Yngve Åberg:

Production Functions and Profit Developments in the Swedish Forest Industries

The problem

The development of production in a company or group of companies can be assumed to be contingent on both changes in the input of labour and capital and changes of a technological and organizational nature. The effect of these changes on production is determined by the relationship between production and the factors of production and by shifts in this relationship over time. In order to analyze production developments, such relationships—or production functions—have been calculated for the Swedish forest industries, on the basis of time series data. The calculations refer to the 1947—1965 period and cover sawmills and planing mills, wallboard factories and the pulp and paper industry.

By means of these production functions, which are of the Cobb-Douglas type, we obtain a measure of the sensitivity of production to changes in capital and labour. This measure has the character of an elasticity, indicating the percentage rise in production when one of the factors of production increases by one per cent while the other factor is unchanged (as is technology). Technological and organizational development is in turn measured by reference to the increase in production in terms of an annual percentage figure, that arises at given inputs of the factors of production.

With the aid of these calculations, we have been able to identify the contributions to the increase in production made by the two factors of production and by technological advances. The estimated functions have also been used for calculating the marginal productivity of labour at current prices, which has then been compared with money wages. This comparison has been made as an average for the whole of the period under study, as well as for each separate year. The latter comparison has been carried out in order to study the development of profits in the industries concerned: if marginal productivity deviates from money wages, this is a sign that capital is being over- or undercompensated.

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The method of calculation

If we have access to statistical data on the development of the volume of production, employment and capital, we can calculate the production functions by means of regression analysis. A problem here, however, is the difficulty in obtaining statistics on the development of the volume of capital. Even if these data were available, though, we still have the problem that it is not the existing capital that should be incorporated in the production function but the capital that is actually in use.

In this study an attempt has been made to solve this problem by using not the capital stock but capital incomes, recomputed into constant prices, as a measure of the capital input. In addition to the fact that capital income data are easier to obtain than data on the capital stock, an advantage of this method is that it takes into account the degree of utilization of the capital. It is based on the assumption that capital incomes in fixed prices vary proportionally with the volume of capital in use. This means that capital incomes can replace the capital stock in the production function.[1]

If capital incomes are to be able to serve as a measure of the development of the capital volume in use, they must be free from all price fluctuations. Otherwise, there can be a change in capital incomes without there being any corresponding change in the capital stock. The capital incomes have therefore been arrived at through reducing the value-added of the sector in fixed prices by the wage bill, after this has been deflated by means of the index for the general price level. No profit fluctuations caused by changes in sector prices will then be reflected in capital incomes; the latter will thus only vary with the volume of capital in use.

Our measuring the development of the volume of capital in this way means that, in regard to the capital stock in use, the rate of return in real terms will be constant over time. There is thus nothing to prevent there being variations in the rate of return with respect to the total physical capital

[1] A detailed description of this method can be found in Y. Åberg, *Produktion och produktivitet i Sverige under perioden 1861—1965*, Industriens Utredningsinstitut, Stockholm 1969.

given, acceptable labour market situation is accompanied by a lower rate of wage drift than that recorded previously.

With a more efficient direct and indirect wage policy of the type indicated here, the thinking underlying the above-discussed paper on wage formation and the economy should provide valuable support. This paper has given us a new perspective for appraising the margin in an economy for wage increases, a perspective which should create a sounder platform for the future wage policy debate.

stock. According to the assumptions made here, such fluctuations are interpreted as changes in the intensity of use of the capital. In other words, the actual rate of return in real terms is assumed to be constant only when the capital stock is fully utilized.

This assumption of a constant rate of return at full capacity utilization is, in turn, based on the assumption that the market requirements as to the rate of return on capital do not change over time. Since this is a basic assumption in the study, it would be an advantage if it could be empirically tested. This can indeed be done in connection with the calculation of the production functions, so we will not need to feel uncertain as to the correctness of the assumption.

The statistical data

The statistical basis for the calculations made here comprises data from the official industrial statistics. Value-added in fixed prices has thus been used as a measure of the production volume. Furthermore, the measure of employment includes all persons employed in the sector—both workers and salaried employees, males and females, adults and minors. As regards workers, however, we have not used the data on the number of individuals but the figures for the number of hours worked, which have then been recomputed into the number of workers. Finally, as mentioned above, the capital incomes have been obtained by deducting the wage bill, expressed in terms of a fixed general price level, from the value-added in fixed prices. The consumer price index has been used as a measure of the general price level.

Table 1 shows, for each of the branches, the annual percentage changes under the various headings during the period under review. As regards labour, the figures for workers and salaried employees have been given separately. Furthermore, the number of work-places covered by the study has been set out. By way of comparison, development in total Swedish industry has also been given in the table.

