Chapter Title: Aggregate Factory Employment and Output

Chapter Author: Solomon Fabricant

Employment in Manufacturing, 1899–1939:

An Analysis of Its Relation

to the Volume of Production
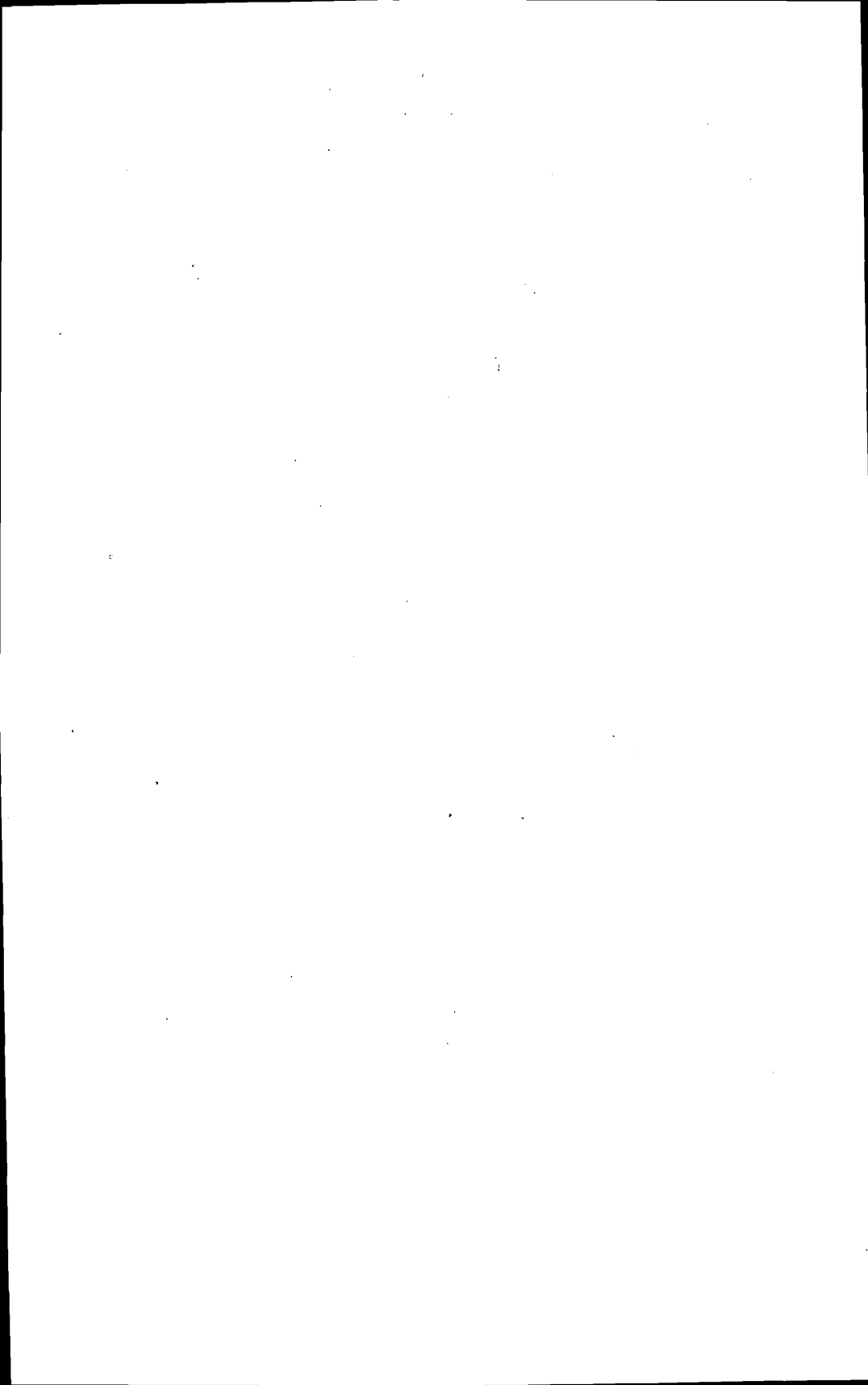
Aggregate Factory Employment and Output

THE rise of "the factory system" was a major economic devel-opment of the nineteenth century. Increase in scale of operations, detailed division of labor, intensified geographi-cal concentration of industry, and mechanization of produc-tion are just a few of the many processes which the historian, of whatever school, cannot fail to record. Yet the nineteenth century witnessed only the infancy and youth of the factory. Manufacturing continued to grow, and its techniques to develop, well into the twentieth century, reaching a stage which some observers have called "maturity." It is upon this recent part of its history, beginning with 1899, that the present report on America's factories is concentrated.

Two of the more significant indexes of manufacturing growth are output or physical product, and employment or number of workers actually occupied in turning out the product. A third measure, the ratio of employment to output, that is, the amount of labor required to produce a unit of goods, is an especially vivid indicator—when observed at various points in time—of the transformation of the manu-facturing process. Since we cannot describe the tightly woven pattern of manufacturing development in all its aspects we choose to trace the course, from the turn of the present cen-tury, of these major strands.

