Lars Wohlin:
Structural Change in the Forest Industries

One of the important aims of active industrial policy in Sweden is said to be the co-ordination of efforts to accelerate structural rationalization as a means of strengthening the international competitiveness of industry, with efforts to promote security of employment. It has also been asserted that one of the aims of labour market policy should be to stimulate the mobility of labour in order to facilitate more rapid structural change. It is argued that the macroeconomic gain from labour moving to more productive firms and production units justifies substantial compensatory payments. Similar ideas have been expressed with reference to regional development policy, the differences in productivity between similar production units in different regions being used as an argument when discussing the pros and cons of further growth in the major cities.

Considering the importance that is being attributed to structural questions in the aims and means of government policy in these fundamental matters, it is essential to define what is meant by structure in these contexts and what is to be regarded as an optimal structure. By the same token it is important to study the magnitude and causes of differences in productivity and to find ways of measuring the effects of structural change on the development of productivity. Our knowledge is slight in this field, particularly in the latter respect. The present article deals with my attempts to quantify the magnitude and causes of differences in productivity and to measure the influence exerted by structural change on the development of labour productivity in the forest industries.

The structure of productivity in the pulp and paper industry

The theoretical analysis is based to a large extent on Salter's *Productivity and Technological Change* (1960), though it also utilizes more recent articles concerning capital vintage models. Fundamental to the analysis is the idea that the production of capital goods casts the technology known at the time of the investment into a mould and that it is extremely difficult, if not impossible, for capital goods created in this mould to be adapted in order to take advantage of improved technology. Thomas and Bessemer furnaces, for instance, can hardly be converted into oxygen furnaces for the production of steel. In such cases the new technology is said to be embodied in capital. As a result the labour input per unit output will rise with the age of the capital vintage.

For a firm to invest in the latest capital vintage, it requires sufficient funds, after covering operating costs, to pay for amortization and interest on the capital. Similarly, plant which does not cover operating costs over a certain length of time will not be retained in production. When the total unit cost at the latest vintage undercuts the operating unit cost for an older plant, the firm has cause to replace the latter. From this it follows that within a branch, the difference in operating unit cost between today's optimal plant and the oldest plant still in operation tends to be equalized with *the amortization and interest costs of investing in today's optimal plant.*

Since the difference between plants in operating costs per unit produced—measured in terms of value added—arises because wage costs increase with the age of the vintage, the dispersion of labour productivity in a branch is determined by the size of capital costs per unit produced. The higher the capital ratio in a branch—and this ratio is certainly very high in the pulp and paper industry—the greater the dispersion in productivity and *the longer the lag for the introduction of new technology.*

In the forest industries it is difficult to date plants according to their year of construction. One finds that many plants were first constructed a long time ago and have subsequently undergone extensive alterations and rebuilding. Instead of using age as a criterion (which might be possible, for instance, in the case of tankers), I have ranked all independent pulp mills and all integrated paper mills according to the size of gross profit margins in 1964 and studied the characteristics of this grouping. The material is based on a detailed analysis of the costs, receipts and input requirements reported by the firms for each plant in their returns to the official Swedish industrial statistics. Ranking the plants by diminishing gross profit margins is equivalent to ranking them by variable unit costs.

The level of prime unit costs is indicated in Figs. 1 and 2 by the height of the bars. The level has been calculated as an average for a number of plants (group of plants),

---

Lars Wohlin, D. Econ., is assistant director of research at the Swedish Industrial Institute for Economic and Social Research. The present article is a summary of sections of a book written by him and published by the Institute (*Skogsindustrins strukturomvandling och expansionsmöjligheter,* IUI 1970). For reasons of space, details of the theory underlying the analysis have had to be omitted from the present account.

