SOLOMON FABRICANT

The Relation between

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Factory Employment and

Output since 1899

THE INDEX of the nation's economic welfare is the quantity
of goods and services at the disposal of the people. Change
in this quantity may be regarded as dependent on the extent
to which our industrial system uses more or less labor to
turn out a unit of product and employs a smaller or larger
aggregate labor force. The less labor needed for a unit of
goods the greater is the yield of goods for a given labor
effort, of course. But this yield alone does not determine
output; for, if aggregate employment declines, even an in-
crease in the product of a given amount of labor may be
accompanied by stable or falling output. Nor does aug-
mented employment in itself mean a greater flow of goods
and services, since it may be offset by a decline in the yield
of goods per unit of labor.

Changes in the economy at large, moreover, are the net
result of changes in the segments that make up the in-
dustrial system, embracing activities as diverse as agricul-
ture, mining, manufacturing, construction, and personal
services. Within any one segment, as in the entire economy,
variation in output is a function of changes in labor per
unit and in total employment. The complete picture of
changes in the entire economy must therefore be a com-
posite of the diverse changes in output, employment, and
labor per unit within the several segments. A vital part of
this composite consists of the changes in manufacturing,
to which this paper is confined.

We trace the trends in manufacturing output, employ-
ment, and labor per unit of product since 1899. As factory
output was discussed in detail in *The Output of Manu-
facturing Industries, 1899–1937*,[1] we concentrate attention
here on changes in employment and in its relation to out-
put. By output we mean the physical quantity of goods
produced, not their pecuniary value. By employment we
mean the average number of workers engaged. Because
changes in hours of labor greatly affect the relation between

National Bureau of Economic Research, 1940.

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employment and output, we inquire also into changes i
manhours worked, though data are less adequate tha
on workers employed. Chief emphasis is on long-perio
changes during the last four decades; we do not discu:
cyclical movements in detail because for this purpose ar
nual data are not fine enough.

CHANGE IN EMPLOYMENT AND OUTPUT

American manufacturing industries gave a livelihood t
five million workers in 1899—wage earners, salaried pe:
sons, corporate officials, and independent entrepreneur:
constituting about 22 per cent of all persons attached t
industry in that prosperous year. In 1937, the latest pea
year of business preceding the current defense boom an
therefore more comparable with 1899 than are more recen
years, manufacturing absorbed the services of ten millio:
persons, amounting to some 24 per cent of the entire worl
ing population. In the four decades factory employee
doubled while total employment increased about 85 pe
cent, and the population, about 75 per cent.

The twofold increase in factory jobs did not come abou
through uniform annual increments, but was the net resul
of a series of rises and declines. Unfortunately, we have n
year-to-year record for all types of factory personnel, bu
we do have it for wage earners, who constituted 85 per cen
of all persons engaged in manufacturing in 1937. In thi
large category the number employed declined during a
many as nine intervals after 1899 (Chart 1).[2] Only one c
these declines lasted more than a year, that from 1929 t
1932, which brought wage-earner employment to a poir
almost 40 per cent below the 1929 average and 20 per cen
below the low levels of 1921 and 1914. Fewer wage earne:
were employed in factories in 1932 than during any ca
endar year for more than a generation.

[2] Figures supporting all the charts except the fifth appear in Tables 1 and
More details will be presented in the volume on which this paper is base

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The low level of factory employment in 1932 reflects both its failure to grow during the 1920's and the severe decline after 1929. The annual record, 1899–1937, shows that the entire twofold increase was during the first two decades, the fastest rate being between 1913 and 1918. The demand for munitions and other manufactured goods consumed in military and naval operations helped to raise factory employment in 1918 to a peak that was not surpassed in 1923, 1929, or 1937—all prosperous years. During the major portion of the first two decades of the twentieth century, apparently, many of the youths and immigrants entering the American labor market found opportunity for employment in factories; but during the 1920's and 1930's

CHART 1

All Manufacturing Industries Combined
Indexes of Physical Output, Wage Earners
Employed, and Total Employed

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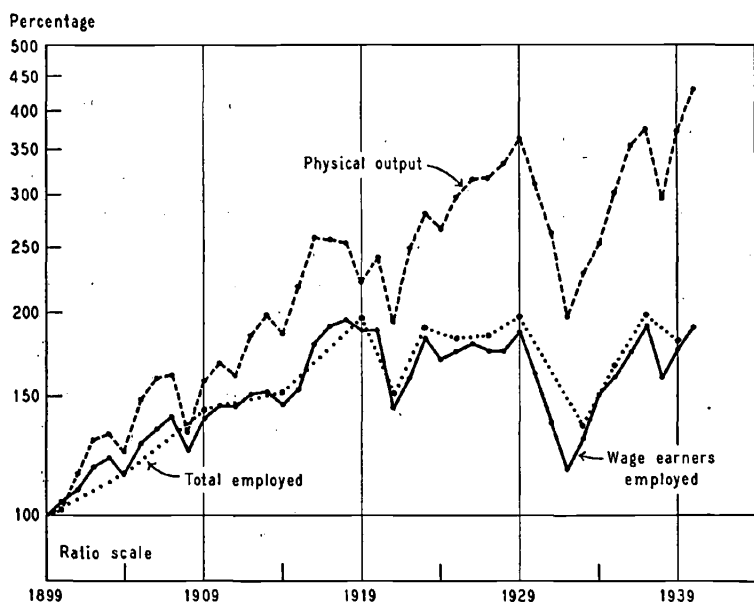
there were openings only for those needed to replace the workers who left or were forced out of this branch of our industry. With factory employment in 1941 well above that in any preceding year, it is clear that the present defense program has radically altered the picture, though for how long we cannot as yet say.

The course of factory employment takes on added interest when contrasted with factory output. During shorter intervals there were, of course, similar cyclical fluctuations in each (Chart 1), but when successive peaks are compared, we find that employment and output diverged more or less progressively. In only two periods, 1913–18 and 1929–37, were the net changes in output and in employment equal. In the other periods output expanded from peak to peak more rapidly than employment or expanded while employment contracted. Especially noteworthy is the continued growth of factory output during the 1920's to heights well above those of 1916–18. Not until 1941 did factory employment surpass the levels of those war years.

THE NET DECLINE IN LABOR PER UNIT OF PRODUCT

Perhaps the most striking figure in this paper defines the decline in factory workers employed per unit of product from 1899 to 1937. For the aggregate of all manufacturing industries, large and small, advanced and laggard, labor per unit of product was cut in half. The processed goods turned out in 1899 required 5 million factory workers; in 1937 four times the goods were produced by only twice as many factory workers.

Formidable though a cut of one-half is, it probably understates the actual decline in the employment-output ratio. The 1937 output was, on the average, of better quality than commodities manufactured at the opening of the century. Further, from what we know concerning the reduction in waste and the utilization of byproducts we may infer that

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ess raw material went into a unit of output than in 1899.[3] If we could take account of these changes, we would probably conclude that our estimate that one-half as many workers turned out a given quantity of goods in 1937 as were required in 1899 was too high.

Labor per unit of product declined more drastically than even such a refined figure, if we had it, would imply; for the decrease in factory workers employed per unit was accompanied by a very considerable drop in weekly hours of labor. A full-time week fell from an average of about 60 hours per person in 1899 to about 40 hours in 1937. The upshot of halving the number of workers per unit of product and cutting hours a third is a drop of two-thirds in aggregate manhours per unit. In short, by 1937 only about one-third as many manhours of factory work went into the fabrication of a given quantity of goods as 38 years earlier.

This enormous decline in labor per unit reflects a transformation in manufacturing techniques, and different conditions of work, intensity of labor effort, and material means of production. The industrialist of 1900 would rub his eyes in amazement were he suddenly set down in the United States of 1940. He would see new materials, more and bigger machines, novel and flexible sources of power, giant factories and industries, more efficient mechanical, chemical, and electrical processes, assembly lines speeding the flow of work, intensified division of labor, revised methods of labor management. These and a host of other things made for economy in factory labor per unit of product.

Some changes may be defined quantitatively. For example, between 1904 (the earliest year for which we have data) and 1937, the net book value of capital assets used in manufacturing rose from about $6 billion to almost $25

[3] That is, the *net* output of manufacturing industries rose more rapidly than their *gross* output, because of a slower rise in the input of materials. For a discussion of the bias that characterizes indexes of physical output, when they are taken to represent net output, see *The Output of Manufacturing Industries, 1899–1937*, Ch. 2.

billion, or from about $1,000 of capital assets per worker to over $2,000. Price increases between 1904 and 1937 must account for a good portion, but even after allowing for them, so far as we can, we get an increase of at least 30 per cent in the net value of capital instruments per worker Again, the aggregate rated horsepower capacity of prime movers and of electric motors driven by purchased energy in manufacturing plants rose from 10 million horsepower in 1899 to over 50 million in 1939, or at a rate two and a half times that at which employment in factories advanced. The expansion in the scale of industrial operations, with all that it implies in respect of intensified specialization of industries, plants, and labor, is measured roughly by the almost fourfold expansion in output itself.