The table shows that production has increased faster in all the industrial groups studied than in industry as a whole, with the exception of the sawmills and planing mills group. This is also true of the development of the volume of capital. The growth rate for capital has been particularly low in the sawmills and planing mills, while it has been relatively high in the wallboard factories. This means that the volume of capital per unit of production has fallen in the former group and risen in the latter. The table also shows that there has been some increase in the volume of capital per unit of output in the pulp and paper industry, too.

With respect to employment, we find that the number of salaried employees in all groups has risen much faster than the number of workers. Furthermore, we see that the total number of employees has decreased in the sawmills and planing mills and, to some extent, in the pulp factories, too. The steepest increase in the number of employees is shown by the wallboard factories and by the paper and combined pulp and paper mills. Finally, we learn from the table that production per employee has risen much more rapidly in

Table 1. The number of work-places and annual percentage changes in the volume of production and factor inputs in the forest industries, 1947—65

Group	Average number of work-places	Percentage change in				
		Volume of production Q	Capital R	Number of workers L_A	Number of salaried employees L_T	Number of workers + salaried employees L
Saw mills and planing mills	1 096	1.97	0.77	—0.50	0.95	—0.35
Wallboard factories	17	7.34	8.47	0.70	5.93	1.22
Pulp and paper industry	142	5.19	5.43	0.25	4.09	0.79
thereof:						
Pulp mills	70	4.71	5.01	—0.69	4.30	—0.02
Paper and combined mills	72	5.77	6.02	1.03	3.93	1.45
Total industry[1]		4.26	4.00	0.10	3.51	0.81

[1] Refers to 1947—1964 period

Source: Central Bureau of Statistics

the groups studied than in industry as a whole. However, in this respect, too, the sawmills and planing mills are the exception to the rule, despite the fact that employment in this branch has fallen back.

The production functions

As mentioned earlier, the calculation of the production function involves the identification of, on the one hand, the production elasticities in respect of capital and labour and, on the other hand, the importance of technological advances. The values that are thus obtained for the elasticity of capital α and the technological factor λ are set out in Table 2. The elasticity in respect of labour β is obtained by deducting the elasticity α from one. This means that the scale of production is assumed not to have any effect on the volume of production. With unchanged technology, a one per cent increase in both capital and labour is thus assumed to lead to a one per cent increase in production.

Table 2. The elasticity of capital, the technology factor and the development of real wages in the forest industries, 1947—65

α = elasticity in respect of capital
β = (1—α) elasticity in respect of labour
S_α = standard deviation for α
λ = technology factor
H^2 = multiple correlation coefficient
λ/β = annual percentage increase in real wages according to the production function
h_w = actual annual percentage increase in real wages

Group	α S_α	λ	H^2	λ/β	h_w
Sawmills and planing mills	0.49 0.014	1.77	0.996	3.47	3.62
Wallboard factories	0.54 0.025	2.20	0.998	4.78	4.28
Pulp and paper industry	0.56 0.028	1.80	0.998	4.09	3.97
thereof:					
Pulp mills	0.61 0.025	1.69	0.999	4.33	4.03
Paper and combined mills	0.51 0.030	2.00	0.996	4.08	3.97
Total industry[1]	0.44 0.024	2.06	0.998	3.65	3.71

[1] Refers to 1947—1964 period

Source: Central Bureau of Statistics

As regards the elasticity of capital, Table 2 shows that the highest value is registered by the pulp mills. For each percentage increase in capital volume, the production of these companies rises, *ceteris paribus*, by just over 0.6 per cent. The lowest values are noted by the sawmills and by the paper and combined mills. However, we find that the sensitivity of output to changes in the volume of capital is greater in all the branches studied than in industry as a whole. This can be interpreted as reflecting the fact that capital intensity, i.e., the amount of capital per worker, is generally higher in the forest industries than in the rest of industry.

If we now look at the technology factor, we find that it is only the wallboard factories that have experienced faster technological development than total industry. According to Table 2, technological advances in these companies have generated an annual production increase averaging 2.2 per cent during the period studied. It is also interesting to note the much lower rate of technological development in the pulp mills compared with the paper and combined mills.

Table 2 also sets out the ratio between the technological factor λ and the elasticity of labour β, as well as the development of real wages h_w according to the trend. On the basis of these data, we are able to test the assumption of a constant rate of return, an assumption that underlies the calculation of the production functions. It can be shown that the λ/β ratio should be equal to the development of real wages if the calculated production function is to correspond to the production relationship we are seeking. Now it can be seen from Table 2 that these two figures are not, admittedly, exactly identical. But the difference between them is so small that the calculations can be considered satisfactory. It can easily be seen that only minor changes are required in the values of the elasticities and the technology factor for the λ/β ratio to assume the same value as the development of real wages h_w.