Fig. 1. Independent pulp mills in Sweden in 1964 ranked by prime unit cost

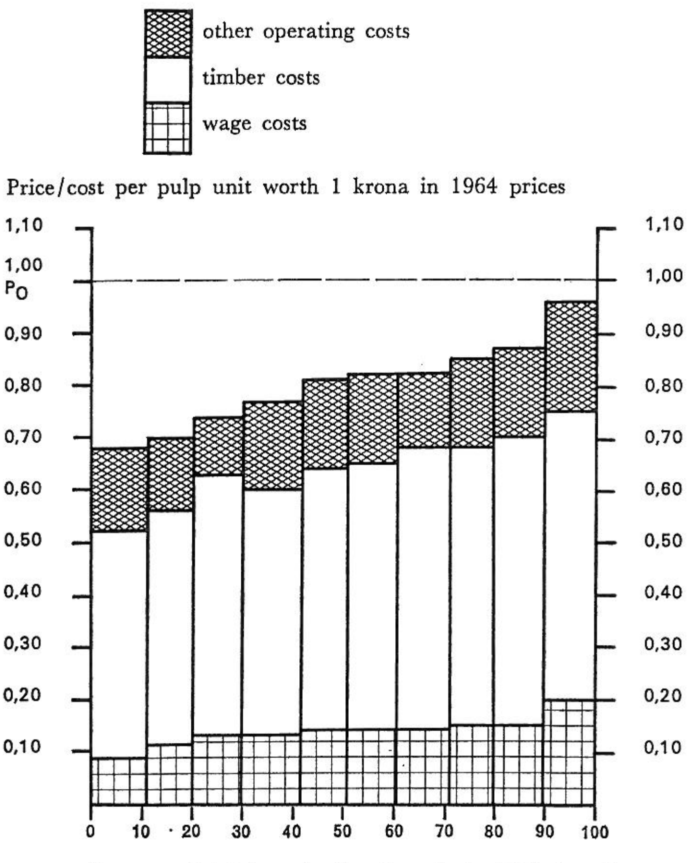
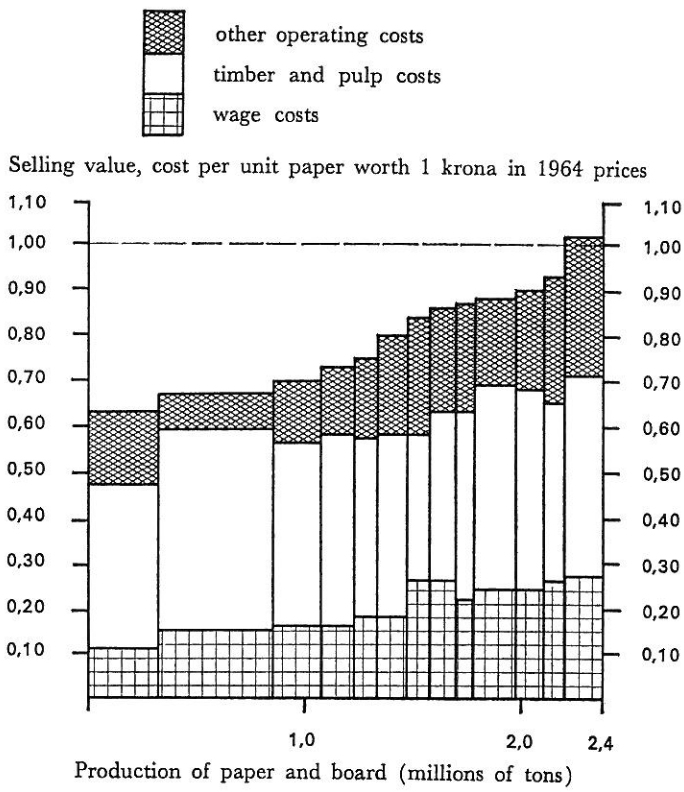


Fig. 2. Swedish paper mills (integrated) grouped by operating unit cost in 1964

Each level represents the average for three mills, though the group on the far right comprises five mills.



aggregated in the case of independent pulp mills so that each group accounts as nearly as possible for 10 per cent of total production measured in tons. Changes in the structure of productivity over time are easier to compare with this form of aggregation compared with an arrangement of units into groups of three plants each. In the case of integrated paper mills, however, the information required for a complete classification by deciles is confidential. Furthermore, data on the paper industry is available only for 1964, which rules out comparisons over time. Under these circumstances I have chosen to present this structure in groups of three units.

The price of pulp is indicated in Fig. 1 by the horizontal line intersecting the y-axis at P_0. In view of the necessity of aggregating pulp grades that have different prices per ton, output has been standardized to a quantity of pulp valued at one krona at mean prices for 1964. Costs have therefore been measured in öre per krona sales value. The area between this broken line and the bars represents the return on capital or, if it is preferred, the gross profit (though certain costs for central administration have to be covered by the gross profit). Fig. 2 has been obtained in a similar way.

Ranking the plants according to their gross profit margins can be regarded as a means of distributing the capacity of a branch according to the productivity of the capital. The plants furthest to the left in Figs. 1 and 2 may be defined as those with the best practice technique. This interpretation presupposes that the differences in operating unit cost reflect differences in the expenditure of labour and input goods and are not a result of plants with the highest gross profit margin paying lower wages and prices for timber, power and other input goods by virtue of market dominance or misleading accounting prices.