Though statistics on these and other changes may be readily cited, there are direct or precise measures for few. The shortening of the work-week is a factor making for greater efficiency of labor, but the one-third decline in hours is hardly an adequate index. The elimination, in large part, of the child labor employed in 1899 is another factor, but it too is difficult to weigh. Furthermore, many of the changes, such as revisions of plant layout, are qualitative. Incommensurable and differing vastly in degree and kind, their total effect is hard to grasp. The ratio of labor input to units of output is itself perhaps the simplest and most readily computed single index of all these changes, large and small. Whether appraised in terms of men or of manhours, the decline in this ratio is the most telling measure.

Because the reduction in labor per unit of product reflects many diverse changes, it cannot be taken as a measure of change in the efficiency, amount, or character of any one production factor. Those who consider the figures cited to be indexes of labor efficiency or of invested capital and improvement in capital equipment are, in fact, ascribing to one or another factor in a complex situation the net result

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of changes in all factors. Nor is it justifiable to focus attention exclusively on any one motivating force behind the far-reaching changes measured by the decline in labor per unit. If we stress management as their initiator we may underestimate the other factors that must have stimulated management: for example, trade union efforts to raise wage rates and encouragement by governmental agencies of standardization of products and regulation of hours and labor conditions. Sometimes, of course, a specific change in labor per unit may be accurately ascribed to some single factor; but this is not true of changes in broad industrial categories during long periods. Even all factors of manufacturing production considered together may not be given the entire credit or responsibility for the changes in manufacturing. They do not function in a vacuum, for manufacturing is but a part of the integrated economy, as we note in the final section of this paper.

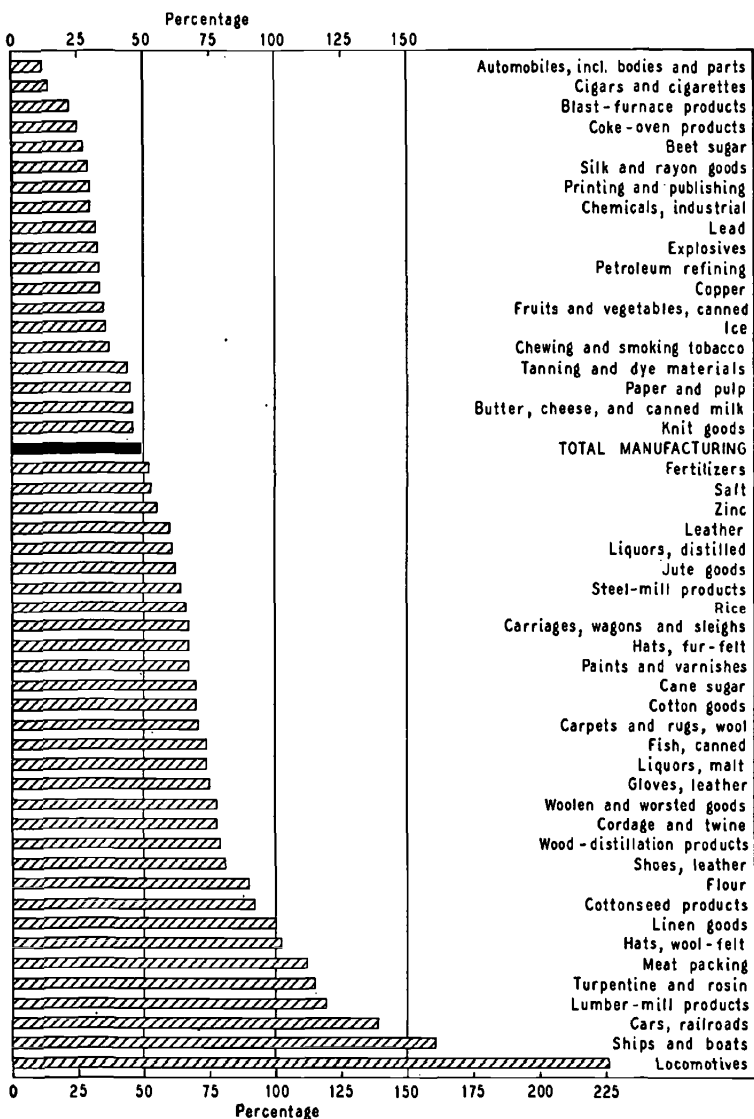INDUSTRIAL DIFFERENCES IN THE CHANGE IN LABOR PER UNIT

The impact of the factors making for reductions in labor per unit of product has not been the same on all manufacturing industries. For this reason, as we would expect, the averages for all manufacturing industries combined conceal wide differences. In some industries merely minor declines or even increases occurred in the labor-output ratio, in others, precipitate drops.

In 8 of the 50 industries for which there is information covering the period 1899–1937, workers per unit of product decreased 70 per cent or more (Chart 2). Heading the list is automobile manufacture (with an 88 per cent decline), followed by industries as diverse as beet sugar, silk and rayon goods, industrial chemicals, and blast-furnace products. At the bottom of the list are 8 industries in which the employment-output ratio rose: 3 in the field of transportation equipment (railroad cars, locomotives, and ships), as well as turpentine and rosin, lumber-mill products, meat packing,

CHART 2

Manufacturing Industries
Indexes of Wage Earners Employed per Unit of Product
1937 (1899 : 100)

Percentage

Scale top	0	25	50	75	100	125	150

Automobiles, incl. bodies and parts
Cigars and cigarettes
Blast – furnace products
Coke – oven products
Beet sugar
Silk and rayon goods
Printing and publishing
Chemicals, industrial
Lead
Explosives
Petroleum refining
Copper
Fruits and vegetables, canned
Ice
Chewing and smoking tobacco
Tanning and dye materials
Paper and pulp
Butter, cheese, and canned milk
Knit goods
TOTAL MANUFACTURING
Fertilizers
Salt
Zinc
Leather
Liquors, distilled
Jute goods
Steel-mill products
Rice
Carriages, wagons and sleighs
Hats, fur-felt
Paints and varnishes
Cane sugar
Cotton goods
Carpets and rugs, wool
Fish, canned
Liquors, malt
Gloves, leather
Woolen and worsted goods
Cordage and twine
Wood – distillation products
Shoes, leather
Flour
Cottonseed products
Linen goods
Hats, wool-felt
Meat packing
Turpentine and rosin
Lumber-mill products
Cars, railroads
Ships and boats
Locomotives

0	25	50	75	100	125	150	175	200	225

Percentage

and 2 small textile industries (linen goods and wool-felt hats).

The indexes of manhours per unit, too, vary from industry to industry in the rate of change, although in all except one of the industries covered by separate indexes, they declined. The exception is locomotive manufacture, one of the eight industries in which employees per unit of output rose. As for the other seven, when labor is measured in terms of manhours instead of men, we find that they too are to be classed with the industries in which labor per unit of product was cut.

Locomotives improved substantially in quality and increased greatly in size. No doubt the industry's exceptional position in Chart 2 is to be attributed in some degree to our inability to take statistical account of these advances, and it is likely that a similar explanation applies to some of the other industries that lagged in reducing labor per unit of output. Perhaps more important, these industries either failed to expand their output between 1899 and 1937 (even with liberal allowance for quality changes) or actually curtailed it. On the other hand, the industries at the head of the list usually expanded output faster than the average. This interesting relation is considered in detail in a subsequent section.[4]

In many industries, aggregate manhours worked declined very rapidly in relation to goods produced. The two-thirds drop in the ratio for total manufacturing in the 38 years means that each year, on the average, manhours per unit declined 2.7 per cent. In many industries the per annum rates are phenomenal. For example, in the automobile industry it was 9 per cent; in tobacco manufacture, 7 per cent; and in

[4] Another possible explanation of increase or slow decline in labor per unit is, of course, inaccuracy of the underlying Census data. (This affects all the indexes in Chart 2, not only those at the bottom of the list.) No statistics are perfectly accurate, but there is no evidence of any bias on this account that need worry us.

silk and rayon goods, blast-furnace products, and industrial chemicals, 5 per cent. Reductions in the manhour-output ratio of 10, 15, or 20 per cent were a matter of a few years, not of decades, as is attested by the cumulative effect of these rates of decline: an average annual decline of 5 per cent in the manhour-output ratio amounts in three years to 14 per cent. As we shall see in the next section, in some periods the annual rate was well above the average. Evidently, important changes often took place within the span of a single business cycle.