GROWTH AND STAGNATION IN EMPLOYMENT

In 1899, a prosperous year, five million persons earned a live-lihood in American factories. Of these, about nine tenths
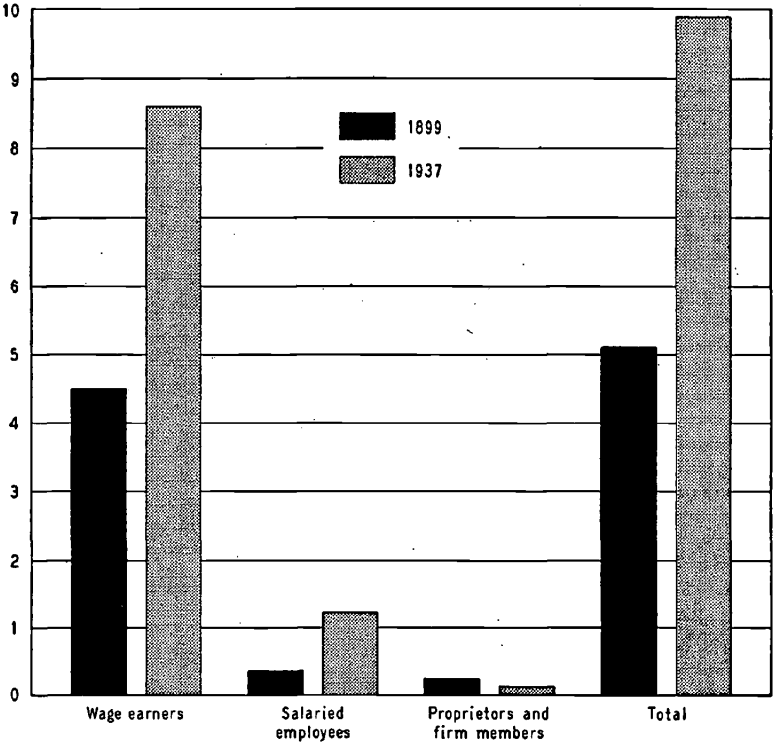
were wage earners, and the remainder were white-collar workers (including corporate officers), and entrepreneurs (Chart 1). By 1937, the latest year of peak business preceding the current war boom, the number of persons engaged in

Chart 1

ALL MANUFACTURING INDUSTRIES COMBINED

Number of Persons Engaged, 1899 and 1937

Millions of persons

Based on Table B-5

manufacturing industry had grown to ten million. In a little less than four decades, therefore, the total number engaged in manufacturing—again including salaried workers, corporate officials and working proprietors as well as wage

earners—had increased by 100 percent. This rise exceeded the growth over the same period not only of the nation's population, which went up 75 percent, but also of aggregate employment in all branches of American industry (including mining, trade, farming and other nonmanufacturing activities), which rose 85 percent. Because of its more rapid rate of increase, factory employment in 1937 accounted for a somewhat larger proportion of all American workers and proprietors than it had in 1899: at the close of the nineteenth century its contribution to the total was 22 percent, as compared with 24 percent some four decades later.

Within manufacturing itself there were several noteworthy changes in the composition of employment. Wage earners, whose numbers rose by a little more than 90 percent between 1899 and 1937, lost some ground to salaried or white-collar workers, whose jobs increased by 250 percent. Entrepreneurs, on the other hand, declined both in relation to the total of manufacturing employment and absolutely: there were only half as many factory proprietors in 1937 as there had been in 1899. Since wage earners constituted the great majority of all persons engaged in factories over the entire period, the net result of these shifts was a slight decline in their share of factory employment, from about 90 percent to 85. The rapid multiplication of the number of openings for white-collar workers reflects the growing importance of supervisory, technical, and clerical functions in the manufacturing process. As for the sharp decline in the number of proprietors and firm members, it is attributable in large measure to the tendency to incorporate partnerships and single proprietorships and in part also to the growth of large-scale enterprise at the expense of the small concern.

Returning to the 100 percent rise in total factory employment, we should note two outstanding characteristics of this growth. In the first place, it was the result not of a cumulation of steady increases from year to year but of varying

annual rates of change. Even from the series based only on Census years wide fluctuations are apparent (Chart 2). The annual series for wage earners, estimated for intercensal years, tells a more complete story. According to this record there were absolute declines in employment during as many as nine intervals, only one of which, the period 1929–32, exceeded a calendar year in duration. That spectacular slump brought factory employment down to a trough that was almost 40 percent below the 1929 average and 20 percent short of the low levels of 1921 and 1914.

In the second place, the entire 100 percent increase in manufacturing employment occurred during the first two decades of the period 1899–1937. After the peak reached during the war years 1917–18 there was no net gain in factory jobs. Up to 1914 factory employment rose at a fairly substantial average annual rate. Then came the upward spurt resulting from war orders by European belligerents, followed by an imperative domestic demand for factory-made munitions of war—guns, uniforms, trucks, motor fuel, ships and airplanes. Responding to these powerful stimuli, manufacturing employment in 1917–18 touched a peak that was not surpassed in the prosperous 1920's or in the good business years 1937 and 1940. Translated into terms of human beings in the labor market, this dispassionate digest of employment data means that during most of the years in the first and second decades of the twentieth century large numbers of youths leaving school, women entering industry and immigrants crossing our borders found new jobs in American factories, as well as opportunities to fill places left by other workers. While labor turnover continued on into the 1920's and 1930's, these years brought no important net increase in factory employment; newcomers found openings in manufacturing only when existing positions became vacant.
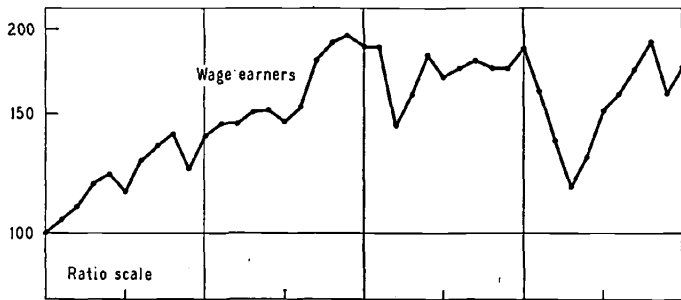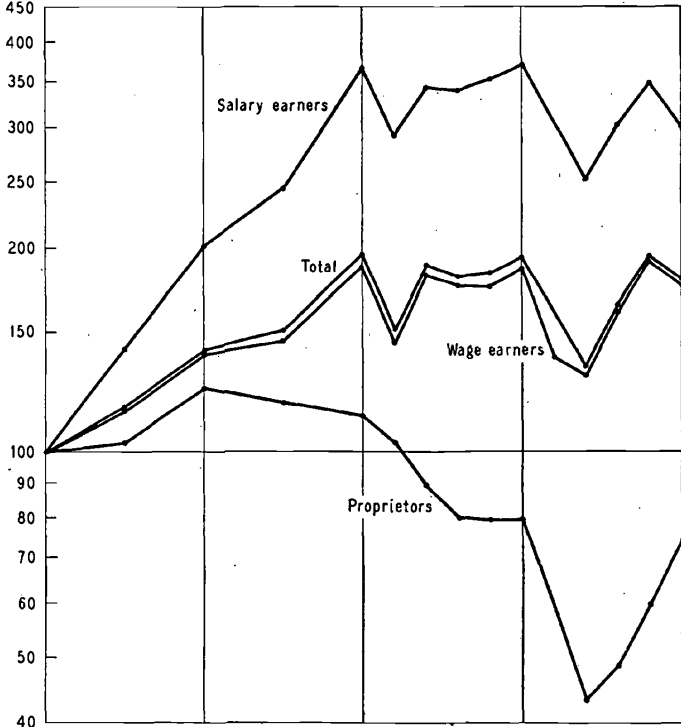
The current transformation of our industrial system into a war economy is augmenting employment at a rapid pace,

