b]*
		(7)	(68)	(20)	(5)
VI	1,000+		6.3	10.5	
			(27)	(15)	

Notes: Numbers in parentheses refer to the number of mills in that size class. * indicates the maximum profitability. The superscript b indicates that some larger mills were included.

fore, it is of interest to know the effect of such integration on plant performance. The Bureau of the Census collects data by size classes for both integrated and nonintegrated paper mills, paperboard mills and building paper and board mills. However, disclosure rules prevent the publication of many data. A notable exception, however, is paper mills, except building paper (SIC 2621) for which fairly complete data are available. For this class of mills, we have computed the profitability and productivity indices described above, for both integrated and nonintegrated mills (Table 3).

It appears that at equal size, paper mills integrated with a pulp mill are generally

TABLE 3. *Value added and gross rent per hour of production worker for integrated and nonintegrated paper mills.*

Plant size		Integrated with a pulp mill		Not integrated with a pulp mill	
Class	Number of employees	VA/H ($/hr)	P ($/hr)	VA/H ($/hr)	P ($/hr)
I	20–49	11.0	6.2	11.5	6.5*
		(7)		(24)	
II	50–99	11.2	5.6	11.8	6.3
		(8)		(25)	
III	100–249	13.1	6.7	12.3*	6.3
		(27)		(53)	
IV	250–499	14.3*	7.9*	12.0	5.7
		(31)		(25)	
V+	500+	13.2	6.7	11.2	4.8
		(79)		(16)	

Notes: Numbers in parentheses refer to the number of mills in that size class. P is the profitability index (gross rent per hour of production worker). VA is value added in millions of dollars. H is thousand man-hours. * indicates maximum labor productivity and profitability.

both more labor productive and more profitable than nonintegrated mills, except for mills with less than 100 employees. For integrated mills, labor productivity and profitability tend to increase with size, up to 250 to 500 employees. Both productivity and profitability appear to decrease beyond that size. Nonintegrated mills, on the other hand, seem to reach maximum labor productivity at smaller sizes (100 to 250 employees), while profitability is greatest in very small mills (fewer than 50 employees). In summary, paper mills integrated with a pulp mill appear to be both more productive and more profitable. However, even for integrated mills there is a limit to the gains resulting from increases in size. These gains are much smaller for nonintegrated mills.

LABOR PRODUCTIVITY AND WAGES IN PULP AND PAPER PLANTS OF VARIOUS SIZES

The profitability index used above gave some indication of the advantages (disadvantages) of various pulp and paper plant sizes from the point of view of the owners of capital. In a similar manner it is of interest to determine whether, and by how much, returns to labor vary in mills of different size.

According to economic theory, under competitive conditions any input into a production process is paid the value of its marginal product. For labor this should lead to a close relationship between the wage rate and labor productivity. Guthrie (1972) argues that in the pulp and paper industries wage rates are a direct function of productivity. While the industries are strongly unionized (97% for papermakers and 100% for pulp mill workers), contracts are normally negotiated independently at each mill. Hence, wage rates largely reflect productivity (Guthrie 1972). According to Guthrie (1972), unions have modified their wage demands in low productivity mills in the past. In this section we examine whether variations in wages by size of plant follow the pattern of variations in labor productivity reported in Table 1.

Average wage rates for production workers have been computed for all mills in each size class for pulp mills, paper mills, paperboard mills, and building paper and board mills (Table 4). These wage rates are based on census data for total wages and total number of production worker man-hours.

The results indicate that wage rates do follow the general trend of labor productivity, both within and across industries. Within each industry, as the size of plants increases, wages and labor productivity tend initially to rise rapidly but then to rise only slowly as labor productivity reaches a plateau.

As Table 4 indicates, the difference between wage rates in the smallest and largest mills may be considerable, ranging from 20% for paperboard mills to 69% for pulp mills. Furthermore, these differences in average wage rates underestimate the differences in actual wage rates because the average wage rates in Table 4 are computed by aggregating normal and overtime work hours. An overtime index computed from census data and assuming a regular working year of 2,000 hours indicates that workers in small mills do considerably more overtime work than those in large mills. For example, in 1972 the average worker in pulp mills with fewer than 50 employees worked 24% more overtime hours than his counterpart in mills with more than 500 employees. Nevertheless, his average hourly wage was $3.20 versus $5.40 for workers in the largest plants, and his total annual earnings were 36% lower. Only in the paperboard industry did pay of workers in

TABLE 4. *Labor productivity and wages in pulp and paper plants of various sizes.*