FLUCTUATIONS IN THE RATE OF DECLINE IN LABOR PER UNIT

Halving the ratio of employees to output in all factories combined is the net result of four decades of change. On ten occasions, as the year-to-year record in Chart 3 shows, the

CHART 3

All Manufacturing Industries Combined
Indexes of Wage Earners and Aggregate Wage
Earner Hours per Unit of Product

Percentage
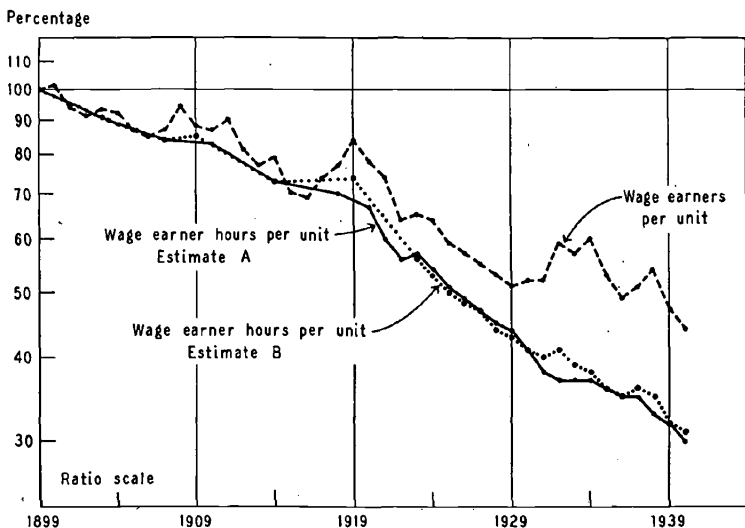
downward trend was reversed and more, rather than fewer, workers were employed per unit of output. Besides these cyclical fluctuations there were more persistent tendencies in the rate of decline in the ratio. By comparing low points several years apart in the chart, one observes that for all factories combined the employment-output ratio tended to move horizontally or to rise during three periods: it did not fall below the low point touched in 1906 until 1912, below the low of 1916 until 1922, or below the low of 1929 until 1936. On the other hand, the declines between the lows of 1910 and 1916, and between those of 1922 and 1929 were especially rapid.[5]

Changes in hours must have contributed to these fluctuations. The manhour-output ratios are much more stable from year to year than the employment-output ratios; [6] and while they are characterized by a roughly similar sequence

[5] Those interested particularly in the period after 1933 should be warned that, owing to revisions of the Census schedules, the Census understates the number of factory workers in 1935–39. The understatement is slight for 1935 and 1937; for 1939, however, it may perhaps be as much as 5 per cent; see the notes to Table 1.

[6] It should not be assumed that the effect of changes in hours on the labor-output ratio is segregated when labor is measured in manhours rather than in men. The effect is reduced, not removed, for changes in hours influence even the manhour-output ratio. Such an influence is exerted in several ways worth brief mention to indicate how complex the relations are.

The ratio may decline as an immediate and direct effect of greater labor efficiency, for workers putting in 50 or 60 hours a week work at a slower pace than those employed 30 or 40 hours. Indirectly, the ratio may decline through revisions in organization and techniques which are usually stimulated by changes in the length of the work week and the changes in the level of wage rates frequently associated with them. The net effect of changes in hours remains, of course, exceedingly difficult to measure, for it depends not only on their amount but also on the initial level of hours, the number and kind of concomitant managerial and technical innovations, and other elements in the situation. For example, a reduction of weekly hours from 60 to 50 may be expected to have a more marked effect on labor efficiency than from 50 to 40; and a permanent reduction in the work week during a period of prosperity will have an influence different from that of a work-sharing program instituted during a depression.

of rapid and slow decline (note the slow rate of decline during 1907–10, 1914–20, and 1930–38, as compared with contiguous periods), the alterations in their rate of decline are less pronounced. Indeed, the most striking revelation of Chart 3 is the persistence with which manhours per unit declined. Unfortunately, we do not know enough about actual hours worked per week to describe the movement during the entire period since 1899. For some years we have no information, and for a few other years the data are rather inconsistent, as can be inferred from the divergence between the two estimates of manhour-output during the early 1930's (Chart 3).[7] Yet it is safe to say that in only a few of the years since the turn of the century did no reduction in the manhour-output ratio occur.

Interestingly enough, capital investment, considered one of the chief factors making for reductions in unit labor requirements, has fluctuated rather violently, apparently without any noteworthy or even consistent effects on short-time changes in the manhour-output ratio. The ratio dropped sharply from 1920 to 1921 and again from 1929 to 1931, yet capital investment by manufacturers fell in both periods, in the latter to a level actually below current depreciation charges. But during another period when manhours per unit were declining rapidly, 1923–29, capital investment remained at a high level. It is surprising, also, that 1936–37 are among the few years in which there was no appreciable decline in manhours per unit, for capital investment rose to heights comparable with those of the 1920's.

One explanation lies in the difference between the current *flow* of capital and changes in the existing *stock* of capital assets. Even violent fluctuations in new investment cause relatively mild changes in assets; and capital assets do not actually decline until new investment becomes too small

[7] There is little choice between the two estimates for the period prior to 1932. For the later period, however, Estimate B is to be preferred since it is based on a superior sample of data on hours per week.

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to offset depreciation charges. Yet through changes in the quantity and character of assets alone can fluctuations in investment influence directly the labor-output ratio.[8] And if a period of adaptation (for reorganization or breaking-in) is necessary, the ratio does not react immediately even to fluctuations in assets.[9]

Also contributing to an explanation of the relatively mild fluctuations in labor per unit—despite large fluctuations in capital investment—is the removal from service of less efficient equipment as output (and with it new investment) contracts, and its return when output (and new investment) expands. Equipment set aside and then brought back into use presumably requires more manhours per unit of output than equipment kept continuously in use. The alternation of use and disuse of the less efficient equipment helps to offset the influence of fluctuations in new investment upon the labor-output ratio.

The net effect of the influences noted in the preceding paragraphs is difficult to assess. Variation in the degree to which they balance one another may help to explain the inconsistent relations between capital investment and the manhour-output ratio. But it is hardly likely that they are alone. There are also modifications in relevant factors other than capital investment and the efficiency of the equipment in actual use: in the quality and character of products as prices fall and rise; in managerial efficiency with recession and recovery; and in labor efficiency as unemployment con-

8 Changes in investment have indirect effects on the ratio through their influence on the national output. This chain of relationships is too complex to trace here.
9 Even mild fluctuations in the book value of capital assets may be more violent than concomitant fluctuations in the gross book value of assets (before deduction of depreciation reserves); yet the latter is even more closely related than the former to changes in the capital stock conceived of in some physical sense—which is the relevant sense when we consider shifts in labor per unit. We cannot say anything definite about gross value of assets because data are lacking.

tracts or expands, as hours of labor are cut or lengthened, and as labor organization waxes and wanes. These and other changes, some peculiar to single periods, others occurring in many business cycles, must be analyzed before we can understand why the labor-input ratio for all manufacturing industries combined behaves as it does during short periods.

It is conceivable that the cyclical fluctuations in the ratios for individual manufacturing industries are much more consistent in behavior and extreme in amplitude than the ratio for all factories combined. The average hides the diverse movements characterizing individual industries, and these may cancel one another more completely in some cycles than in others, depending on the shifting relative importance of each industry in the total.[10] The evidence collected in this study does no more than suggest that there is some industrial diversity of cyclical pattern and that in a few industries there is a fairly considerable amplitude of fluctuation, although here too the general impression is one of gradual decline rather than of considerable variation about a downward trend. Our statistics tell us little about the consistency of the cycles in labor-output in individual industries. To study these fluctuations we need better and more extensive monthly data.

EMPLOYMENT IN RELATION TO OUTPUT AND TO UNIT LABOR REQUIREMENTS IN INDIVIDUAL INDUSTRIES

In manufacturing as a whole a reduction in the number of workers engaged in producing a unit of output was accompanied in some periods by an expansion in total employment and in others by a contraction. That is, no consistent relation between the ratio and the aggregate is discernible when all manufacturing industries are lumped together. When we examine the component branches, however, cer-

10 Shifts in the relative importance of individual industries will affect the aggregate labor-output ratio also if they are correlated with the absolute levels of labor per dollar of value added in the various industries.