Chart 2

ALL MANUFACTURING INDUSTRIES COMBINED

Indexes of Employment

Percentage

Salary earners

Total

Wage earners

Proprietors

Wage earners

Ratio scale

1899   1909   1919   1929   1939

Based on Tables B-5 and F-1

very much as it did during the war of 1914–18. The clamorous demands for workers are being met in part through absorption of those still unemployed (a reservoir less important in 1914 than it was in 1939), in part through the diversion of workers from jobs in other fields, and in part through a call upon persons not normally employed. Already there is unmistakable evidence of this new upward trend. The latest figures available at this writing indicate that in 1941 employment in American factories was 19 percent higher than in 1937, and that it has climbed still further in 1942. It is likely that opportunities for factory work will fall off again when the present war has come to an end. But whether such a decline will in fact occur, and if it does to what level and at what rate it will proceed, must depend not only on economic forces, many of which are still imperfectly understood, but on political and other noneconomic factors as well.[1]

OUTPUT IN RELATION TO EMPLOYMENT

The foregoing section has sketched in brief the changes in the number and composition of factory personnel since 1899. At this point we take up a new thread in the pattern of manufacturing development, and trace the growth of the product turned out over the four decades by the army of workers that swelled from five to ten million.

Factory output rose very sharply between 1899 and 1937. Indeed, in absolute terms, the rise in output dwarfs the gain in employment. By 1937 the physical product of our factories had increased 276 percent, the number of employees only 100 percent.

Like the volume of employment, the course of output fluctuated markedly. It is true that the cyclical fluctuations in each were quite similar, as the timing of the peaks and troughs in both output and employment shows (Chart 3).

[1] For some comments on the problem of forecasting the future of factory employment, see Chapter 6.

But when successive peaks are compared, output is found to
have registered a series of more or less steady gains over em-
ployment. Except in three of the periods (1907–10, 1913–18
and 1929–37), the movement of output diverged progres-
sively from that of employment. Output rose more rapidly

Chart 3

ALL MANUFACTURING INDUSTRIES COMBINED

Indexes of Output, Wage Earners Employed, and Total Employed
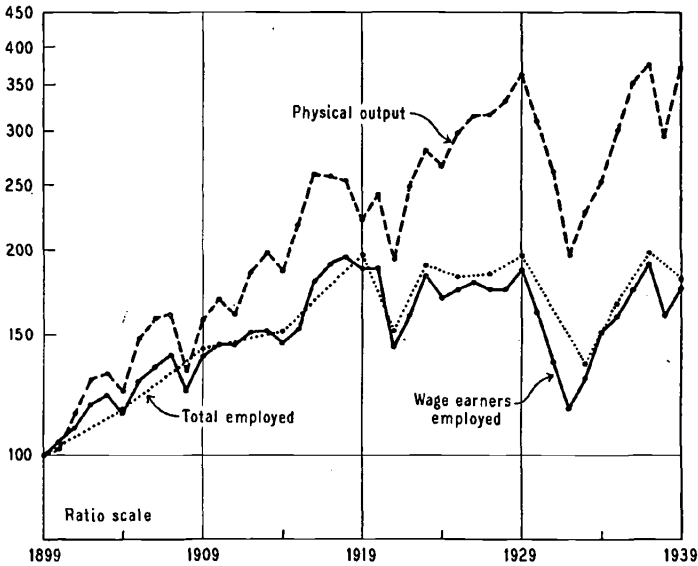
Based on Table F-1

than employment in the years 1899–1903, 1903–07, 1910–13
and 1926–29. When employment declined in 1920–23 and
again in 1923–26 output continued to increase. And in
1918–20, when the movements of both were downward, the
drop in output was less severe than that in employment.
Especially noteworthy is the continued growth of factory pro-
duction during the 1920's to heights well above those of

1916–18, whereas employment, as we have seen, did not surpass the peak attained in the first World War until 1941.

The fourfold increase in output between 1899 and 1937, while employment merely doubled, means that there was a decline, during the 38 years, of 50 percent in the number of workers employed per unit of product.[2] The processed foods, beverages, clothing, chemicals, metals, machines, carriages and wagons, and the host of other factory products turned out in 1899, were made with the aid of 5 million workers. In 1937, four times as large a bundle of goods—greatly changed in composition, of course—was produced by only twice as many workers.