Plant size		Labor productivity ($/hr)	Average wage rate ($/hr)	Overtime index[1]
Class	Number of employees			
		Pulp mills, except building		
I	20–49	10.4	3.2	1.25*
II	50–99	12.6	4.7	1.16
III	100–249	21.5*	5.2	1.07
IV	250–499	19.7	5.7*	1.09
V	500+	15.9	5.4	1.01
		Paper mills, except building		
I	20–49	11.4	3.9	1.25*
II	50–99	11.6	4.0	1.18
III	100–249	12.6	4.4	1.12
IV	250–499	13.3*	4.9	1.06
V	500–999	12.9	4.8	1.11
VI	1,000+	12.9	5.0*	1.08
		Paperboard mills		
I	20–49	10.6	4.1	1.26*
II	50–99	11.0	4.2	1.19
III	100–249	11.7	4.5	1.17
IV	250–499	19.7*	5.2*	1.13
V	500–999	18.8	5.1	1.10
VI	1,000+	17.5	4.9	1.04
		Building paper and board mills		
I	20–49	7.6	3.5	1.12*
II	50–99	8.2	4.3	1.09
III	100–249	12.0	4.3	1.20
IV	250–499	10.7	4.4	1.04
V	500+	13.3*	4.5*	1.05

[1] Computed as total number of man-hours per year divided by 2,000. * indicates maximum productivity, wages, or overtime.

the smaller mills match the yearly pay of workers in the largest mills, but they achieved this by working 21% more hours.

To summarize, there appears to be a clear advantage to working in large mills; e.g., less work for better wages. These differences may arise in part from differences in labor productivity and related differences in labor skills. For example, differences in wage rates between the largest and smallest paperboard and building paper and board mills are more than compensated for by differences in productivity. But this is not the case in pulp mills and paper mills. It may well be that there are some economies of scale in labor organization itself (Masters 1969). Larger plants are likely to face stronger unions capable of obtaining better contracts for their members.

EFFECT OF PLANT SIZE ON SURVIVAL

Because of the measurement and definition problems attached to the productivity and profitability indices used above, additional evidence was sought regarding the effects of plant size on economic performance. A good indicator of the economic efficiency of a plant of a particular size is its ability to survive over

TABLE 5. *Distribution of pulp mills by size of establishment, period 1947 to 1972.*

Plant size		Percentage of plants in each size class[1]						Changes	
Class	Number of employees	1947	1954	1958	1963	1967	1972	1947 to 1967	1947 to 1972
I	20–49	17.4	13.7	22.9	15.0	18.6	20.0	+1.2	+2.6
II	50–99	15.9	21.2	12.5	17.5	14.0	17.1	−1.9	+1.2
III	100–249	30.8	23.1	20.8	12.5	16.3	14.3	−14.5	−16.5
IV	250–499	20.0	24.5	22.9	27.5	30.2	28.6	+10.2	+8.6
V	500–999	14.4	15.1	16.7	20.0	14.0	17.1	−0.4	+2.7
VI	1,000+	1.5	2.4	4.2	7.0	7.0	2.9	+5.5	+1.4

[1] Percentages may not add up to 100 because of rounding.

a long period of time. This simple idea has been used to develop a method of analysis of plant-size effects called the survivor technique (Saving 1961; Gorecki 1978). In its simplest form, this procedure examines the changes over time in the relative frequency of plants in various size classes. A size class or a group of contiguous size classes showing an increasing percentage of the total number of mills in an industry is judged to be within the range of most successful, and therefore economically efficient, mill sizes. Cases of noncontiguous size classes showing increases result in inconclusive findings. Competitive efficiency is therefore defined as historical viability, shown by the relative increase or decline in the number of mills in a certain size class.

The data reported by the Bureau of the Census can be used for a survivor analysis of pulp and paper plants. For pulp mills, data on number of plants by number of employees have been obtained for the census years 1947, 1954, 1958, 1963, 1967, and 1972. For each year the percentages of plants in each size class have been computed (Table 5). Only data for plants having more than 20 employees have been used because there appear to have been several problems in classification for smaller mills. In addition, in 1972 a number of establishments that were previously classified as pulp mills were recorded as paper mills and paperboard mills because the operations involved integrated mills. For that reason Table 5 reports changes in percentage of plants in each size class both for 1947 to 1967 and 1947 to 1972. The results indicate a strong increase in the relative frequency of plants in size class IV (250 to 499 employees), and an even larger decrease in size class III (100 to 249 employees). This is somewhat surprising, in view of the fact that data in Tables 1 and 2 tended to indicate that in 1972, plants in size class III were the most productive and profitable. It is also of interest to observe that there has not been a decline in the proportion of establishments in the very small size classes.

The same computations have been done for paper mills, paperboard mills, and building paper and board mills. However, only the 1958, 1963, 1967, and 1972 data could be used because earlier censuses did not disaggregate the paper and paperboard industry into compatible groups. The results for the three subindustries appear in Table 6. They are generally inconclusive; there is no clear increase or decrease in the relative frequency of small or large establishments over the period of observation. Only for paper mills is it observed that the relative number of plants in and above size class V (500–999 employees) has tended to increase.