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tain relations between long-time changes in the two emerge, as well as between them and changes in output.[11]

First, as might have been expected, there has been a high degree of correlation between trends in output and in number of workers (Chart 4).[12] The biggest increases between 1899 and 1937 in both employment and output were in the industry assembling motor vehicles. Other industries with large increases in both are industrial chemicals (including also rayon and compressed gases), petroleum refining, beet sugar, and canned fruits and vegetables. Declines or small increases in employment have usually occurred in those industries in which output also has lagged or declined. Among the industries laggard in both respects are those producing carriages and wagons (with declines of 95 and 96 per cent in output and employment, respectively), railroad locomotives, lumber-mill products, flour, and chewing and smoking tobacco. To be sure, some of these industries greatly improved the quality of their products, but even if these improvements could be taken into account it is unlikely that the conclusions would have to be altered much.

Another set of relationships stands out rather vividly in Chart 4. The bars representing declines in the employment-output ratios shrink from left to right, just as do the bars that stand for changes in output and employment. That is, for the period as a whole the industries with greater-than-average increases in both employment and output tended to have exceptionally large declines in employment per unit,

11 As stated earlier, we measure employment by the average number of workers on the payroll. For the present purpose, data on hours of labor per week are inadequate, precluding discussion of trends in aggregate manhours. What data we have indicate clearly, however, that reductions in the working week have been widespread and that they have not been correlated with trends in the number employed. The reader may therefore safely assume that the discussion of employment, in terms of men, applies equally well on the average to manhours, except that the trend in the latter is less steep.

12 The coefficient of rank correlation between percentage changes, 1899–1937, in output and employment in the 50 industries listed in Chart 4 is .83.

Percentage change

CHART 4

Individual Manufacturing Industries
Indexes of Physical Output, Wage Earners
Employed, and Wage Earners Employed
per Unit of Product, 1937 (1899 : 100)
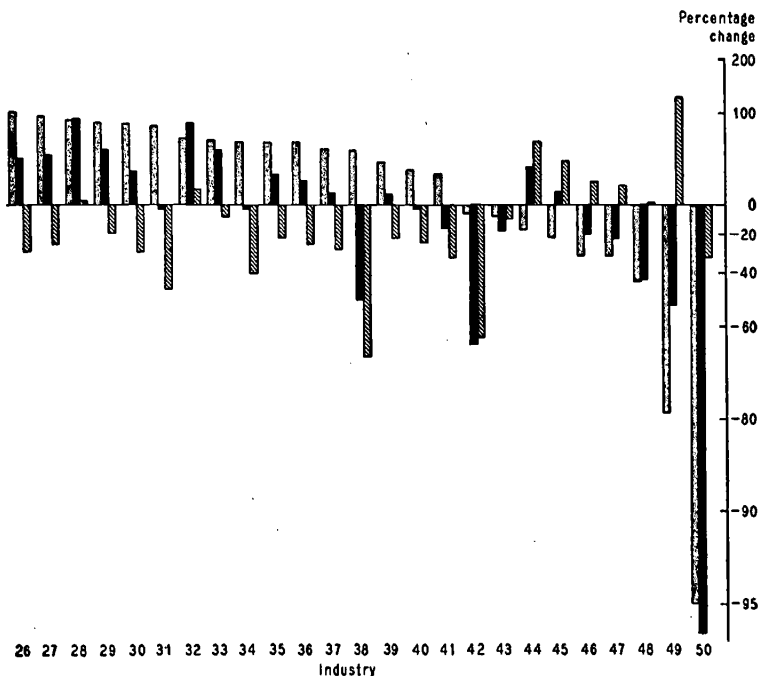
Output
Wage earners
Wage earners per unit

Ratio scale

Industry

INDUSTRY
 1 Automobiles, incl. bodies & parts
 2 Chemicals, industrial
 3 Petroleum refining
 4 Beet sugar
 5 Fruits & vegetables, canned
 6 Ice
 7 Paper & pulp
 8 Silk & rayon goods
 9 Knit goods
10 Printing & publishing
11 Butter, cheese, & milk, canned
12 Cigarettes & cigars
13 Rice
14 Paints & varnishes
15 Coke-oven products
16 Zinc
17 Liquors, distilled
18 Steel-mill products
19 Tanning & dye materials
20 Copper
21 Explosives
22 Wood-distillation products
23 Fertilizers
24 Blast-furnace products
25 Jute goods

INDUSTRY
26 Cotton goods
27 Fish, canned
28 Hats, wool-felt
29 Shoes, leather
30 Cane sugar
31 Salt
32 Meat packing
33 Cottonseed products
34 Leather
35 Woolen & worsted goods
36 Liquors, malt
37 Carpets & rugs, wool
38 Lead
39 Cordage & twine
40 Gloves, leather
41 Hats, fur-felt
42 Chewing & smoking tobacco
43 Flour
44 Ships & boats
45 Cars, railroad
46 Lumber-mill products
47 Turpentine & rosin
48 Linen goods
49 Locomotives
50 Carriages, wagons & sleighs

Percentage
change

26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
Industry

and those with less-than-average increases in both tended to have declines in employment per unit that also were less than average.[13] Jobs per unit of product fell most precipitately in the automobile industry and, as we have just seen, this industry is to be credited also with the largest expansions in both total employment and output. Again, in industrial chemicals total employment increased 690 per cent, and output, 2,500 per cent, with a consequent decline of 70 per cent in employment per unit of output; therefore, it stands close to the top in all three respects. In lumber mills, on the other hand, employment per unit increased 19 per cent; at the same time total employment decreased 20 per cent and output 32 per cent. We may conclude then that when output expands rapidly, even a substantial decrease in the men employed per unit may not be, and in the past usually has not been, accompanied by fewer jobs in an industry. If output expands only moderately, however, a decline in the ratio of men employed to units produced usually means rather slow growth in jobs in an industry, and sometimes actually fewer jobs. On the other hand, an increase in workers employed per unit has not necessarily meant more jobs in an industry, for frequently output was meanwhile curtailed.

So far we have considered relations among the average rates of change in employment, output, and the employment-output ratio, during a specific period, 1899–1937. We now turn to these relations during the successive stages through which an industry passes. For obviously all industries were not in the same phase of development during

13 The coefficient of rank correlation between percentage changes, 1899–1937, in output and employment per unit is —.74; between changes in employment and employment per unit, —.29. Much lower than the former, the latter coefficient seems just barely significantly different from zero. However, whatever errors there may be in the basic data would in themselves tend to cause a *positive* correlation between changes in employment and employment per unit and a *negative* correlation between changes in output and employment per unit.

these years—some were coming into being, some were reaching their prime, some were already on the way out.

The development of an industry, in terms of output, proceeds at a rate that diminishes more or less steadily from decade to decade, until, when peak output is attained, it becomes zero, then negative.[14] The course of retardation in manufacturing is especially notable in the automobile industry. Its output grew less rapidly during the second decade of the century than during the first, less rapidly during the third than during the second, and less rapidly during the fourth than during the third (Chart 5). Other industries with marked and fairly uniform rates of retardation in growth of output are those producing flour, ice, cigars, chewing and smoking tobacco, and carriages.

Similarly, employment grows at a decelerating rate. Just as output in most industries has tended to expand less and less rapidly with the passage of time, so the percentage increase in employment has usually diminished. Reductions in hours of labor have modified this pattern, but have not radically altered its general outline.

Retardation of growth in both output and the number employed does not mean, of course, that the graph of employment is superimposed exactly on that of output or that the shapes of the graphs are identical. Because of widespread and more or less persistent declines in employment per unit of product, the growth in aggregate employment in any one period is usually slower than in output; and maximum peaks in employment frequently precede maximum peaks in output. Among 55 industries in which trends in both employment and output have been downward since 1929 or earlier, in only 4 has the peak in employment followed the peak in output. In 17, mainly because of cyclical and random fluctuations impressed on both, the two dates

[14] This pattern was established by Arthur F. Burns not only for manufacturing but for industry in general; see his *Production Trends in the United States since 1870* (National Bureau of Economic Research, 1934), Ch. IV.