Thus far we have considered only the size of the product. If we could take statistical account of improvements in its quality, we should almost certainly find that the 50 percent decline in employment per unit is an understatement. For the commodities processed in 1937 were, on the average, superior to those made at the opening of the century.[3]

The measurable drop of 50 percent in the ratio of factory employment to product is equivalent to an average rate of decline of 1.8 percent per annum for the period under discussion. Yet from an examination of Chart 4 it appears that the rate of change in employment per unit of output was far

[2] The ratio between employment and output may be expressed either as the number of men used in the production of a unit of goods, or as the volume of product per man employed. The use of one form or the other is a matter of choice.

[3] Further, in many fields of manufacture a unit of output was made from less material in 1937, thanks to the reduction of waste and the utilization of by-products. That is, the *net* output of manufacturing industries (and it is net output which is the better measure of the contribution of factories to our national product) probably rose more rapidly than their *gross* output, because of a slower rise in the input of materials. (For a discussion of the bias in indexes of physical output, when they are taken to represent net output, see Solomon Fabricant, *The Output of Manufacturing Industries, 1899–1937* [National Bureau of Economic Research, 1940], Ch. 2.) For this reason the 50 percent cut in workers per unit of product is less than the reduction that would be found in workers per unit of *net* output if we could measure it adequately.

from uniform. There were short cycles as well as more persistent differences from period to period. The year-to-year movements are indicated only approximately because the figures for intercensal years are rather rough estimates. Yet it is safe to conclude that there were 10 separate occasions during the last four decades when the number of workers em-

Chart 4

ALL MANUFACTURING INDUSTRIES COMBINED

Indexes of Wage Earners and Total Workers per Unit of Product

Percentage
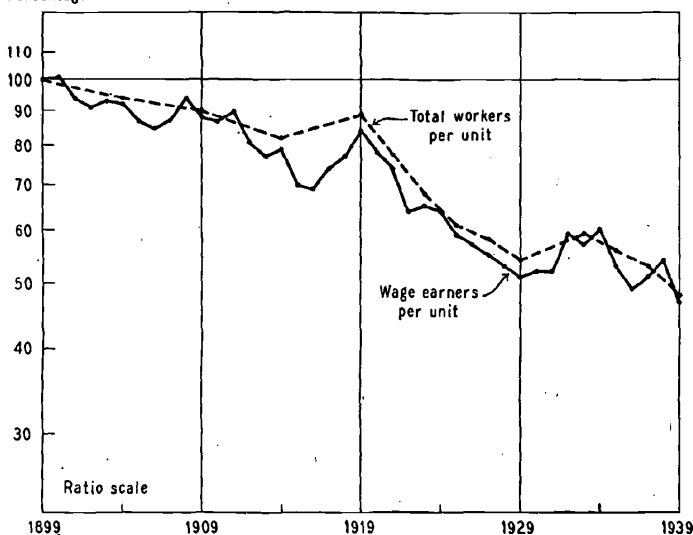
Based on Table F - 1

ployed to turn out a unit of product increased, thus running counter to the general trend. Over several rather long periods, 1903–11, 1916–21 and 1929–36, this ratio tended either to move horizontally or to rise. In the years 1911–16 and 1923–29, on the other hand, there were specially notable declines in employment per unit.

One explanation of the fluctuations in the ratio of number employed to goods produced is to be found, of course, in the

modifications in weekly hours of labor over the four decades we are studying. In the following section the principal changes in the working week are noted, and an attempt is made to describe the rather complex effects of reduced hours upon the output of factory workers.

REDUCTIONS IN THE WORK WEEK AND THEIR RELATION TO EMPLOYMENT PER UNIT OF PRODUCT

The changing ratio of workers to product may be regarded as a function of the length of the work week and of the amount of labor, measured in manhours, employed per unit of product. If the number of manhours required to produce a unit of output remains unchanged, a decline in hours worked per man will raise the ratio of workers employed to output; conversely, if the length of the working week is unaltered, but the number of hours of labor needed per unit of product is reduced, employment will decline in relation to output. But the two variables are not mutually independent, and it is common knowledge that change in one tends to induce change in the other. For this reason a movement upward or downward in the ratio of employment to output usually reflects both a change in weekly hours of work and a modification of unit hourly labor requirements.

Reductions in the work week have occurred under varying circumstances. Often a rise in the volume of goods turned out per manhour has implemented the efforts of organized labor to share in the benefits of the accompanying reductions in costs by working less hours per week. Sometimes labor's campaign to reduce hours of work has antedated a decline in real costs and spurred the employer on to institute labor-saving improvements; in such cases a cut in hours of work has been a stimulus to the entrepreneur as well as a reward to the worker. That a reduction in hours tends to lead to improvements in methods of management, in machinery and in other

factors, has been noted, for example, in a study of cotton manufacturing by the National Industrial Conference Board.[4] As N. I. Stone has observed, "the threatening diminution of profits acts as a powerful stimulus to the owner or manager of a plant who is anxious to make possible savings where he was satisfied before to plod along in the established rut." [5] Occasionally the entrepreneurial reaction to reductions in hours has been so prompt and far-reaching as to surprise the trade union which initiated the demand for it.[6]

Again, a widely prevalent reason for reduction in the hours of labor—at least during the earlier part of the century when the work week was very long—has been the experience, or at least the presumption, that the average worker can actually produce about as much in ten hours as in a twelve-hour day, even with all other conditions of production unchanged. Classic examples often cited are the experiences of the Engis chemical factory near Liége in 1892, the Salford iron works in Manchester in 1893, and the Zeiss optical plant in Jena in 1900. In all of these plants moderate reductions in hours per day were accompanied by increases in output per manhour, and in two by increases in output per worker.[7]

In recent years reduction of hours has been strongly supported not as a means of sharing prosperity or effecting re-

[4] *Research Report No. 4* (March, 1918).