This problem was studied as thoroughly as the data permitted in the investigation on which the present article is based. The following observations may be noted here. It will be seen from Fig. 2 that in the paper industry there is a clear relationship between the size of mills and gross profit margins. This also applies to the pulp industry. The correlation, however, is not perfect. In both industries some of the largest mills are to be found in the second and third deciles. Since the scale of production has grown very rapidly over time, the close relationship between gross profit margins and size is a clear indication that ranking according to gross profit margins corresponds approximately to ranking according to the productivity of these plants.

It will also be seen from the figures that wage and timber costs tend to account for a declining proportion of the value of production as gross profits rise. The same applies to the costs for power and other input goods. This congruence indicates that more modern capital not only saves labour but also requires proportionally less expenditure on power and timber. The best mills utilize the cheaper grades of pulpwood (spruce and softwood) to a large extent or produce pulp and paper from a lower input of wood fibres per ton (as well as per krona sales value).

The level of wages varies somewhat between the plants, the difference between the highest and lowest wage as a percentage of the mean wage amounting to 15—18 per cent in the years for which data are available. No relationship was found between gross profit margins and average hourly wages. It is possible that wages are somewhat higher in the best groups of mills than in the worst, an important reason for this being that continuous production (shift workers are paid higher hourly wages) had not been fully introduced at the worst plants.

The return on capital in the best group of plants

In the best group of pulp mills (the bar furthest to the left in Fig. 1), the profit margin amounts to 32 öre per krona sales value and the difference in operating unit cost between the best and worst group of plants amounts to 28 öre. In the paper industry the profit margin in the best group of mills is 37 öre per krona output.

These figures for the gross profit margin may be compared with those computed from available engineering data concerning input requirements for optimal pulp and paper mills according to the technology current in the mid-Sixties. Inserting product and factor prices for 1964 in these engineering data shows, that the gross profit margin for a pulp mill for bleached sulphate with an annual capacity of 270 000 ton was 28 öre per krona output if one reckons with a gross yield of 15 per cent of the total utilization of real capital and 7 per cent on working capital. In the case of optimally integrated newsprint mills and kraft liner mills, the corresponding returns were 35 öre and 32 öre respectively per krona output.

The gross profit margin for the mills with the best practice technique thus agreed fairly well with the value calculated from engineering data. Another way of putting this, of course, is that in the best group the gross profit achieved after deducting interest on working capital corresponded approximately to 15 per cent earning power on the replacement costs of the capital.

When is structure optimal?

Labour productivity is usually measured as value added per unit labour input. If all units have the same wage level, labour input can be measured from wage costs and productivity can be measured by dividing gross value added by these costs. Labour productivity has been calculated for the best and worst group of mills as well as for the average for each branch (see Table 1). One would not expect productivity to be lower than 1, i.e. the case when wages account for the whole of value added. Productivity at the best group of mills in the pulp industry is twice as high as the average for the branch (4.6/2.3) and the same is approximately true in the paper industry.

In what sense, then, can the structure of, for instance, the pulp industry in 1964 be said to have been sub-optimal? Obviously it can be argued that if all production for sale had been undertaken at mills that were optimal according to technology in 1964, 12—14 mills would have been sufficient instead of the 60 or so that were actually in use and the employment of labour would have been about half or approximately 10 000 men fewer than was actually the case.

The flaw in this argument, of course, is that it would be

Table 1. Productivity in the best and worst groups of plants and the average productivity in the pulp and paper industry in 1964

	Pulp industry			Paper industry		
	best group	worst group	average	best group	worst group[1]	average
Labour productivity	4.6	1.2	2.3	4.4	1.0	2.0

[1] Productivity was calculated in this case for the worst 10 per cent of capacity in the integrated paper mills and not for the worst group in Fig. 2.

Table 2. Development of gross profit margin, value added and income ratios for the best-practice technique plants and for the total pulp industry 1949—1964

Year	Gross profit margin		Value added as a share of selling value		Income ratios			
	Best group	Pulp industry	Best group	Pulp industry	Best group		Pulp industry	
					Labour	Capital	Labour	Capital
1949	0.38	0.20	0.47	0.32	0.20	0.80	0.39	0.61
1954	0.40	0.24	0.51	0.37	0.21	0.79	0.34	0.66
1959	0.37	0.20	0.48	0.36	0.23	0.77	0.44	0.56
1964	0.32	0.20	0.41	0.34	0.22	0.78	0.41	0.59

quite uneconomic to adjust the entire capital stock immediately to the optimal technology of the day. It is not economic to close down older plants as long as they cover more than the operating costs. The central thesis, therefore, is that all branches of industry that have been built up over several decades and undergone technological development are *bound to display a dispersion in productivity* that does not automatically indicate a sub-optimal structure. This dispersion in productivity is liable to be very great in branches with such a high capital ratio as the pulp and paper industries. It is therefore invalid to conclude that the structure of a branch is sub-optimal just because it contains a large number of small units and the optimal size is perhaps three or four times as large as the average size.