TABLE 6. *Distribution of paper mills, paperboard mills and building paper and board mills, by size of establishment, period 1958–1972.*

Plant size		Percentage of plants in each size class[1]				1958 to 1967	1958 to 1972
Class	Number of employees	1958	1963	1967	1972		
				Paper mills, except building			
I	20–49	12.6	11.2	11.5	10.5	−1.1	−2.1
II	50–99	13.8	15.3	11.8	11.2	−2.0	−2.6
III	100–249	27.7	27.2	26.8	27.1	−0.9	−0.6
IV	250–499	19.8	17.9	21.1	19.0	+1.3	−0.8
V	500–999	16.4	17.3	16.6	23.1	+0.2	+6.7
VI	1,000–2,499	8.5	10.2	11.2	8.8	+2.7	+0.3
VII	2,500+	1.3	0.3	1.0	0.3	−0.3	−1.0
				Paperboard mills			
I	20–49	15.2	15.8	13.6	9.7	−1.6	−5.5
II	50–99	21.6	21.2	23.1	26.6	+1.5	+5.0
III	100–249	38.0	36.7	36.4	32.3	−1.6	−5.7
IV	250–499	14.4	13.3	15.2	17.3	+0.8	+2.9
V	500–999	7.6	8.5	6.8	8.1	−0.8	+0.5
VI	1,000–2,499	3.2	3.5	4.6	6.1	+1.4	+2.9
VII	2,500+	0.0	0.0	0.4	0.0	+0.4	0.0
				Building paper and board mills			
I	20–49	35.4	31.1	35.1	39.2	−0.3	+3.8
II	50–99	28.1	29.9	24.3	25.7	−3.8	−2.4
III	100–249	19.8	23.4	24.3	21.6	+4.5	+1.8
IV	250–499	10.4	10.4	9.5	6.8	−0.9	−3.6
V	500–999	3.1	2.6	4.1	4.1	+1.0	+1.0
VI	1,000–2,499	3.1	2.6	2.7	2.7	−0.4	−0.4

[1] Percentages may not add up to 100 because of rounding.

This is consistent with data in Tables 1 and 2 showing labor productivity and profitability reaching a plateau for paper mills in size class IV and above.

INFLUENCE OF FIRM SIZE ON PRODUCTIVITY AND PROFITABILITY

The preceding analysis has implied that at the level of the plant there is a limit to increases in profitability and efficiency arising from increases in the size of operations. Additionally, survivor data indicated that small establishments do survive competition with large mills. This would seem to mitigate the idea that giant mills are naturally more efficient than small mills. However, economies of scale, if they exist, may arise not only at the plant level, but also at the level of the firm. In the same manner that plants tend to become larger and larger in the pulp and paper industries, so too firms attempt to grow. Indeed, many would argue that there is no economic alternative to this expansion. As observed by Miller (1978b), there is a very general tendency in all industries for the growth of plants and firms to develop in parallel. This leads to large firms owning the larger mills.

The Bureau of the Census ranks firms according to the value of shipments, and reports the number of establishments owned by firms in different size classes. All other data on labor input, costs and value added available by plant size are also

TABLE 7. *Size of firms and average plant size in the pulp and paper industry in 1972.*

Industry	Rank of firms by value of shipments				
	1–4	5–8	9–20	21–50	51+
	Average number of employees per plant (Average number of plants per firm)				
Pulp mills	492	560*	75	8	—
	(3.3)	(1.3)	(1.3)	(1.0)	
Paper mills	681	921*	611	485	106
	(10.5)	(6.0)	(4.4)	(2.0)	(1.2)
Paperboard mills	539*	371	500	198	81
	(8.2)	(6.0)	(2.8)	(3.0)	(1.1)
Building paper and paperboard mills	387*	153	84	16	—
	(3.8)	(3.8)	(3.1)	(1.0)	

Notes: * indicates firms with establishments of maximum average size for that industry.

available by firm size. These data have been used to compute the average number of plants owned by each firm in a particular size class, as well as the average number of employees in each plant (Table 7). It can be observed that the largest firms do tend to have establishments of largest average size. This is especially true of paperboard and building paper and board in which the four largest firms have the largest establishments. But it is true for pulp mills and paper mills only if one considers the eight largest firms as a whole. For these last two industries, the four largest firms achieve their size by having more rather than larger mills.