[5] "Is the Minimum Wage a Menace to Industry?" *Survey,* Feb. 6, 1915.

[6] "The shorter work-week, as established by the thirty-five hour week, was promptly met by employers with new labor-saving devices, a more intense speed-up system of production and the establishment of the section system of production in factories where it never existed before, thus tending to destroy the immediate gains which were obtained by the thirty-five hour week. . . ." (Resolution adopted at the International Ladies' Garment Workers' convention in May 1937, cited by Harry Ober, *Trade-Union Policy and Technological Change* [National Research Project, Philadelphia, 1940], p. 82.)

[7] These and other cases are summarized in Josephine C. Goldmark's *Fatigue and Efficiency* (Russell Sage Foundation, 1912). For more recent citations covering American industry see Harry Ober, *op. cit.,* Ch. IV, and the 1940 *Annual Report* of the Wage and Hour Division of the U. S. Department of Labor, Ch. I. It is very difficult to determine from the cases described in these and other sources the extent to which changes in factors other than hours of labor affected labor productivity.

ductions in costs, but in order to spread available employment among a larger number of workers and thus to help absorb the unemployed.

Finally, throughout our country's industrial history much effort has been devoted to putting a ceiling on hours of labor in general, and in particular to restricting the number of hours worked by women and children, and by men engaged in hazardous occupations. Behind such regulation of hours has been the consideration that despite the possibility of immediate curtailment of production per employee, the advancement of the health and happiness of the people at large would counterbalance the loss in output, and perhaps even lead ultimately to a stepping up of labor efficiency.

Whatever the grounds for reductions in the average length of the work week, the statistical evidence, assembled from rather fragmentary data and diverse sources,[8] shows a definite downward movement in number of hours worked during the period since 1899. In that year the average full-time week for all manufacturing was about 60 hours, whereas in the years 1937–40, just prior to the acceleration of preparations for war, the average work week was about 40 hours. The decline in hours was slow during the first decade and a half, and very slight during the 1920's. The largest cuts came during and immediately following the war of 1914–18, a period in which the full-time week fell from 55 to 50 or 51 hours, and again during the recent great depression, with full-time hours declining from an average of 50 in 1929 to 40 in 1937-39.

The foregoing summary refers to the nominal work week. Data on the number of hours actually worked, including overtime and excluding undertime, are unfortunately less reliable. Such as they are, however, they do indicate that the trend in actual hours worked roughly paralleled the changes in the normal or full-time week.

[8] Appendix C.

Despite the general decrease in labor time per wage earner, the number of workers used per unit of product declined over the period as a whole. The employment-output ratio fell by one half, while weekly hours of work declined by one third. These are the end results, reflecting net changes over four decades. If we follow the year-to-year fluctuations in the employment-output ratio, we find that the number of workers employed per unit increased during business recessions, when hours were reduced temporarily to lessen the number of lay-offs. Similar rises in employment per unit occurred also during the first World War and in the 1930's when the work week was cut drastically. Ultimately, however, we have seen that these temporary upswings in employment per unit were more than counterbalanced, resulting in long-term reductions in workers per unit.

To the 50 percent decline in workers per unit the one-third cut in hours must itself have contributed by enhancing labor's efficiency and stimulating managerial initiative. One should not infer, however, that stated reductions in hours of work have augmented workers' productivity at a constant rate throughout the four decades that have elapsed since 1899. It is more than likely that a given cut in the working day or week has had a progressively slighter effect upon labor efficiency with the passage of time. For the reaction to a reduction in hours depends, first of all, upon the absolute length of the working week that is cut. A 10-hour reduction from an average of 60 hours per week (the prevalent working period in 1899) will, as a rule, result in a greater increase in labor efficiency than an equally large cut from a 50-hour week (the average during the 1920's). Because of the downward trend in hours, then, the influence on labor efficiency of given reductions, and thus on labor requirements per unit of product, must have diminished. The rate of diminution would be all the greater if, as was the case, there were many industries in 1899 with hours well above the average of 60.

whereas in 1937 industries clustered closely about the 40-hour level.[9]

The level of hours is not the only factor, among those affecting labor efficiency and unit labor requirements, that changed during the past four decades. There was also an increase in the kind of mechanization that lessens the relative importance of labor intensity in the productive process: for example, the widespread introduction of instrumental controls, and a marked trend toward automaticity of machine operation. With these changed characteristics of the factory job itself, a given reduction in hours from a specified level would have less effect on output than an identical reduction from the same level under the old conditions of work. This consideration lends added weight to the thesis that in the earlier part of the century cuts in hours must have enhanced labor efficiency and reduced unit labor requirements more drastically than shortening of hours in the latter part of the four-decade period. Unfortunately, no statistics are available to measure the precise effect on labor requirements of changes in these factors.

AGGREGATE MANHOURS AND MANHOURS PER UNIT

Because of the reductions in hours of work, the course of aggregate manhours of labor diverges from that of average number of workers, as Chart 5 shows.[10] The peak in man-

[9] See Chapter 3, Table 2.