The contributions to the increase in production

With the aid of these production functions, we can now work out the contributions made by capital and labour to the rise in production during the period. All we need to do is multiply the elasticities of the factors of production with the annual percentage change in these factors. Together with the technology factor, the resultant contributions to

production constitute, by definition, the total annual increase in production. Table 3 sets out the results of these calculations.

Table 3. The contributions to production increases in the forest industries made by capital, labour and the technology factor, 1947—65

Group	Volume of production	Contribution from Capital	Labour	Technology factor
Sawmills and planing mills	1.97	0.38	—0.18	1.77
Wallboard factories	7.34	4.57	0.56	2.20
Pulp and paper industry	5.19	3.04	0.35	1.80
thereof:				
Pulp mills	4.71	3.04	—0.02	1.69
Paper and combined mills	5.77	3.07	0.71	2.00
Total industry[1]	3.26	1.75	0.45	2.06

[1] Refers to 1947—1964 period

Source: Central Bureau of Statistics

We can see in this table that, in all branches, capital has been much more important than labour for the growth of production. The contribution from capital has been particularly large in the wallboard factories and in the pulp and paper industry. In these companies, moreover, capital has played a greater part in raising output than has been the case in industry as a whole. However, this does not apply to the sawmills and planing mills, where capital has been of secondary importance. Furthermore, in this latter group labour has made a negative contribution to production growth; this is also the case in the pulp mills. The reason for this is that the labour force in these branches has, according to the trend, shown a decline during the period studied.

In the sawmills and planing mills group the major part of the increase in production derives from the technology factor, which is responsible for no less than 90 per cent of this increase. In the other groups, however, the contribution from the technology factor is not strikingly large in relation to the growth in production. The share of growth attributable to this factor is between 30 and 35 per cent in these branches, while the corresponding figure for total industry is about 50 per cent. It is capital, instead, that is responsible for the major part of production growth in these branches.

The productivity and wages of labour

The estimated production functions also make it possible for us to calculate the value of the marginal productivity of labour. This productivity can be obtained by multiplying the value-added per employee in current prices with the elasticity of labour. The resultant figure for marginal productivity can then be compared with money wages, so that we can see how labour has been paid in relation to its marginal productivity.

The annual average figure for marginal productivity has been calculated for the various branches in respect of the whole of the period under review. These calculations are given in Table 4, which also sets out the average annual money wages during the period. Furthermore, the ratio between productivity and money wages has been worked out in the table.

In this table we can observe that, during the period studied, the value for the productivity of labour has been at a higher level in the wallboard factories and in the pulp and paper industry than in industry as a whole. We can also establish that productivity in these branches is 6 to 8 per cent higher than money wages, while the corresponding figure for total industry is no higher than 3 per cent. And this is in spite of money wages in the companies studied here having been higher than in industry as a whole. The fact that labour has thus been underpaid in relation to its productivity means that capital has received correspondingly higher compensation than is warranted by its productivity.

Table 4. The average value of the marginal productivity and money wages of labour in the forest industries, 1947—65

$P\delta Q/\delta L$ = $\delta PQ/L$ = value in kronor of the marginal productivity of labour

$\bar{w}$ = money wages in kronor

Group	$P\delta Q/\delta L$	$\bar{w}$	$(P\delta Q/\delta L)/\bar{w}$
Sawmills and planing mills	8 347	9 217	0.91
Wallboard factories	12 855	12 092	1.06
Pulp and paper industry	12 656	11 743	1.08
thereof:			
Pulp mills	12 572	11 866	1.06
Paper and combined mills	12 575	11 619	1.08
Total industry[1]	11 303	10 932	1.03

[1] Refers to 1947—1964 period

Source: Central Bureau of Statistics

Quite a different picture is shown by the sawmills and planing mills, where the productivity of labour has been much lower than for industry as a whole. In this group marginal productivity is even lower than money wages, despite the fact that these wages have been low compared with those paid in other branches of the forest sector. In contrast to what has been the case in the other branches, labour in this group has thus been overpaid; this can be interpreted as a sign that competition on the labour market has prevented wages from falling to the level of productivity.

It should be noted in this context that the money wages used here do not include any indirect wage costs. On average during the period, however, these costs have not been very high in relative terms; furthermore, it is only after 1959 that they have arisen at all. According to estimates made by the Swedish Employers' Confederation, these costs have gradually risen during the 1960—1964 period from one to barely five per cent of the total wage bill.