CHART 5

Selected Manufacturing Industries
Indexes of Physical Output (————),
Wage Earners Employed (--------), and
Wage Earners Employed per Unit of Product (················)
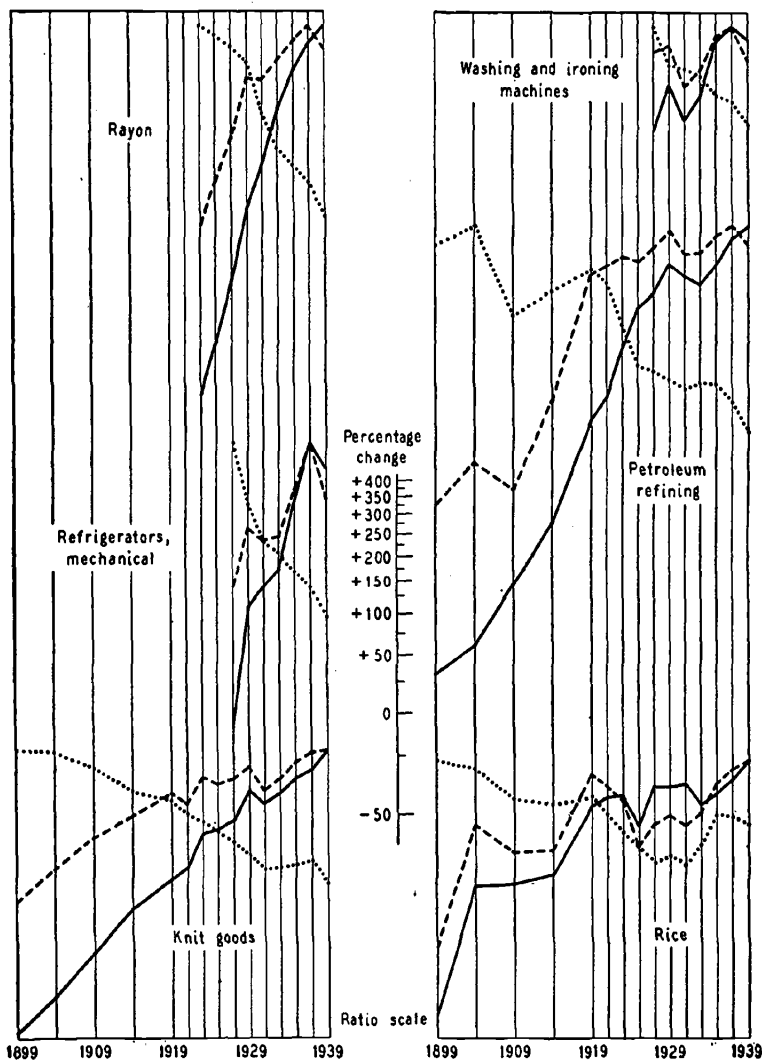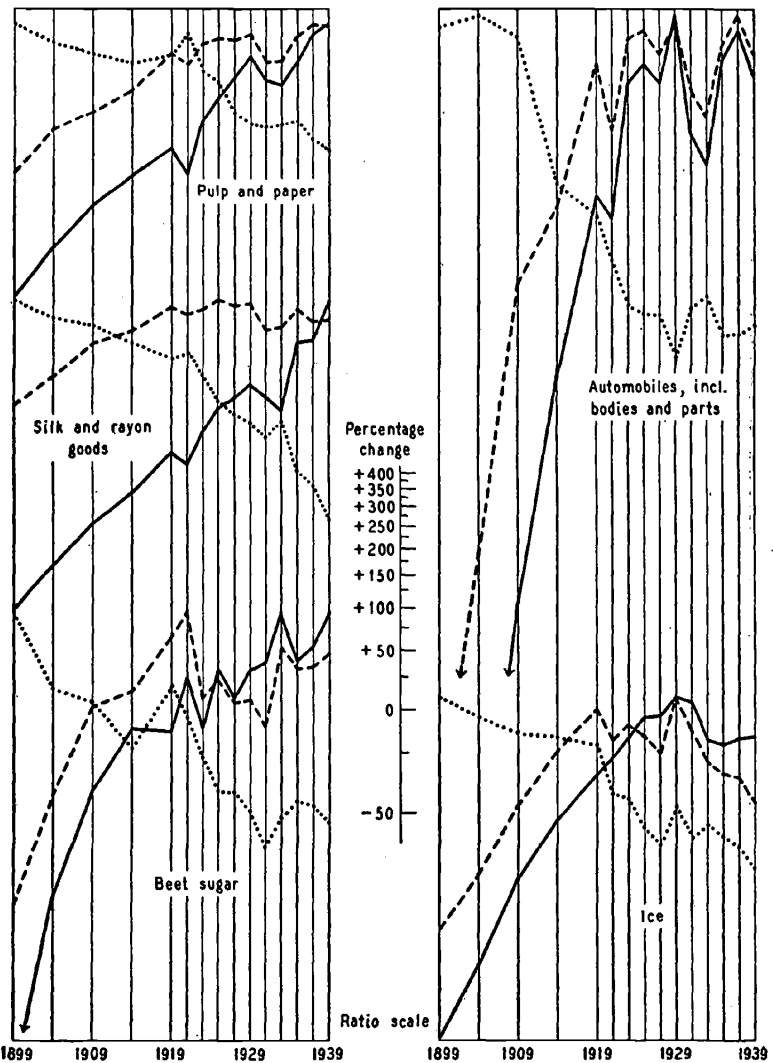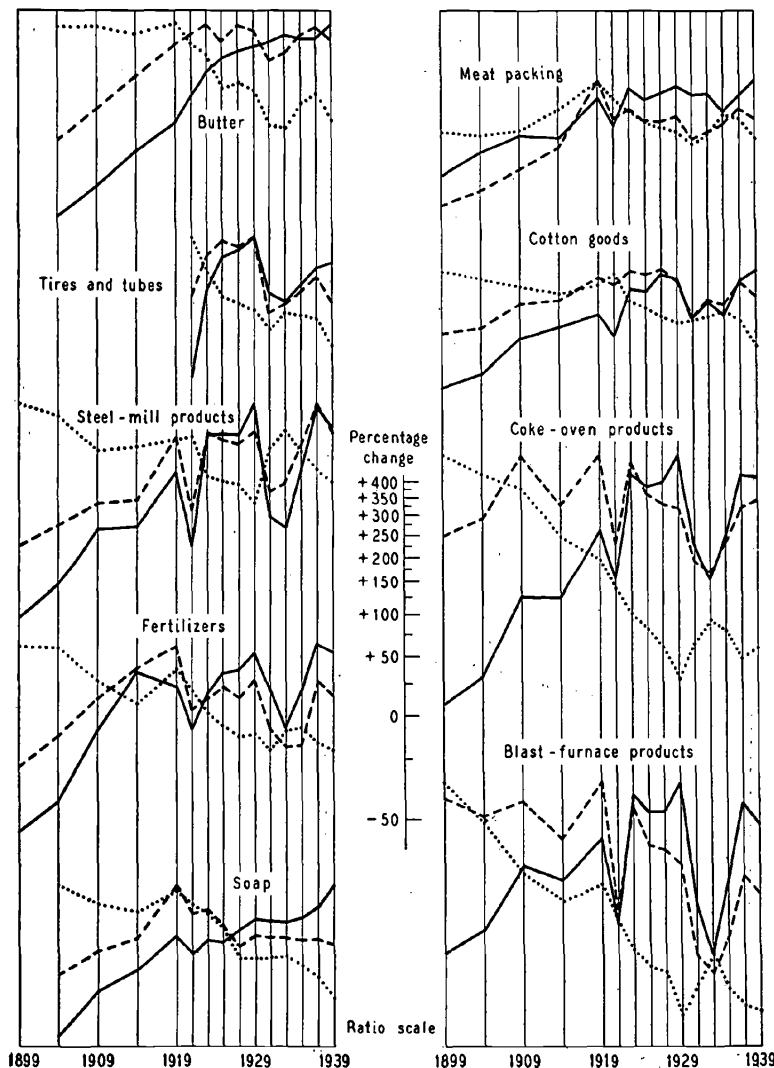

Rayon

Washing and ironing
machines

Refrigerators,
mechanical

Percentage
change
+400
+350
+300
+250
+200
+150
+100

+ 50

0

Petroleum
refining

− 50

Knit goods

Rice

Ratio scale

1899   1909   1919   1929   1939   1899   1909   1919   1929   1939

CHART 5 (CONT.)