[10] The data on hours of labor relate to hours per week. It is not apparent at first sight that multiplying the index of average number of workers employed by the index of weekly hours will yield an index of aggregate manhours worked during the year, for a question arises concerning changes in the number of weeks worked per person per year. As we indicate in Appendix A, however, in the computation of the average number of persons employed account is implicitly taken of change in number of weeks per worker, and the average number of workers so calculated is, in effect, the number of persons that would be employed if all persons worked a full year; i.e., two persons working half a year each are counted as one full-time worker.

hours before the present war boom came during the war of
1917–18,[11] as did the high point in number of workers; but
whereas the latter series was only a little higher in 1917–18
than in 1929 or 1937, the earlier war level of manhours stands
out well above the heights reached in the subsequent years

Chart 5

ALL MANUFACTURING INDUSTRIES COMBINED

Indexes of Employment and Manhours
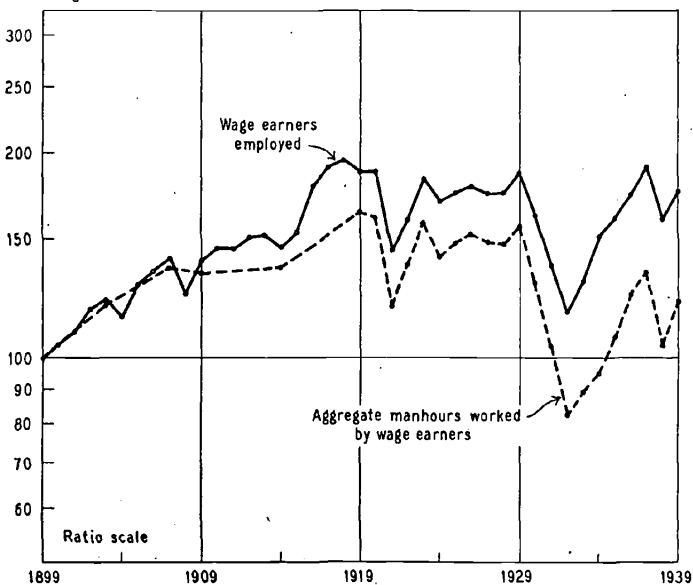
Based on Table F-1

shown in the chart. Again, the number of workers in 1937
was slightly higher than it had been in 1929; manhours,
in contrast, stood much lower in 1937 than in 1929. In
short, after 1918 wage-earner employment fluctuated about

[11] The chart shows no 1917 or 1918 figure for manhours, owing to lack of
precise information on hours actually worked in those years. But it is safe to
say that the number of manhours was greater in 1917 and 1918 than in 1919,
the highest figure plotted in the chart.

a horizontal trend; in manhours the trend was definitely downward. As a consequence, the number of manhours worked in factories in 1937 was no greater than it had been thirty years earlier in the prosperous year 1907, although the number of workers employed was substantially larger.

The preceding conclusion leads us to what is perhaps the most striking figure in this report, namely the estimate of the drop in manhour requirements per unit of fabricated product during the 38 years following 1899. For a halving of the number of workers employed per unit of product and a one-third reduction of the working week amounts to a decline of two thirds in the number of manhours employed per unit of goods produced. And if improvements in quality of products and savings of materials could somehow be worked into the calculations we should find an even greater cut in manhours per unit.

The two-thirds reduction in the ratio of manhours employed to quantity of product manufactured is the net result of almost four decades of change. Like the employment-output ratio, the ratio of manhours to output did not decline smoothly, but shifted in tempo from one brief period to another (Chart 6). Yet in comparison to the movement of workers employed per unit, the fluctuations in manhours per unit are relatively mild. The scarcity of data on actual hours for each year since 1899, and the lack of precision in such hours data as are available, make it difficult, of course, to place complete trust in such summary statements. It is possible that an abundance of reliable data would show more fluctuations than does the series charted, although there can be little question that the manhour-output ratios are much more stable from year to year than the corresponding employment-output ratios.

Despite this relative stability in the manhour-output ratio several interesting changes occurred in its average rate of decline. Here too the lack of complete and accurate data on

actual hours makes it hard to define the shifts. Nevertheless one can conclude, first, that the five-year period terminating with the end of the first World War witnessed practically no net decline in the manhour-output ratio.[12] Second, during most of the 1920's there was an exceptionally rapid drop in

Chart 6

ALL MANUFACTURING INDUSTRIES COMBINED

Indexes of Wage Earners and Aggregate Wage-Earner Hours per Unit of Product

Percentage

Based on Table F-1
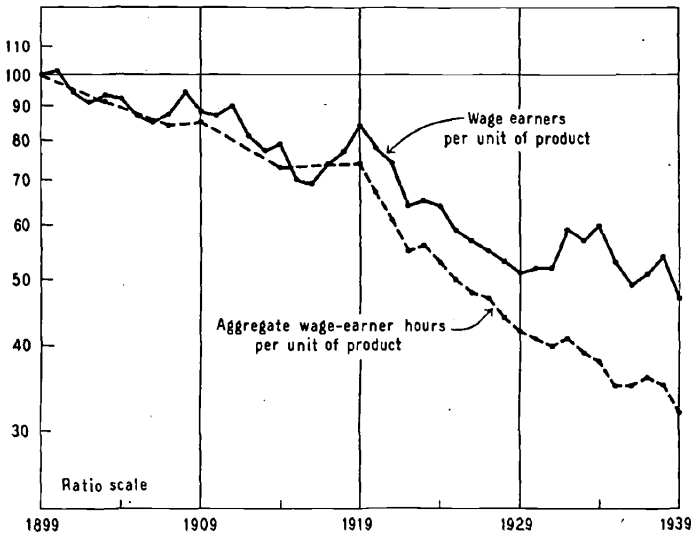
manhours per unit. The manhour-output ratio fell during the decade 1919–29 at a rate of more than 5 percent per annum. If this rapid rate of decline had prevailed during the entire period after 1899, unit labor requirements in 1939

[12] It seems likely, though not certain, that manhours per unit fell considerably from 1914 to 1915, dropped slightly from 1915 to 1916, rose sharply from 1916 to 1917, and went up slightly from 1917 to 1918. That is, the slow rate of decline during the first World War period was due entirely to the failure of manhours per unit of output to fall during 1917 and 1918.