To determine the effect of the size of pulp and paper firms on economic performance, the labor productivity and profitability indices used to compare plants of various sizes were also computed for firms (Table 8). The profitability trends across firm size classes are very similar to the productivity trends; therefore only the former are reported. The results indicate that only in the paper and building paper and board mills do the four largest firms have highest productivity. For building paper and board, this is consistent with our previous findings that the largest plants were the most productive since the largest firms operate the largest plants. For paper, high productivity in the largest firms was not achieved by using plants of largest size. This result is consistent with the finding that productivity tends to stagnate or decline in very large plants. For the pulp industry, maximum productivity occurs in the firms ranked 9th to 20th, which often operate a single mill of relatively small size (circa 75 employees), a finding which is consistent with the sharp drop in productivity noted previously in the largest mills. Finally, the most profitable firms in the paperboard industry also rank 9th to 20th; the typical firm operates fewer than three mills of intermediate size (500 employees). This plant size was found to be close to the optimum in terms of productivity (Table 1), with little decline for larger plants.

In summary, firm data do not in general show economies of scale at the firm level offsetting the stagnation or decline of productivity and profitability in large plants for the three major pulp and paper industries. The variations in productivity and profitability according to size of firm can generally be explained by the size of plants used.

TABLE 8. *Labor productivity and profitability in pulp and paper firms of various sizes.*

Industry	Ranks of firms by value of shipments				
	1–4	5–8	9–20	21–50	51+
	Labor productivity ($/hr)				
Pulp mills	17.1	17.6	20.4*	7.8	—
Paper mills	14.6*	12.1	13.4	12.9	10.1
Paperboard mills	18.4	17.6	19.4*	14.6	9.6
Building paper and board mills	12.9*	11.5	9.4	8.2	—
	Profitability index ($/hr)				
Pulp mills	9.8	10.4	14.4*	1.5	—
Paper mills	8.0*	5.8	6.8	6.5	4.6
Paperboard mills	11.8	11.6	12.1*	8.4	4.3
Building paper and board mills	7.5*	6.3	4.6	2.5	—

Notes: Labor productivity measured as value added per hour of production worker, profitability as gross rent (value added-payroll) standardized by hours of production workers. * indicates firms of maximum productivity or profitability.

SUMMARY AND CONCLUSIONS

Readily available census data have been used to analyze the effect of plant and firm size on labor productivity, profitability, and wages in the United States pulp and paper industries. It was found that in the three largest industries (pulp, paper, paperboard), labor productivity and profitability, after a brief rise from small to intermediate mills, tended to stagnate or even decline over a wide range of large sizes. For the pulp industry, labor productivity and profitability appeared to decline sharply for mills with more than 500 employees. For paper and paperboard, there seemed to be no increase, and actually a small decline, in labor productivity and profitability for mills with more than 500 employees. Only for the building paper and paperboard sector did the largest mills show the highest level of labor productivity. It appeared that paper mills integrated with a pulp mill were more productive and profitable than nonintegrated mills. However, even for integrated mills, there seemed to be a limit to productivity gains resulting from larger sizes.

It was found that workers in large mills, while they did significantly less overtime work, received much better wages than workers in small mills.

Survivor data for pulp mills indicated a strong increase in the relative frequency of plants with 250 to 499 employees, and a large decrease in plants with 100 to 249 employees. For other industries, survivor data were generally inconclusive, showing no clear change in the relative frequency of small or large mills over the period of observation. For paper mills the data indicated that the relative number of plants with more than 500 employees has tended to increase.

For the three major industries, data relating to firms of various sizes (as measured by value of shipment) did not in general show economies of scale at the firm level offsetting the stagnation or decline of productivity and profitability in large plants. The variations in productivity and profitability according to size of firm can generally be explained by the size of plants used.

The United States has long sought to promote economic competition by actively discouraging strong concentration within industries. This policy can be

attacked as inefficient whenever one of two situations exist: 1) if economies of scale are present with regard to firm size, regardless of the size of the firm's manufacturing plants, or 2) if economies of scale with regard to manufacturing plant size exist to such a degree as to make small- or medium-size firms incapable of investing in such facilities. The data examined in this paper do not support the existence of either of these situations in the U.S. pulp and paper industries, except for building paper and paperboard.

The results suggest that competition might be enhanced with little or no loss in economic efficiency if the largest firms in the pulp and paper industries, except for building paper and paperboard, were divided into smaller units. We would caution, however, that this statement is more in the form of a working hypothesis than a definitive conclusion. The analysis reported in this paper is greatly restricted by lack of data on total factor costs. In addition there are problems due to the type of data used. Each one of the four industries considered, corresponding to the four digit SIC classification, includes very different mills in terms of products manufactured, processes used, and plant location. It may well be that diversity is what allows small mills to survive and even prosper because of a combination of protected markets and low cost of local labor and materials (Sandwell 1960), marketing flexibility (Rich 1972) and high-value product specialization (Guthrie 1972). In future work on economies of scale, it would be of interest to take this diversity into account, but this will be very difficult until data for individual mills are available.

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