Selected Manufacturing Industries
Indexes of Physical Output (————),
Wage Earners Employed (--------), and
Wage Earners Employed per Unit of Product (·················)
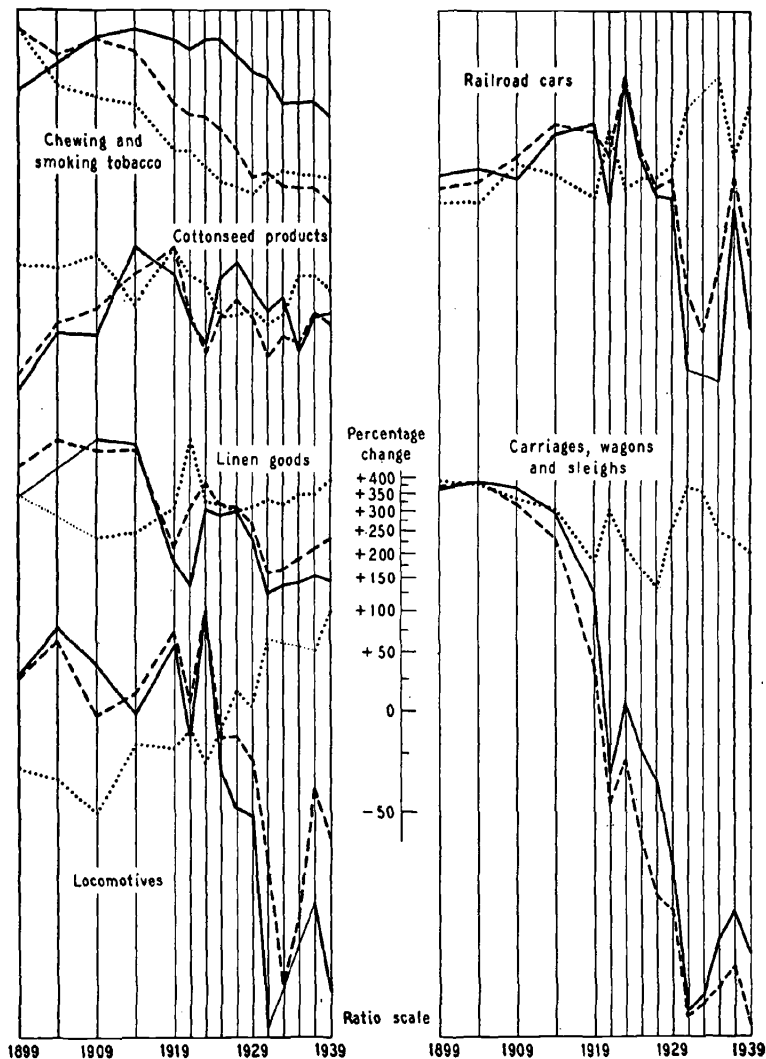

Pulp and paper

Silk and rayon
goods

Automobiles, incl.
bodies and parts

Percentage
change
+400
+350
+300
+250
+200
+150
+100
+ 50
0
− 50

Beet sugar

Ice

Ratio scale

1899   1909   1919   1929   1939   1899   1909   1919   1929   1939

Selected Manufacturing Industries
Indexes of Physical Output (————),
Wage Earners Employed (--------), and
Wage Earners Employed per Unit of Product (·············)

Butter

Tires and tubes

Steel-mill products

Fertilizers

Soap

Meat packing

Cotton goods

Coke-oven products

Blast-furnace products

Percentage
change

+400
+350
+300
+250
+200
+150
+100
+ 50
0
− 50

Ratio scale

1899   1909   1919   1929   1939   1899   1909   1919   1929   1939

CHART 5 (CONT.)

Selected Manufacturing Industries
Indexes of Physical Output (————),
Wage Earners Employed (————), and
Wage Earners Employed per Unit of Product (················)
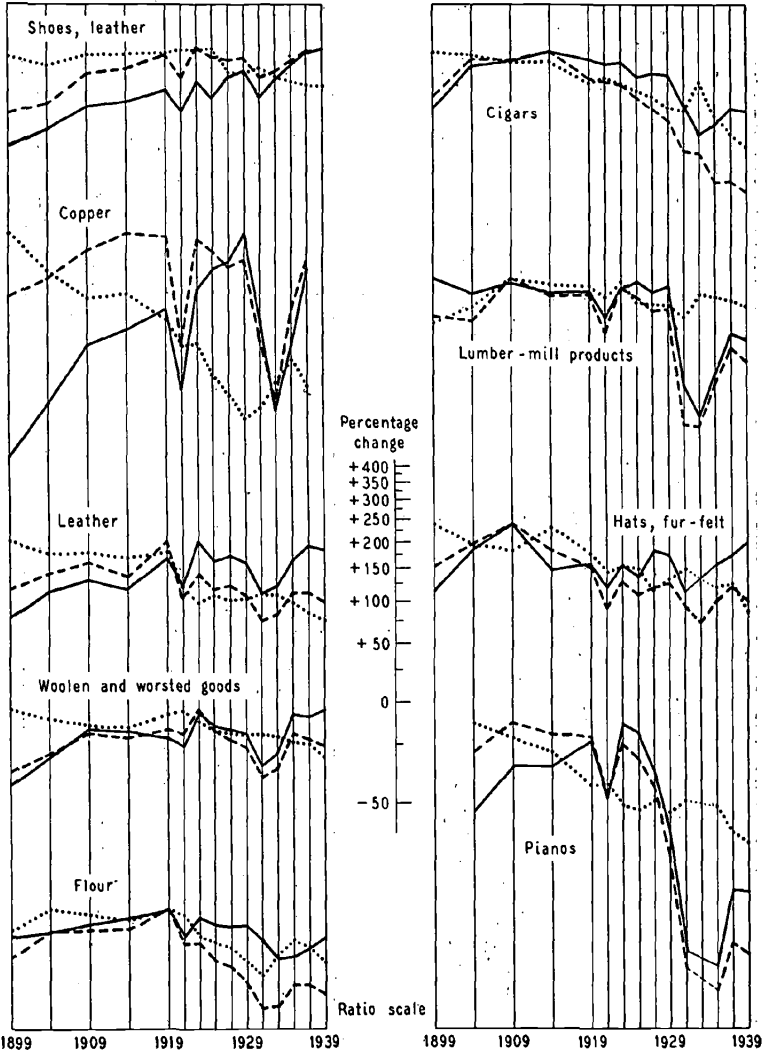
CHART 5 (CONCL.)

Selected Manufacturing Industries
Indexes of Physical Output (————),
Wage Earners Employed (--------), and
Wage Earners Employed per Unit of Product (·················)

Railroad cars

Chewing and
smoking tobacco

Cottonseed products

Linen goods

Percentage
change
+400
+350
+300
+250
+200
+150
+100
+ 50

0

Carriages, wagons
and sleighs

− 50

Locomotives

Ratio scale

1899   1909   1919   1929   1939   1899   1909   1919   1929   1939

coincide. In the other 34 industries, over half of the sample, employment reached a peak and began to recede while output was still expanding; and in as many as 10 of these, output reached its peak more than a decade later than employment. It is likely that annual data would show an even greater proportion of industries with the highest peak in employment preceding the highest peak in output, and that the highest peak in *manhours* would lead the highest peak in output in a proportion of industries greater than 34 out of 55, and that the average lead of the manhour peak over the output peak would be longer than the average lead of the employment peak over the output peak.

Against this background of growth and decline in individual industries we may re-examine certain conclusions brought out in analyzing employment and output during the four decades. Employment moves in the same direction as output, but not as that of employment per unit, during the early stages of an industry's career; during the middle stages its movement corresponds in direction with employment per unit rather than with output; and during the late stages all three tend to follow the same direction. In young industries, whose output characteristically shoots up quickly, the enormous gains usually more than counterbalance the declining trend frequent in the labor-output ratio; as a consequence, employment too expands, usually rather rapidly. During the mature phase of an industry output expands slowly, if at all, and the gain is usually more than counterbalanced by the declining trend in the labor-output ratio; as a result jobs decrease with employment per unit of product, unless the length of the working week is reduced sufficiently to offset the decline in the latter. In old and waning industries, falling output offers no counterpoise to diminishing labor requirements per unit, and even substantial cuts in the hours of work per week fail to halt reductions in the number employed.

These conclusions are based in part on the decline com-

mon in the ratio of labor utilized to goods produced during all stages of an industry. If changes in the working week could be taken into account, few of the apparent exceptions to this rule would remain.

It is amusing to consider how these conclusions would have to be modified if it were found that the labor-output ratio not only shrinks but does so at a rate that follows some general pattern from stage to stage. The most interesting possibility is that the rate of decline diminishes from stage to stage.[15] If unit labor requirements do shrink at a decelerating rate, the most precipitate drops must occur in precisely the stages at which output is expanding most rapidly; and since the pace of the latter much more than counterbalances the shrinkage in the former, the number employed mounts most rapidly in the same period. And again, the change in labor per unit becomes less and less noticeable just when employment is expanding only slowly or actually receding, for in this period output is either lagging behind that of most other industries or definitely sagging. One would have to conclude, if deceleration of change in unit labor requirements is a fact, that employment usually expands most rapidly when reductions in labor per unit in an industry are most drastic, and that employment expands least rapidly or diminishes when the industry has ceased to reduce labor per unit substantially.