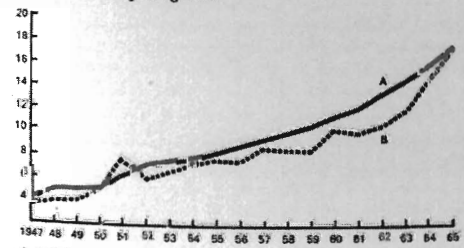
The development of profits

When labour is paid according to the value of its marginal productivity, capital will also receive compensation corresponding to its productivity. Capital will be over-compensated, however, if the wages paid to labour are lower

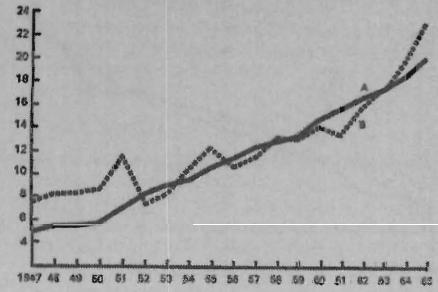
Chart 1. The development of money wages and the marginal productivity of labour in the forest industries, 1947—65
Kr. 1 000

A = Money wages per year
B = Value of marginal productivity of labour per year

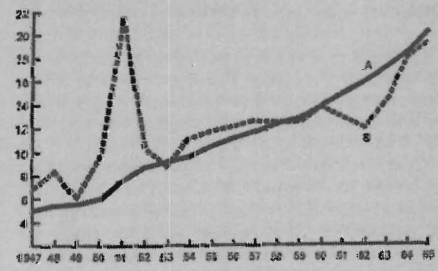
1a. Sawmills and planing mills



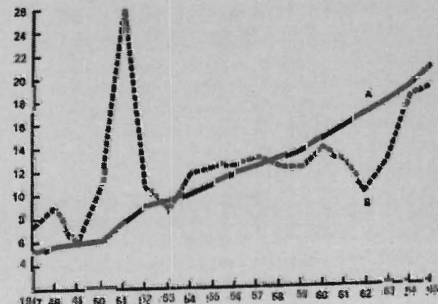
1b. Wallboard factories



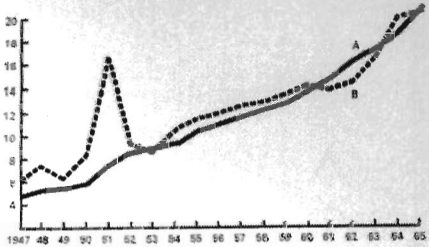
1c. Pulp and paper industry



1d. Pulp mills



1c. Paper and combined pulp and paper mills



Source: Central Bureau of Statistics

than its productivity, and vice versa. This over- or under-compensation of capital results from changes in the purchasing and selling prices of the branch, as well as from changes in the intensity of use of the capital. If such changes take place over time, this is an expression of changing profitability in the branch. We can consequently follow profit developments in the branch through studying how the value of the marginal productivity of labour varies in relation to money wages.

Chart 1 has been drawn up for this purpose, showing the year-by-year development of the marginal productivity and money wages of labour in each of the different branches. By definition, there is no profit or loss if the curves for productivity and wages coincide. There will, on the other hand, be a profit or loss if the productivity curve is above or below the wages curve. However, it should be particularly noted that nothing has here been said about the level for the profitability of capital, only about the changes in such profitability. Even if the productivity curve is below the wages curve in a certain branch, profitability may thus be higher there than in a branch where the curves are reversed. These charts only give information as to the pattern of profit developments in one and the same branch during the time period studied.

As was earlier illustrated in Table 4, money wages in the sawmills and planing mills have exceeded the marginal productivity of labour over the period as a whole. We can now observe from Chart 1 a that this has in fact been the case in every year except for 1951. Up to 1962 productivity in the branch has gradually fallen in relation to wages, leading to a deterioration in the profitability of capital. After this latter year, though, the gap between productivity and wages seems to have contracted, implying that profitability has improved. Chart 1 b shows that in the wallboard factories, too, the profitability of capital has improved towards the end of the period. What is perhaps most striking about this branch, however, is the relatively high compensation to capital during the early years of the period.

Judging from Chart 1 c, the curve for the marginal productivity of labour in the pulp and paper industry has fluctuated much more around the wages curve than was the case in the other two branches. The chart thus shows that capital was heavily over-compensated in 1951, while the opposite was true in 1961—1963. We can see from Charts 1 d and 1 e that this variation in profit development is ascribable more to the pulp mills than to the paper and combined mills. The fact that the compensation to capital rose so sharply in 1951 is principally due to the increase in pulp prices that year in connection with the Korean War. The squeezed profit situation in the pulp and paper industry during the 1960's can, likewise, be chiefly attributed to the unpropitious development of pulp prices over this period.