would have been less than one half of what they actually were in that year. Finally, the decline in labor per unit after 1930, while much slower in pace than that which characterized the 1920's, was not very much behind the average for the entire four decades.[13]

Chart 6 depicts also a fairly high degree of persistence in the declining trend of manhours per unit. While we know all too little about actual hours worked per week during the years since 1899, it seems reasonable to conclude that the years when there was no reduction in the manhour-output ratio are relatively few. These years, interestingly enough, were sometimes periods of growing business, in which output and investment rose rapidly, and sometimes poor business years, when output and investment fell off. Capital investment, widely considered one of the significant sources of decline in unit labor requirements, has in fact fluctuated rather violently,[14] apparently without any noteworthy or even con-

[13] Reference should be made again to a factor generally affecting our measures of output, namely, change in the quality of goods produced by factories. On net balance there has been improvement: if we were to compare the products of American factories turned out in 1937 with corresponding goods produced in 1899 the greater number of them would be found to be more durable, more efficient, less noisy in operation, or otherwise better. But such comparisons might not lead to similar results if shorter intervals were considered. To the extent that there have been fluctuations in the rate of improvement in the quality of fabricated commodities, some of the variation in the rate of decline in manhours per unit of product may be accounted for, though it is unlikely that the quality factors can explain a very large amount of this variation. In particular, it is possible that improvements in quality were least noteworthy, if not actually negative on the average, in the period following 1929. One reason for measuring only the net change between 1929 and 1937 and ignoring the years between is to eliminate as far as possible the effects of cyclical changes in quality and other factors. But there is some ground for the belief that the long recession following 1929 resulted in a deterioration of the average quality of some goods, not entirely counterbalanced in the revival that followed. Thus there seems to have been a tendency, especially in consumers' semidurable goods like shoes and clothing, for factories to shift their emphasis to the cheaper grades. Since these require much less labor in fabrication than do the more expensive qualities or styles, the change in the character of output would be accompanied by a decline in the measure of manhours per unit even in the absence of other factors affecting this ratio.

[14] Appendix E.

sistent effects on short-term changes in the manhour-output ratio. The ratio dropped from 1920 to 1921 and again from 1929 to 1931, yet capital investment fell in both periods, in the latter to a level actually below current depreciation charges. But during 1923–29, another period when manhours per unit were declining rapidly, capital investment was at a high level. It is surprising, also, that the period 1935–37 is to be counted among those in which there was no decline in unit manhour requirements, for in these three years capital investment rose to heights comparable even with the level of the boom period 1923–29.

One explanation lies in the difference between the current *flow* of capital and changes in the existing *stock* of capital goods. Even violent fluctuations in new investment cause relatively mild changes in plant and equipment; and capital goods do not actually decline until new investment falls below the rate of wear and tear. Yet it is alone through changes in the quantity and character of existing capital goods that changes in new investment can exert a direct influence upon the ratio of labor to product.[15] And if a period of adaptation (for reorganization or breaking-in) is necessary, the labor-output ratio fails to react immediately even to fluctuations in the volume of capital goods.

The relatively minor fluctuations in unit labor requirements—despite severe fluctuations in capital investment—may be explained in part too by the customary removal from service of less efficient equipment as output (and with it new investment) declines, and its return when output (and new investment) rises. Equipment set aside and then brought back into use presumably requires more manhours of labor for the production of a unit of output than equipment kept continuously in operation. An outstanding example is provided

[15] 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.

by the intermittent resort to beehive ovens in coke production. These ovens yield half the product per worker that is derived from byproduct ovens. As a consequence they have been declining in importance ever since the introduction of the byproduct oven during the 1890's and now contribute less than 5 percent of total coke production. Yet during peaks in coke output, the inefficient beehive ovens are restored to use, only to be set idle again when output falls. The alternation of use and disuse of less efficient equipment thus helps to offset the influence of fluctuations in new investment upon the labor-output ratio.

Still another explanation of the comparatively steady course followed by the manhour-output ratio is to be found in the frequent utilization of factory labor to maintain old machines and plant and sometimes even to construct new plant and equipment. When investment in purchased capital goods is declining, investment in capital goods produced by the entrepreneur for his own use and for the maintenance of old fixed assets is commonly decreased. At such times manhours expended in the latter types of investment activity are cut down, presumably more drastically than total manhours of work. The consequence, in the absence of other influences, is a drop in total manhours per unit of output during recession and a rise during recovery.[16]

[16] The reverse seems to apply, however, in a few industries. Here it appears that the need for maintaining plant and equipment even during depression results in a smaller decline in maintenance labor than in total labor. This situation, coupled with the inefficiencies of operation at low utilization of capacity, accounts in part for increases in manhours per unit during recession and for decreases during revival. Modern steel mills, for example, are designed for high-speed volume production, and when they are not operating close to capacity they require excessive amounts of labor per ton of output: the unit labor requirement per gross ton of finished steel products at a rate of operation equal to 20 to 25 percent of capacity is 46 manhours as compared with 34 manhours when 55 to 60 percent of capacity is utilized. (B. H. Topkis, and H. O. Rogers, "Man Hours of Labor per Unit of Output in Steel Manufacture," *Monthly Labor Review*, May 1935. For similar data on cement see B. H. Topkis, "Labor Requirements in Cement Production," *Monthly Labor Review*, Mar. 1936.)