This conclusion could be true yet unimportant. It is possible, for example, that deceleration of the rate of change in the labor-output ratio, even if it exists, takes the form,

[15] Some authors have explained retardation of growth in output in part by the slowing down of technical progress, which implies, of course, a slackening in the rate of decline in labor per unit. (See the evidence of a slackening in the rate of technical progress in the cotton, woolen and worsted, iron and steel, shoe, paper, and copper industries, in Simon Kuznets, *Secular Movements in Production and Prices;* Houghton Mifflin, 1930, Ch. I.) Such a slackening should also be expected if unit labor requirements are a function of the scale of an industry's operations; for the scale expands, as does output, at a decelerating rate.

lot of a series of gradual changes from stage to stage, but of
a single abrupt change from a very rapid rate of decline
during the first stages of growth to a moderate rate persist-
ing without any or with only little change during the rest
of the industry's career. That is, the shape of an industry's
labor-output curve could be reasonably approximated by
two connected straight lines, the first (with a sharp negative
slope) covering the early life of the industry, and the second
(with a mild negative slope) covering the later and major
portion. If this is the situation, then the phenomenon of
deceleration would hardly be observable in available data,
which seldom cover the very early years of an industry's
career, and in any case would possess little significance.
Again, gradual deceleration might definitely exist but at a
low rate. The most prominent feature of the long-run
changes in an industry's unit labor requirements, certainly
for a period as short as that since 1899, would then be long
cycles or erratic movements rather than deceleration, for
four decades is hardly a long time in the life of many in-
dustries.

A pulsating rate of decline in unit labor requirements
might well be expected: startling innovations are not intro-
duced every year, although minor improvements in tech-
niques may be made almost continuously. It is interesting
to speculate also on the possibility that long cycles in unit
labor requirements in different industries more or less
synchronize. This concurrence might arise from general
waves of rationalization (such as many economists believe
occurred during the 'twenties), extensive changes in the
working week and in labor relations, generally high levels
of output and capital investment, and so forth.

There is little point in pressing these speculations
further. From the data gathered in this study we cannot say
whether there has been any particular pattern, or even any
pattern at all, of change in the labor-output ratio during
the life of an industry: the period covered is relatively short

and data on actual hours worked in individual industries are inadequate.

Whatever the pattern of decline in unit labor requirements, the course plotted for employment in individual industries rests securely on the data sampled in Chart 5. There one can see clearly that the industrial distribution of employment is in continual flux. Change in aggregate employment is the net result of the shift of workers into new industries, the rapid multiplication of jobs in the young industries that survive in the initial struggle for breathing space, the moderate growth (but from a higher level) of industries close to maturity, the stagnation in older industries, the decline in waning industries, and finally the disappearance of employment in industries that are leaving the economic scene.

Technological changes—and all the other factors apart from technology popularly subsumed under them—play a significant role in these trends. They are basic not only to the ebb of employment in mature and decadent industries but also to the appearance and growth of new fields of employment. Technological evolution is a factor in the hiring of workers as well as in their firing. But the relationships involved are far from simple. Even when employment in an industry is contracting, and its technological level is rising at the same time, we cannot always state unequivocally that technological development is the factor responsible for fewer jobs. For example, in the cigar industry production was 20 per cent less in 1937 than in 1929, and aggregate manhours worked, 52 per cent, but because of a shorter working week only 33 per cent fewer workers were employed. Output per worker rose 20 per cent and output per manhour 66 per cent. Can we say that this gain in productivity led to an equivalent labor displacement? Is it not possible that output, and with it, employment, might have fallen still more had mechanization not been instituted and costs and prices cut? All this is not to deny that the trend

of employment is downward in many industries and that a painful process of adjustment is continually going on. Yet *technological* unemployment, *i.e.*, the fraction of total unemployment that may be ascribed to a particular set of the several sets of factors making for unemployment, remains so complex and theoretical that it can scarcely be estimated with existing statistics.

Capital investment, if it can be considered apart from developments in technology, also has played two roles in opening up employment opportunities and in their industrial distribution. On the one hand, it is unlikely that an industry (and the employment it offers) has expanded without an influx of capital into it, and that aggregate assets in industries with shrinking output and employment have increased. Undoubtedly there have been exceptions. Since pouring capital into an industry is only one of the means by which its output is augmented, some industries may have grown with little or no increase, or even a decrease, in their capital assets; and it is conceivable that capital assets, by displacing other factors of production, have grown even in some decadent industries. Nevertheless, what we know of industrial history bears out our observation. Between 1904 and 1937 the largest increases in jobs were in the major groups of manufacturing industries whose fixed assets, in terms of net book values, increased most rapidly. The automobile, chemical and rubber products groups stand out in this respect. And among the groups with relatively slight increases in employment—notably tobacco, leather, and forest products—are the industries with less-than-average increments to capital assets.[16]

16 Net book values are not the only measures of capital invested, of course, but almost any accepted measures would yield results consistent with the remarks in the text.

These observations apply to changes in aggregate capital assets, not capital assets per worker. Accessible data on capital investment are not to be relied upon for information on the latter; and alternative measures based on these data would probably yield results at variance with one another.

On the other hand, reduction in labor per unit has usually been a concomitant of the inflow of capital. Inevitably, then, when output fails to expand sufficiently to balance the decline in labor per unit, new capital investment is associated with fewer jobs. Here, also, we see that change in the employment offered by an industry corresponds in direction with change in capital investment or in some other related factor at certain stages of an industry and not at other stages. Though adequate statistical information is lacking, it seems likely that in the early stages of an industry capital investment is accompanied by more jobs; that in the mature phases it may be accompanied by static or declining employment (though at this stage improvements in the capital equipment used for replacement, rather than net additions to the capital stock, may constitute the basis for technological advance); and that in the declining stage disinvestment of capital may parallel displacement of labor.

To be sure, the stages of growth do not always follow the pattern of adolescence, maturity, and decline. Sometimes an industry gets a new lease on life. A technological innovation of revolutionary scope may lead to so great a cut in costs and prices that output jumps and with it employment. Or a spurt in demand may be the responsible factor, as when new uses suddenly appear for an old product. In an industry so affected, new capital investment may become associated with an ascending rather than a descending trend in employment, even after it has apparently passed its zenith.

MANUFACTURING PRODUCTIVITY AND GENERAL ECONOMIC DEVELOPMENT

The great reduction since 1899 in the factory labor utilized per unit of output—one-half in terms of workers, two-thirds in terms of manhours—means a very substantial gain in factory productivity, that is, in the power and efficiency with which manufacturing industry has applied itself to turning out goods. These figures, or rather the corresponding ad-

vances in output per worker or per manhour, are not, of course, exact measures of the gain in productivity. Shifts in the ratio between output and labor input may come about through the substitution of other production factors for workers, or of one type of labor for another; and these substitutions must be allowed for in any attempt to measure changes in productivity by shifts in the ratio. For example, if costs are incurred in the operation and maintenance of the cigar machines that have displaced cigar makers, or in the purchase of the electric power that has superseded the factory production of power, it cannot be said that the entire reduction in labor per unit is a net gain. On the other hand, the substitution of unskilled for skilled labor (cigar-machine operators for hand workers) may signify a gain that is not reflected in the measures of labor input we have.[17] Similarly, capital-saving innovations lead to gains not evidenced by the productivity ratio we can compute. Yet even liberal allowance for such biases would not invalidate the conclusion that there have been widespread and, on the average, tremendous strides in the productivity of manufacturing industries.

These strides, however, cannot be fully understood or explained when viewed in isolation, because manufacturing constitutes merely one sector of our economy. Indeed, the career of any single industry, great or small, is a thread woven into a complex pattern, to which it contributes its share of color, texture, and design, and from which it largely derives its meaning.

The labor-output ratio is affected by the kind and quality of the raw and semiprocessed materials an industry consumes. Selection of seed and technological advances have raised the sugar content of beets, with a consequent gain in

[17] If the skill of the displaced workers is thereby rendered obsolete, as it often is, the gain is merely a gross gain (in the accounting sense) from the viewpoint of society at large. In casting up its accounts, the nation must give full consideration to the negative consequences of any industrial development.

the sugar yield obtained by manufacturers per ton of beets treated; and the introduction of the flotation process, which led to the concentration of an increasing fraction of copper ores by the mining industry, has lessened the effort expended in the factory to derive a given quantity of copper in the smelting process. Advances in the processing of steel sheets in steel works and rolling mills have lessened the work to be done per unit in automobile body plants; and the new and better products of the paint and varnish industry have helped to speed up the production and improve the quality of many manufactured products.