Instead one should consider which circumstances are being systematically delayed, e.g. by obstacles to new investments or by old units being kept in production without macroeconomic justification.

The reader may have noticed that some of the paper mills in Fig. 2 do not cover their operating costs. The data on costs and receipts in the pulp and paper industries on which Figs. 1 and 2 have been based indicate that a number of units are kept in production even though this is no longer strictly justified in terms of business economics. Consequently one finds that the range of productivity between the best and worst groups of plants is somewhat greater than we expected on theoretical grounds. One conceivable reason for this is that social considerations cause firms to maintain production until satisfactory alternative employment can be arranged.

Structural changes can be described in terms of the development of gross profit margins, value-added and income ratios for the best groups of units in relation to the average for the branch. The development of these measures is shown for the independent pulp industry in Table 2. The years selected all represent periods of rising business activity in the pulp industry.

It is particularly noteworthy that the best group of plants has a considerably higher value-added ratio than the average for the branch, a circumstance that has to do with savings on input goods and the adaptation of production equipment to more profitable grades. It is also worth noting that the income share of labour and capital in this group hardly changed during the period.

Technical progress

The optimal combination of labour and capital for the most recent capital vintage is contingent on the price expectations for factors of production and on the current production technique when drawing up plans. Since the rate of technical progress for new capital vintages has a great deal to do with the rate at which older capital becomes outmoded as well as with the long-term rate of technical progress in the branch as a whole, it is worth trying to assess how rapidly technology has advanced in the past. An approximate measure of this factor can be obtained by studying how factor inputs per unit produced have changed over time in the best group of plants alone.

For this purpose the best group (corresponding to the block furthest to the left in Fig. 2) was selected for each of the years 1950, 1955, 1960 and 1964 and the changes between

†3—703306

these years were measured for the input of capital and labour per unit produced. Capital input was measured with the fire insurance value, which closely agrees with the cost of replacing the capital of the best group in each year. Since it is important that inputs are estimated at full capacity utilization, care was taken to choose boom years. The years selected all represent periods of very high capacity utilization with the exception of 1964; an adjustment was made for this year to neutralize the effect of the somewhat lower capacity utilization at that time.

Technical progress has been measured as the difference between the growth of production and a weighted sum of the relative change in labour and capital inputs, so that it comprises the part of production growth that cannot be attributed to increases in labour and capital inputs. The income ratios in the best plants at the outset of the period have been used as weights, corresponding approximately to those given in Table 2. Alternatively—though with exactly the same implications—technical progress can be measured by subtracting from the relative growth of labour productivity that part which is attributable to the increase in the capital-labour ratio and weighting the latter contribution to the rise in labour productivity with the share of capital income in value added.

Table 3. Contributions from technical progress and greater capital intensity to the rise of labour productivity in the best-practice technique pulp plants 1950—1964

Period	Rise in labour productivity	Contribution from capital intensity	Contribution from technical progress
	(average annual percentage increase)		
1950—1955	2.1	0.7	1.4
1955—1960	7.8	4.8	2.9
1960—1964	9.6	7.6	2.0
1950—1964	6.2	4.0	2.2

The results are given in Table 3, from which it will be seen that approximately two-thirds of the rise in labour productivity is attributable to the increase in capital intensity and one-third to technical progress.

Effects of structural change on the growth of productivity

There are three ways in which average labour productivity in a branch can be increased: by the addition of better plants, by closing down plants with below-average productivity and by rationalizing existing plants. Besides studying the development of average productivity it is interesting to investigate how this development has been achieved.

Table 4a. Development of labour productivity in the best-practice technique pulp mills and in the total Swedish pulp industry 1950—1964

Period	Average annual growth of production volume	Labour productivity in the best group	Labour productivity total pulp industry	Capacity closed down during the period (per cent of total capacity in initial year)
1950—1955	4.2	2.1	3.3	3
1955—1960	5.8	7.8	6.7	3
1960—1964	4.1	9.6	6.8	6
1950—1964	4.8	6.2	5.7	17

Table 4b. Productivity relationships in the pulp industry 1950—1964

Year	Ratio between labour productivity in best group of mills and branch average	Ratio between labour productivity in worst group of mills and branch average
1950	1.95	0.42
1955	1.84	0.45
1960	1.93	0.49
1964	2.09	0.42

In the study an equation was derived that describes the growth of the average productivity in a branch as a weighted result of (a) the rate of expansion in the branch (the net increment to capacity), (b) the rise of productivity with the best-practice technique, (c) the rate of closures (scrapped capacity in per cent of total capacity), and (d) the ratios between productivity in the best and worst-practice technique plants respectively and the average for the branch in the initial year.