Although the net effect of the various influences noted in the preceding paragraphs is difficult to assess, variation in the degree to which they offset one another may help to explain the inconsistent relations between capital investment and the manhour-output ratio. But it is hardly likely that these are the only relevant factors. There are also modifications in factors other than capital investment, the efficiency of the equipment in actual use, or the number of maintenance workers. Among these are changes in the quality and character of products as prices fall and rise; in managerial efficiency with recession and recovery; and in labor's productivity as unemployment contracts 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 most business cycles, must be analyzed before we can understand why the labor-output ratio for all manufacturing industries combined behaves as it does during short periods.[17]

SIGNIFICANCE OF THE DECLINE
IN UNIT LABOR REQUIREMENTS

The reduction of over two thirds in labor per unit of product, measured in manhours, and of one half in terms of men employed, reflects a very marked transformation in

[17] 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; 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. The evidence collected in this study (Appendix F and Chart 12, below) goes little further than to suggest that there is some industrial diversity of cyclical pattern and that in a few industries there is fairly considerable amplitude of fluctuation. Here too, however, the general impression is one of gradual decline with moderate and random fluctuations, rather than of considerable and systematic variation about a downward trend. Our statistics tell us little about the consistency of the cycles in labor per unit of output in individual industries. To study these fluctuations adequately we should need extensive monthly data.

manufacturing techniques, conditions of work, intensity of labor effort, and material means of production. The industrialist of 1899 would rub his eyes in amazement were he suddenly set down in the United States of today. He would find new materials, more and bigger machines, novel and flexible sources of power, giant factories and nation-wide industrial networks, advanced mechanical, chemical, and electrical processes, assembly lines speeding the flow of work, intensified division of labor, and revised methods of labor management. These and a host of other innovations and developments coincided with the drop in labor requirements per unit of product, and many of them no doubt contributed to that decline.

A few of the changes may be defined quantitatively, though their influence is not subject to exact appraisal. For example, the net book value of capital assets used in manufacturing between 1904 (the earliest year for which we have data) and 1937 rose from $6 billion to almost $25 billion, or from about $1,000 of capital assets per worker to over $2,000. Price increases between 1904 and 1937 must have accounted for a good part of this rise, but even after allowing for them so far as we can, we find an increase of at least 30 percent in the net value of capital instruments per worker.[18]

Again, the aggregate rated horsepower capacity of prime movers and of electric motors driven by purchased energy utilized in manufacturing plants increased from 10 million in 1899 to over 50 million in 1939—a rate more than twice as rapid as that at which employment in factories advanced. As for the expansion in the scale of industrial operations, with all that it implies with respect to specialization of industries, plants, and labor, the fourfold increase in output serves as a rough measure of its scope.

Unfortunately there are direct and precise measures for very few of the phenomenal developments in contemporary

[18] The data are presented and discussed in Appendix E.

manufacturing.[19] No information is available for years prior
to about 1920 on such an important form of capital as manu-
facturing inventories, which amounted to over $12 billion
in 1937 (equal to 50 percent of the value of net capital as-
sets); yet inventories are in some degree substitutes for equip-
ment, particularly in meeting seasonal peaks in demand, and
they affect manhours per unit of output directly by enhanc-
ing the regularity of the flow of work.

As for the increased efficiency of labor itself, the one-third
drop in hours must have contributed to it, but this figure is
hardly an adequate gauge of the influence of the reduction
in the work week. The elimination, in large part, of the child
labor that was employed in 1899 is also a factor in greater
labor efficiency, yet its effect, too, is difficult to weigh quan-
titatively. In addition, of course, many of the important
changes are qualitative: revisions of plant layout; improve-
ments in equipment, notably increases in the size of ma-
chines; accelerated speed of operation; more precise control
devices; and less susceptibility to breakdown. Together with
air conditioning, improvements in lighting, elimination of
disturbing pillars, and other refinements in factory building
and design, these qualitative advances have been so revolu-
tionary that one might well venture the statement (though
it cannot be substantiated in quantitative terms) that they
have contributed as much to reducing unit labor require-
ments as has the growth in the physical stock of productive
instruments.

Confronted by this complex of influences which is beyond
synthesis or direct measurement, we must return to the ratio
of labor input to units of output as perhaps the simplest and
most readily computed single index of all the changes, large

19 As is noted in Appendix E, statements concerning changes in capital as-
sets must be accepted with caution. On the incommensurability of the horse-
power capacity of different types of engines and motors see W. L. Thorp,
"Horsepower Statistics for Manufactures," *Journal of the American Statistical
Association*, Dec. 1929.

and small, that have shaped contemporary manufacturing processes. Appraised either in terms of men or of manhours, the decline in this ratio is the most telling measure of their cumulative impact.

This complex effect should not be considered identical with change in "efficiency," or with any other single aspect of manufacturing development. If the reduction in labor requirements per unit of product, whether calculated in numbers employed or in hours worked, can be held to reflect a multitude of changes in the processes and means of production, it cannot be regarded also as a measure of change in the efficiency, amount or character of any one factor of production. Those who consider the figures cited to be indexes of labor efficiency, of quantity of capital invested, or of improvement in capital equipment, are in effect ascribing to one or another factor the result of changes in all factors. For the same reason one cannot reasonably 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 of standardization of products and regulation of hours and conditions of labor by governmental agencies. Sometimes, of course, a specific change in unit labor requirements may be accurately ascribed to some single factor; but this is hardly true of changes in broad industrial categories over long periods. And finally, developments in manufacturing alone cannot account for the decline in its unit labor requirements, for the latter reflects also changes in other parts of the economy.[20] The reduction in the utilization of labor per unit of product in American factories since 1899 cannot be viewed, therefore, as the result of the operation of

[20] See Chapter 6 for a discussion of the relation between developments in factories and those in the economy at large.

any one factor of production, or even of all the factors resident in manufacturing. It must be interpreted rather as reflecting, in just one segment of our industry, the cooperative action of all factors, both within manufacturing and outside it.