Similarly, industries supplying equipment have helped the productivity of other manufacturing industries. Improvements in capital equipment have sometimes originated in the equipment industries themselves, sometimes in the industries ordering and using the equipment, and frequently in a collaboration between the two groups. And such forms of nonmanufacturing endeavor as engineering and independent research have made their contribution to manufacturing. Even intangibles—such as ideas concerning organization and management—seldom originate in the industries utilizing them. They spring up in different areas of our industry as well as abroad and come to form part of a common pool, drawn upon by all types of enterprise. Industries consuming the products of other industries have contributed to the progress of the latter. Discoveries of uses by consuming industries for materials formerly thrown on the waste heap have swelled the output and enhanced the productivity of the producing industries.

Perhaps the stellar role in the contribution of nonmanufacturing industries to factory productivity has been played by transportation. Through the railroad system manufacturers have been able to tap new sources of raw materials. To cite one industry, lumber manufacturers have extended their operations to virgin forests, thereby at least retarding increases in their costs. Again, highly concentrated localiza-

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ion of factories, with the fine division of labor and other
dvantages it implies, depends upon cheap and efficient
ransportation not only from sources of supply to factory but
lso among specialist plants. Indeed, it is clear that the im-
nense expansion of the factory system itself went hand in
1and with the extension of the railway system. Advances in
vater transportation and in other industries facilitating for-
:ign trade have done much to bring materials and machines
o our factories and open up markets for their products.

The augmented scale on which manufacturing is done in
tself makes for greater factory productivity. The growth of
:he economy at large has aided in stepping up the scale of
)perations in manufacturing even more rapidly than in
)ther industries, owing to the emphasis on fabricated goods
n consumer budgets as incomes have become more ample.
Of course, bigger operations may press upon limited natural
resources and cause the employment of more, rather than
less, labor per unit of product. There is frequently such a
tendency in mining; and, if demand leads to the exploita-
tion of mines yielding low grades of ore, even manufactur-
ing productivity may be affected adversely. But the evidence
cited in the preceding section suggests that in the past, at
least, greater factory output has not usually been associated
with less output per unit of labor.

Manufacturing has always stood in a reciprocal relation
to the economy at large. Developments in factories have
been stimulated from the outside and have given impetus
in turn to advances in other sectors of the economy. With
the expansion of manufacturing the scale of operations
in nonmanufacturing industries, and thereby their pro-
ductivity, has risen. Manufacturing industries have further
enhanced the productivity of nonmanufacturing both by
relieving them of work and by giving them better and
cheaper equipment and materials. The substitution of the
factory-made tractor for the farmbred horse, for instance,

set free the farm labor that formerly went into rearing, feed
ing, and caring for draught animals. The railroad industry
has benefited from lighter and stronger freight cars and
locomotives, and improved fuels.

Since the growth and efficiency of a single industry or
group of industries cannot be treated apart from the prog
ress of the entire system, we must view the increase in
output per unit of labor in manufacturing as merely one
observation on the change in the productivity of the entire
economy; and not only the growth but also the stagnation
of factory employment falls into perspective as an aspect of
our general economic advance.

TABLE 1

All Manufacturing Industries Combined

Indexes of Production, Employment, and Employment and Manhours per Unit of Product (1899: 100)

| | PHYSICAL OUTPUT | NUMBER EMPLOYED | | NUMBER EMPLOYED PER UNIT OF PRODUCT | | | |
		Wage earners	All workers	Wage earners	All workers	Aggregate wage earner hours Est. A	Est. B
1899	100	100	100	100	100	100	
1900	102	104		101			
1901	115	109		94			
1902	129	118		91			
1903	132	122		93		91	
1904	124	115	116	92	94		
1905	148	128		87			
1906	159	134		85			
1907	161	140		87		84	
1908	133	124		94			
1909	158	139	143	88	90		85
1910	168	145		87		83	
1911	161	145		90			
1912	185	151		81			
1913	198	152		77			
1914	186	146	152	79	82	73	73
1915	218	153		70			
1916	259	179		69			
1917	257	191		74			
1918	254	195		77		70	
1919	222	188	197	84	89		74
1920	242	188		78		67	
1921	194	144	152	74	78	60	
1922	249	160		64		56	
1923	280	183	190	65	68	57	56
1924	266	170		64		54	53
1925	298	175	183	59	61	51	50
1926	316	179		57		49	48
1927	317	175	184	55	58	47	47
1928	332	175		53		45	44
1929	364	187	197	51	54	44	43
1930	311	162		52		41	41
1931	262	137		52		38	40
1932	197	117		59		37	41
1933	228	129	136	57	59	37	39
1934	252	151		60		37	38
1935	301	160	167a	53	56a	36	36
1936	353	174		49		35	35
1937	376	191	198b	51	53b	35	36
1938	295	160		54		33	35
1939	374	176	181c	47	48c	32	32
1940d	429	190		44		30	31

SOURCES: The index of output for 1899–1937 was taken from *The Output of Manufacturing Industries, 1899–1937* (National Bureau of Economic Research, 1940), p. 44, and extended by a preliminary index derived by the National Bureau from data in the 1939 Census of Manufactures, with estimates for 1938 and 1940 based on the Federal Reserve index as given in current issues of the *Federal Reserve Bulletin*.
Sources and notes continued on page 36.

TABLE 2

Individual Manufacturing Industries

Percentage Changes in Physical Output, Number of Wage Earners, and Wage Earners per Unit of Product, 1899–1937

INDUSTRY	PHYSICAL OUTPUT	WAGE EARNERS	WAGE EARNERS PER UNIT OF PRODUCT
	(percentage change, 1899–1937)		
Foods			
Meat packing	66	85	12
Flour	—8	—18	—10
Rice	416	241	—34
Fish, canned	96	46	—26
Fruits & vegetables, canned	792	213	—65
Butter, cheese, & canned milk	460	157	—54
Beet sugar	1,690	375	—73
Cane sugar	86	29	—30
Ice	668	173	—64
Beverages			
Liquors, malt	60	19	—26
Liquors, distilled	315	153	—39
Tobacco products			
Cigarettes & cigars	454	—19	—86
Chewing & smoking tobacco	—6	—65	—63
Textile products			
Cotton goods	101	42	—30
Woolen & worsted goods	60	25	—22
Silk & rayon goods	512	79	—71
Knit goods	506	177	—54
Carpets & rugs, wool	52	8	—29
Cordage & twine	38	7	—22
Jute goods	134	45	—38
Linen goods	—44	—43	0.3
Hats, fur-felt	26	—16	—33
Hats, wool-felt	90	92	2
Leather products			
Leather	61	—3	—40
Shoes	87	52	—19
Gloves	29	—3	—25
Paper products			
Pulp & paper	518	177	—55
Printing & publishing			
Printing & publishing, total	494	78	—70

INDUSTRY	PHYSICAL OUTPUT	WAGE EARNERS	WAGE EARNERS PER UNIT OF PRODUCT
	(percentage change, 1899–1937)		
Chemical products			
Chemicals, industrial, incl. gases, compressed, & rayon	2,500	693	—70
Cottonseed products	63	51	—8
Wood distillation products	259	184	—21
Explosives	267	20	—67
Fertilizers	248	80	—48
Paints & varnishes	391	228	—33
Salt	82	—3	—47
Tanning & dye materials	292	71	—56
Petroleum & coal products			
Petroleum refining	1,920	583	—66
Coke-oven products	380	21	—75
Forest products			
Lumber-mill products	—32	—20	19
Turpentine & rosin	—32	—22	15
Iron & steel products			
Blast-furnace products	171	—41	—78
Steel-mill products	313	162	—36
Nonferrous-metal products			
Copper	272	28	—66
Lead	51	—51	—68
Zinc	318	132	—45
Transportation equipment			
Automobiles, incl. bodies & parts	180,000	21,300	—88
Carriages, wagons & sleighs	—95	—96	—33
Cars, railroad	—22	9	39
Locomotives	—79	—53	126
Ships & boats	—17	33	61

SOURCES: The figures on output are from *The Output of Manufacturing Industries, 1899–1937* (National Bureau of Economic Research, 1940), pp. 106-7, except the index for leather gloves, which has been revised; the changes in number of wage earners, from the Census of Manufactures. The industry titles are not the full Census titles; for the full titles see the volume cited. The industry called 'chewing and smoking tobacco' above is called 'other tobacco products' in this volume.