Capacity in the pulp industry has been extended largely by investing in existing plants rather than by constructing new ones. The relation between structural change and the growth of productivity has been derived on the assumption that "marginal" productivity for the capacity added to existing plants is as high as the average productivity in best practice technique plants. This assumption rests on the observation that the greater part of rationalization in existing plants increases their capacity.

The measures listed under a—d are presented in Tables 4a and 4b. Inserting them in the derived equation gave a calculated figure that was compared with the actual growth of average productivity in the branch. It was found that these two values agreed fairly well.

It will be seen from Table 4a that the growth of productivity in the best group was not much higher than the average for the branch over the entire period 1950—1964 but that there were considerable discrepancies in different parts of this period. In the years 1950—1955 labour productivity rose more rapidly in the branch as a whole than in the best group and vice versa in the other two parts of the period.

Tables 4a and 4b also indicate that when—as in 1950—1955—the branch's productivity rises more rapidly than that of the best group of plants, the ratio between the productivity figures falls, whereas when productivity in the best group accelerates to a more rapid rate than the average branch, this ratio rises. The high ratio between productivity in best-practice technique plants and the average productivity in the branch in 1964 indicates that there was a relatively large potential for improvements in productivity this year.

In the period 1964—1969 the annual rise of labour productivity in the pulp industry averaged approximately 8 per cent a year, that is to say it was more rapid than during any of the sub-periods in Table 4a. The volume of production rose at much the same rate in both cases but the rate of closures was considerably higher in the period 1964—1969, amounting to approximately 12 per cent of capacity in 1964. Our computation shows that the acceleration of productivity growth was entirely attributable to the higher rate of closures compared with any of the previous periods. Productivity increases for best practice technique between 1964 and 1969 need not necessarily have been higher than the trend (approximately 6 per cent a year).

Structural data of the kind presented here may be of great assistance when forecasting the development of productivity and the rate of closures. If the structure of productivity had been known at the beginning of the period 1964—1969, it should have been possible to foresee that extensive closures would be made during the next few years (though perhaps not fully to the extent as those which followed the deep recession in 1966—1968) and that productivity would rise more rapidly than previously. There is also reason to believe that the dispersion in productivity was not as wide in 1969 and that conditions for an equally rapid growth of productivity in the period 1969—1975 are consequently less favourable than in the second half of the Sixties.

The data presented in Tables 4a and 4b have also been used in an attempt to calculate the importance of structural change for the growth of productivity in this branch as well as the contribution from improvements in the best practice technique. In the total period 1950—1964, capacity in the branch increased by 91 per cent (4.8 per cent a year over fourteen years) and the total capacity of those plants which were shut down in this period amounted to 17 per cent of the capacity in 1950. The gross increment to capacity thus amounts to 108 per cent (91+17). If one assumes that productivity in this additional capacity was equal to the productivity in the best practice technique plants in 1950 and that the productivity of the closed plants corresponded to the productivity of the worst 17 per cent of that year's capacity, there would have been an average rise in productivity of 3.4 per cent. In other words, the introduction of the best practice technique of 1950 in step with the growth of production and closures would have resulted in approximately 60 per cent of the rise in productivity that was actually achieved in the branch between 1950 and 1964 (3.4 per cent as a percentage of 5.7 per cent; see Table 4a).

Concluding remarks

The growth of productivity can be accelerated for a considerable period by rapidly increasing the rate of expansion. This will augment the proportion of new capital that incorporates the latest technology. In this way the rise in productivity becomes closely bound up with the rate of expansion, a circumstance that it is important to bear in mind when setting up longterm forecasts for different branches. One cannot, for instance, simply deflate the planned growth of production as reported by the firms to the Swedish Long-Term Economic Surveys in order to adjust the growth figures to the expected shortage of labour without also making the necessary adjustment to the productivity increases that are implicit in the plans.

Knowledge of the relationship between productivity for the best-technique technology and the average for the branch has an important part to play when assessing the future rate of structural change. The analysis presented here displays clear parallels with the analyses of Schumpeter and Dahmén concerning the rate at which technical progress—a high rate of innovation—are liable to generate structural crises.